# Herbicide Strategy Case Study Summary and Process

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Office of Pesticide Programs
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# 1 Executive Summary

This document provides description of the risk assessment methods used to develop the draft Strategy (Strategy) through the use of case studies. A primary goal of the proposed Strategy is to develop mitigation measures to help increase the efficiency of EPA meeting its obligations under the Endangered Species Act (ESA).

Under ESA Section 7(a)(2), each Federal agency shall ensure that any action authorized, funded, or carried out by such agency (hereinafter in this section referred to as an "agency action") is not likely to jeopardize (J) the continued existence of federally listed species (listed species) or destroy or adversely modify (AM) designated critical habitat (CH). In fulfilling the requirements of this paragraph each agency shall use the best scientific and commercial data available. As appropriate, federal agencies consult with the United States Fish and Wildlife Service (FWS) and/or National Marine Fisheries Service (NMFS) to ensure that J/AM is not likely because of their actions.

The proposed Strategy is focused on listed species under the jurisdiction of FWS as they have authority over the majority of listed species that EPA determined were the most relevant to this Strategy. The method described in this document illustrates how current risk assessment methodology can be used to develop mitigations prior to making effects determinations or completing ongoing consultations to reduce the potential for population-level impacts to listed species and CH as a result of agricultural uses of herbicides in the conterminous United States.

For the case studies, EPA selected herbicides that represent different modes of action (e.g., photosystem inhibition, growth regulators, lipid peroxidation), different physical-chemical properties, and different toxicities to terrestrial and aquatic plants. For each chemical EPA conducted an assessment focusing on the direct impacts to plants using current modeling approaches and characterization of all available plant toxicity data. These example assessments provide estimates of the potential impacts to plant populations, the magnitude of environmental exposure, and level of spray drift and runoff/erosion mitigation needed to reduce exposure to listed species, which in turn could reduce the potential for population-level impacts for listed species of plants, animals that depend upon plants, and their designated critical habitats, and provide efficiencies for any future consultations related to these herbicides. There are 4 general questions that each case study evaluates:

- Is drift and/or runoff/erosion a concern for impacts to populations of listed plants and populations of listed animals that depend on plants?
- What amount of exposure reduction is needed to reduce the potential for population-level impacts to listed plants and listed animals that depend on plants?
- What mitigation practices can be used to achieve this exposure reduction?
- What is the geographic extent of the mitigation measures?

EPA presents the results of each case study in the subsections of this document starting at **Section 6**. Each case study is a unique situation that was used to inform the proposed Strategy. EPA plans to continue to learn from the development of the proposed Strategy and its relevance for other herbicides beyond the representative active ingredients. EPA may determine changes to the Strategy described herein after considerations of public comment taken on this proposed Strategy.

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## 2 Introduction

The draft Herbicide Strategy (Strategy) focuses on developing, proposing, and then implementing early protections on agricultural uses of conventional herbicide products to reduce/minimize exposure for more than 900 listed species. In turn, these proposed mitigations could reduce the potential for population-level impacts and potentially to minimize take[1] from the ongoing use of registered conventional herbicides. EPA expects that the proposed mitigations would apply broadly to conventional herbicides. These proposed mitigations and potential approaches for implementation are discussed in two associated documents. The first is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. Because individual herbicides do not necessarily share the same fate properties and potential for impacts to federally listed threatened and endangered species, this document supplements the Strategy Framework document and provides illustrative examples of the application of the proposed Strategy and the resulting proposed mitigations. EPA used these case studies to inform the general suite of proposed mitigation options that can be applied to other herbicides based on fate and effects information described in the Framework document. This was an iterative process. EPA evaluated these representative chemical examples, to inform the development of the proposed mitigation framework, and vice versa. The chemical specific case studies included here illustrate:

1. the three steps process proposed for the Herbicide Strategy to identify the need for, level of, and extent of mitigation practices based on chemical-specific use, exposure, and toxicity information; and
2. how mitigation measures could reduce the potential of listed plant and animal population-level impacts, as well as minimize take for listed animals.

EPA conducted case studies of representative herbicides to evaluate and calibrate the proposed three step framework of the Strategy (see details in the **Strategy Framework**). EPA developed these case studies concurrently with the framework. EPA used an iterative process to develop the proposed framework by considering the different toxicity data and use patterns for the selected herbicides. EPA drafted an initial framework and set of mitigations and then applied and revised them based on the case studies. For the case studies, EPA selected conventional agricultural herbicides that differ by 1) modes of action (e.g., photosystem inhibition, growth

[1] Take as defined under the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." ESA § 3(19), 16 U.S.C. § 1532(19). Incidental take is an unintentional take "that result[s] from, but [is] not the purpose of, carrying out an otherwise lawful activity, but not unexpected, taking." See 50 C.F.R. § 402.02.

regulators, lipid peroxidation), 2) use patterns, 3) physical-chemical properties and 4) toxicity to plants. EPA conducted case studies for the following example herbicides:

1. 2,4-D and its salts and esters (referred to collectively as '2,4-D'),
2. dicamba and its salts (referred to collectively as 'dicamba'),
3. diuron,
4. MCPA (2-methyl-4-chlorophenoxyacetic acid) and its salts and esters (referred to collectively as 'MCPA'),
5. metolachlor and its isomer *S*-metolachlor (referred to collectively as 'metolachlor'),
6. metribuzin,
7. oxyfluorfen,
8. paraquat dichloride,
9. pendimethalin,
10. propanil,
11. thiobencarb, and
12. trifluralin.

The 12 chemical example case studies presented in **Section 6** through **Section 17** reflect the proposed framework (see the **Strategy Framework** document for more details). Each case study includes two components. The first component is an application of the three-step process proposed for the Herbicide Strategy. The second component is an analysis identifying specific listed species and CHs with potential population-level impacts prior to considering mitigations identified in this Strategy.

The purpose of the first component of the case studies is to demonstrate how the proposed framework would be applied to different herbicides and illustrate how herbicide specific information may influence the need for, level of, and extent of mitigations that are identified. In these analyses, EPA presents the three steps of the Strategy, including estimates of exposure, a summary of the toxicity endpoints used to calculate magnitude of difference (MoD) values and identify the magnitude of effect (MoE) level, discussion of the level of mitigation identified for terrestrial and wetland/aquatic habitats, and identification of which spray drift and runoff/erosion mitigations would be proposed for the general label and for the four smaller, geographically specific pesticide use limitation areas (PULAs). For this analysis, EPA applied the framework that is described in **Sections 4** through **7** of the **Strategy Framework**. In some cases, EPA simplified the pesticide-specific information (including labeled use information) to concisely demonstrate the framework. The case studies are not intended to support a regulatory action for the specific herbicide active ingredients. The section below summarizes the mitigations that are identified for each of the 12 herbicides when EPA applied the draft Strategy framework.

In the second component of each of these example case studies, EPA identified potential listed species and designated critical habitats (CHs) of listed plants and animals located in the 48 conterminous United States where there may be population-level impacts as identified using the proposed Strategy. The purpose of this analysis was to support future streamlined

consultation with FWS. EPA's proposed Strategy relies upon a streamlined, taxon-based assessment to identify mitigations; however, EPA is providing species specific examples to connect the dots between groups of species and specific species that would receive similar proposed mitigations. To identify those species and CHs with potential population-level impacts, EPA adapted some elements of FWS's method used in the malathion biological opinion (USFWS, 2022); however, EPA did not fully address several aspects of the method that would be necessary to predict the likelihood of potential J/AM. For example, EPA considered the magnitude of effect and degree of overlap to identify these species and CHs, but EPA did not consider species vulnerability nor life history modifiers. This document includes details on the method EPA used in these example case studies to identify specific species and CHs with potential population-level impacts prior to mitigation. Although EPA conducted this analysis to establish a starting point for consultation discussions with FWS, EPA anticipates it may revisit the analyses to incorporate other considerations important to FWS in future consultations.

# 3 Methods Used in Framework Step 1 to Identify Potential Population-level impacts

The draft Strategy relies upon existing standard approaches that EPA uses to conduct a risk assessment to support conventional herbicide registrations under FIFRA. For the case studies, EPA used existing risk assessments as source information for each case study chemical, estimated environmental exposure with current exposure models and approaches, and incorporated a comprehensive consideration of available toxicity data. This section provides a summary of the models and their application to conventional herbicides, and a description of how toxicity data, exposure estimates, scientific support for the establishment of the magnitude of difference, the magnitude of effect level, and the mitigation categories, and discussion of how listed species and CH life history and distribution information are used.

## 3.1 Models Used to Estimate Exposure in Aquatic, Terrestrial and Wetland Habitats

For the Herbicide Strategy, EPA generated estimated environmental concentrations (EECs) to evaluate exposure to chemical-specific residues of concern (identified in the FIFRA assessment) to terrestrial, wetland, and aquatic plants. EPA utilized different exposure models for pesticides applied to terrestrial fields and pesticides applied to intermittently flooded fields, such as applications to rice and cranberries. EPA used various models to calculate aquatic and terrestrial EECs (see **Table 3-1**). Current models and their user guides can be found at https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment. The specific models used in this assessment are discussed below.

**Table 3-1. Models Used to Assess Exposure and Identify Potential Impacts**

| Environment | Exposure/transport Pathway | Models or assumption |
|---|---|---|
| Aquatic | Runoff and Drift for EPA Farm Pond or Larger Waterbody | PWC[1] version 2.001 |
| | Runoff and Drift for Waterbody Smaller than EPA Farm Pond | PWC[1] version 2.001<br>PAT[2] version 2.8 |
| | Spray drift only to Body of Water | AgDRIFT[1] version 2.1.1 |
| | Runoff Concentrations in Rice Paddy/Cranberry Tailwater | PFAM version 2[3] |
| Terrestrial and Wetland | Runoff and/or Spray Drift | PWC[1] version 2.001<br>PAT[2] version 2.8 |
| | Spray drift only (point deposition) | AgDRIFT[1] version 2.1.1 |

[1]PWC = Pesticides in Water Calculator version 2.001 available online at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment.
[2] PAT = Plant Assessment Tool version 2.8 available online at: https://www.epa.gov/endangered-species/provisional-models-and-tools-used-epas-pesticide-endangered-species-biological#pat
[3] PFAM = Pesticides in Flooded Applications Model version 2 available online at: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#PFAM

EPA uses the Pesticide in Water Calculator (PWC) and the Plant Assessment Tool (PAT) models to estimate exposures in bodies of water that represent the aquatic bins (discussed **Appendix A** of the **Strategy Framework**). Within the PWC model, EPA used the standard farm pond to develop EECs for the medium and large static and flowing bins (*e.g.*, bins 3,4, 6 and 7). For the smaller flowing and static bins (aquatic bins 1, 2 and 5), EPA generated exposure estimates with the wetland (WPEZ) module of the PAT model. More discussion of the models used is provided in the sections below.

### 3.1.1 Pesticide in Water Calculator (PWC)

EPA generated surface water EECs) using the Pesticide in Water Calculator (PWC) version 2.001[2] coupled with the Plant Assessment Tool (PAT) version 2.8. EPA selected ecological scenarios coupled with weather information to assess runoff potential from vulnerable agricultural use sites. EPA used these ecological scenarios to specify soil, climatic, and agronomic inputs in the Pesticide Root Zone Model (PRZM) and Variable Volume Water Body Model (VVWM) portions of PWC. For reasons explained in USEPA 2004, EPA designed the PWC model to generate high-end EECs in water associated with a particular pesticide and use within a specific geographic region (e.g., Mississippi corn). Each PWC scenario is specific to an area where the use occurs (*i.e.*, where a crop is commonly grown). EPA designed the model such that soil and agronomic data specific to the location are built into the scenario, and a specific climatic weather station providing a minimum of 30 years of daily weather values is associated with the location. The

[2] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#PWC

chemical input parameters, selected scenario and maximum use application input parameters used for the PWC modeling of the case studies are provided within each of the chemical-specific chapters below. For each of the case studies, EPA modeled maximum application rates, numbers of applications, and minimum intervals between applications for individual or groups of crops as defined on the product labels. EPA estimated EECs using application scenarios registered product labels for the example chemical chemicals. The EECs generated for the EPA farm pond represent 1-in-10 year concentrations (µg a.i./L).

### 3.1.2 Plant Assessment Tool (PAT)

In the Herbicide Strategy, EPA utilized PWC (version 2.001) and PAT (version 2.8) to generate EECs for terrestrial and wetland plants. EPA utilized the same PWC scenarios[3] to support ecological exposure in the EPA farm pond in the PWC modeling for estimating exposure for aquatic plants in larger waterbodies. EPA also utilized AgDRIFT™ modeling to evaluate potential exposure via spray drift for terrestrial and wetland plants, as well as for drift only exposure for aquatic bins 2 and 5 because the dimensions of those aquatic bins are smaller than those in the PAT wetland.

#### *3.1.2.1 Terrestrial Plant Exposure Zone (TPEZ): Runoff and Spray Drift from a Treated Field Deposited onto a Non-Target Terrestrial Plant Area Next to the Field*

The Terrestrial Plant Exposure Zone (TPEZ) is intended to represent a non-target terrestrial (non-inundated) plant community immediately adjacent to a treated field, which is exposed to pesticide via sheet-flow[4] and spray drift from the treated field. The TPEZ is defined as an area adjacent to the treated field with a length of 316 m (equal to the length of the edge of the treated field), and a width of 30 m. The width of the TPEZ represents the distance that overland surface flow can travel before sheet-flow transitions to concentrated (i.e., channelized) flow (NRCS 2010). For the TPEZ, EPA assumes that runoff to an area immediately adjacent to the treated field is in the form of sheet-flow that carries pesticides dissolved in water and/or sorbed to suspended sediments (i.e., erosion) in runoff. Beyond this distance over which runoff moves as sheet-flow, EPA assumes runoff to become concentrated into small streams (rivulets), gullies, *etc*., which is represented by evaluations with the Wetland Plant Exposure Zone (WPEZ) and the PWC - EPA farm pond.

For the TPEZ, EFED uses an instant "mixing cell" approach in the model to represent water within the active root zone area of soil, which accounts for flow through the TPEZ caused by both treated field runoff and direct precipitation onto the TPEZ. Pesticide loss from the TPEZ may occur from transport (*i.e.,* washout and infiltration below the active root zone) and degradation. The EECs generated for the TPEZ represent 1-in-10 year concentrations. For comparison to terrestrial plant toxicity endpoints, EPA calculates the total mass of pesticide per

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[3] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment
[4] A continuous film of water flowing over the soil surface which is not concentrated into channels.

area by tallying the total mass in the TPEZ and expressing it on an area-normalized basis (lbs a.i./A).

#### *3.1.2.2 Wetland Plant Exposure Zone (WPEZ): Runoff and Spray Drift from a Treated Field Deposited into a Non-Target Wetland Area*

The WPEZ is intended to represent a non-target wetland plant community that is exposed to pesticide via sheet-flow and/or overland flow[5] and spray drift. The wetland can be immediately adjacent to the treated field or some undetermined distance away and be exposed via spray drift and runoff or from runoff only. EPA designed the WPEZ to represent a plant community that can exist in a saturated to flooded environment, such as a depression or shallow wetland that would collect and hold runoff from upland areas. EPA assumes this wetland[6] system to be protective of other surface-fed wetland systems (*e.g.*, permanently flooded; riparian) such that it is allowed to dry-down (concentrating contaminants), has a finite volume (considers standing water exposure), and would receive all the runoff from an adjacent treated field.

Similar to the TPEZ discussed above, EPA considers the contribution to concentration from spray drift deposition along with runoff only for the dimensions of the WPEZ. EPA defines the WPEZ as a one-hectare (ha) wetland receiving inputs from the adjacent 10-ha field. Within the WPEZ, EPA defined two depth zones: a standing water zone and a saturated soil pore-water (5 cm benthic) zone. EPA set the maximum depth of standing water to 15 cm, but this water is allowed to dry down to a minimum depth of 0.5 cm using algorithms from the Variable Volume Water Model (VVWM). For comparison to terrestrial plant toxicity endpoints, EPA calculated the total mass of pesticide per area by tallying the total mass in the water column plus that in the benthic sediment layer and expressing it on an area-normalized basis (lb a.i./A).

### 3.1.3 Pesticides in Flooded Applications Model (PFAM)

For applications to intermittently flooded fields such as rice and cranberries, EPA utilized the Pesticide in Flooded Applications Model (PFAM; version 2) to generate water column EECs in the rice paddy or cranberry bog, in tailwater leaving the rice paddy, and in larger order lotic environments (e.g., Sacramento and Black Rivers) to provide a bounding of potential exposure in downstream rivers. EPA directly compared these EECs to aquatic plant toxicity endpoints (*i.e.*, *Lemna*; algae; cyanobacteria). EPA does not currently have a model to estimate EECs for wetland plants from applications to intermittently flooded fields. These waters may be released into adjacent wetlands and into adjacent canals; therefore, wetland plants could be exposed in these receiving habitats. To characterize the potential to impacts on wetland plants, EPA converted the vegetative vigor and seedling emergence terrestrial plant toxicity endpoints from

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[5] Water flow that moves in swales, small rills, and gullies.

[6] Wetland plants may occur in habitats that are not considered wetlands; however, they are all evaluated using the Plant Assessment Tool (PAT) wetland conceptual model (USEPA, 2023) and are therefore referred to as wetland plants throughout the Herbicide Strategy documents even though many of them will not be wetland plants.

units of lbs a.i./A to units of µg a.i./L using the dimensions of the WPEZ to enable direct comparison of these wetland plant relevant endpoints to the PFAM EECs. As the overland sheet-flow runoff is not expected to occur in fields with levees or berms around the fields and in situations where water movement off of the field is controlled with a weir, EPA did not evaluate runoff risks to terrestrial plants for these types of cropping systems. Rice grown in the mid-South is sometimes grown similar to row crops[7] ("furrow irrigated rice" or "row rice"), and traditional runoff models are appropriate for evaluating this exposure pathway. In future evaluations, EPA plans to utilize PAT to evaluate the potential for exposure of terrestrial and wetland plants for herbicide use on row rice in the mid-South. Rice is not currently grown in this manner in California.

#### 3.1.4 Off-field Exposure Resulting from Spray Drift

*Terrestrial and Wetland*

EPA used the AgDRIFT™ model (version 2.1.1) and terrestrial/wetland plant toxicity endpoints to estimate off-field spray drift EECs. Drift analysis assumed a single maximum rate application, represents 90$^{th}$ percentile point deposition estimates (lb a.i./A), and was generated for aerial, ground and airblast application methods. Under this approach, EPA employed the Tier I exposure methods within AgDRIFT.

*Aquatic*

EPA also used the AgDRIFT spray drift model (version 2.1.1) to estimate off-field distances to small waterbodies (aquatic bin 2). Scoping exercises indicated that the spray drift distances based on terrestrial and wetland toxicity endpoints are protective of small water bodies, and therefore, EPA used these distances as surrogates for small water bodies. The EECs generated represent 90$^{th}$ percentile estimates (µg a.i./L).

## 3.2 Effects Endpoints Used in the Herbicide Strategy

The proposed Strategy provides a mitigation menu for spray drift and runoff/erosion to address potential herbicide impacts on plant populations and plant habitats, and potential impacts on the diet and/or habitat availability/quality for animals because of impacts to plants. The case studies evaluate the potential impacts on plants to help illustrate the effectiveness of the draft Strategy. EPA data requirements for terrestrial and aquatic plant testing are currently specified in Title 40 (Protection of the Environment) of the Code of Federal Regulations, Part 158 (Data Requirements for Pesticides) Subpart G (Ecological Effects) § 158.630 (Terrestrial and Aquatic

[7] https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/rice/ArkansasFurrowIrrigatedRiceHandbook.pdf

Non-target Organism Data Requirements Table).[8] For the case studies, EPA used scientifically valid toxicity data submitted by registrants to fulfill data requirements for FIFRA actions because these data are consistently available for herbicides and can be considered representative of effects to plants. For the case studies, EPA did not use other toxicity data that may be available in the open literature (i.e., through the ECOTOX database). This was done for the sake of simplicity and consistency among the case studies. When EPA conducts final risk assessments for these specific chemicals for regulatory decisions using the final Herbicide Strategy, additional toxicity data from the literature may be incorporated, if appropriate.

### 3.2.1 Terrestrial Plant Toxicity Studies

For herbicides, pesticide applicants/registrants typically submit the seedling emergence and seedling growth test (OCSPP Guideline 850.4100) and the vegetative vigor toxicity test (OCSPP Guideline 850.4150). These studies are often conducted with the technical grade active ingredient (TGAI), single active ingredient typical end-use products (TEPs), or multi-active ingredient TEPs[9] (more than one herbicide in the product formulation). Endpoints considered in the guideline studies include growth (height, weight), emergence, survival, and visual signs of toxicity. For each of these measured endpoints, the 25% inhibition concentration ($IC_{25}$) for growth, or 25% effect concentration for survival ($EC_{25}$) is statistically determined from the concentration-response curves for each species tested. For herbicides, the submitted plant toxicity studies are required to include four monocots (e.g., corn, oat, wheat, ryegrass, onion) and six dicots (e.g., soybean, carrot, tomato, sugar beet, cabbage, lettuce). When conducting a screening assessment, supporting the evaluation of the potential impacts to individuals of a listed species or designated critical habitat, EPA relies upon the No Observed Adverse Effect Concentration (NOAEC) or an alternative inhibition concentration (e.g., $IC_x$[10]; **Table 3-2**). Because the Herbicide Strategy is focused on population level impacts, EPA did not include these endpoints in the case studies.

To evaluate population level impacts, EPA developed species sensitivity distributions (SSDs) with the $IC_{25}/EC_{25}$ toxicity endpoints and uses them to inferentially derive the 5$^{th}$ and 25$^{th}$ percentiles (**Table 3-2**). SSDs describe the variation in $IC_{25}/EC_{25}$ endpoint sensitivity across species for a given chemical and life stage (e.g., seedling development; young plant

[8] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158/subpart-G

[9] The inclusion of multiple active ingredient studies should be considered on an individual active ingredient basis. The consideration should include a discussion of the relative contribution of each active ingredient in the observed response based as compared to available single active ingredient toxicity data for each. This comparison should include comparisons for each tested species and endpoint.

[10] In lieu of using NOAEC/LOAEC, the regression-based $IC_X$ values for aquatic and terrestrial plants can be used. In most risk assessments and Data Evaluation Records (EPA's documentation of its review of a scientific study), the $IC_{05}$ is the regression-based endpoint that is available for use in lieu of a NOAEC value. If additional regression-based endpoints are available, the following can be used per EPA's analysis of the variability in terrestrial plant data (USEPA, 2020a; Appendix 1-5): vegetative vigor 850.4150 endpoints for dry weight ($IC_{15}$) and height ($IC_{10}$); seedling emergence 850.4100 endpoints for dry weight ($IC_{20}$) and height ($IC_{10}$); vascular and non-vascular aquatic plant studies and all plants survival-based endpoints ($IC_{05}$).

development). EPA generated the SSDs for each study and endpoint separately (where possible), but depending on the chemical, the SSDs may include toxicity data from tests conducted with the TGAI, single active TEPs, and/or multi-active TEPs. **Appendix A**: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints describes the process EPA uses when generating and selecting SSDs using the SSD Toolbox version 1.0[11] (a program that can be used to fit such distributions).

### 3.2.2 Aquatic Plant Toxicity Studies

The current FIFRA data requirements for aquatic plants include the aquatic plant toxicity test using vascular plants (*Lemna spp*., OCSPP Guideline 850.4400), the algal toxicity test (4 algal species; OCSPP Guideline 850.4500), and the cyanobacteria toxicity test (OCSPP Guideline 850.4550). Aquatic plant toxicity studies are typically conducted with the TGAI, unless direct applications to aquatic habitats are anticipated or there is evidence to suggest increased toxicity of the TEP. Endpoints in the guideline studies focus on growth rates and biomass and are designed to provide the 50% inhibition concentration ($IC_{50}$) that is statistically determined from the concentration-response for each species tested and the NOAEC. For aquatic plants, a minimum of 5 test species is generally available for herbicides. This amount of data may not be sufficient to derive an SSD. In these cases, EPA will use the most sensitive $IC_{50}$ from available aquatic toxicity data (**Table 3-2**).

### 3.2.3 Open literature and non-guideline toxicity data

Although not included in the example case studies provided here, EPA typically examines available scientific information from alternate sources (e.g., searches conducted using the ECOTOX database) for species within a taxonomic group for which other taxa are typically used as surrogates. In situations where such additional data are available, EPA makes decisions regarding the quality and utility of such information in the risk assessment (e.g., a review of the validity and reliability of study protocols), which is consistent with the Agency's risk assessment guidance[12]. The extent to which EPA employs or rejects such additional data is described through a transparent, concise discussion. As discussed further in **Section 3.3.2.3**, available guideline studies for terrestrial and aquatic plants often represent the most sensitive species and endpoints across available scientific studies. Therefore, additional information identified in the open literature are not usually so different as to be determinative with respect to the identification of different risks and related mitigation needs.

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[11] https://www.epa.gov/chemical-research/species-sensitivity-distribution-ssd-toolbox

[12] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/evaluation-guidelines-ecological-toxicity-data-open

### 3.2.4 Endpoints Selected for Evaluating Potential impacts to Individuals and Populations

**Table 3-2** provides a summary of the plant toxicity endpoints discussed above and how EPA uses them in its pesticide risk assessments, how they relate to the evaluation of potential impacts on individuals and populations, how they apply to different listed species groups (*e.g.*, listed plants, critical habitats, animals with an obligate relationship to plants, animals with generalist relationships to plants), and how EPA uses them in an evaluation of magnitude of effect (MoE) for an individual (NE/MA/NLAA/LAA)[13] and to predict the likelihood of impacts to a population or habitat (J/AM). The thresholds EPA uses to evaluate an individual plant (e.g., NOAEC/$EC_{05}$/$IC_{05}$)[14] are more conservative than those EPA uses to evaluate populations of that plant (*e.g.*, $IC_{25}$ or 5$^{th}$ percentile of the SSD). Similarly, the thresholds EPA uses to evaluate listed plants and animals with an obligate relationship with plants (e.g., 5$^{th}$ percentile of the SSD) are more sensitive than those EPA uses for animals with a generalist relationship to plants (e.g., 25$^{th}$ percentile of the SSD). For impacts to designated CHs, EPA uses the same endpoint as for impacts to generalist animals.

In the absence of empirical toxicity data for non-flowering plants (including lichens, ferns, conifers, and cycads), EPA calculated the magnitude of difference for impacts to listed non-flowering plants and listed animals relying on these plants using the monocot or dicot toxicity endpoint. EPA used the most sensitive endpoint for determining population-level impacts to monocots and dicots[15] to determine direct impacts to listed non-flowering plants and diet/habitat impacts to listed animals that obligately depend on these plants. For determining diet/habitat impacts to animals generally relying on non-flowering plants, EPA used the most sensitive endpoint used for determining population level impacts to animals generally relying on monocots and dicots.[16]

Although the endpoints related to individual effects are provided here, the draft Strategy focuses only on those endpoints at the population or habitat level. Furthermore, EPA is not making effects determinations or making a prediction jeopardy or adverse modification in these case studies.

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[13] NE = No Effect; MA = May Affect; NLAA = Not Likely to Adversely Affect; LAA = Likely to Adversely Affect); J/AM = Jeopardy/Adverse Modification.

[14] NOAEC=No Observed Adverse Effect Concentration; ICX = inhibition concentration to produce a particular effect for X% of the organisms tested; ECx = effect concentration to produce a particular effect for X% of the organisms tested.

[15] 5$^{th}$ percentile of the SSD or most sensitive $IC_{25}$ considering monocots and dicots (if no SSD is available)

[16] 25$^{th}$ percentile of the SSD or most sensitive $IC_{25}$ considering monocots and dicots (if no SSD is available)

**Table 3-2. Description of Default Plant Toxicity Endpoints Used for Direct and Diet and Habitat Impacts at the Individual and Population Level**

| Relevant Plant Group (Environmental Compartment) | Units of toxicity endpoints and exposure | Direct Impacts to Listed Plants, Impacts on listed animals with obligate relationship to plants | Diet and Habitat Impacts for Listed Animals with generalist relationship to plants, Impacts on habitat quality and plant relevant PBFs for Critical Habitats |
|---|---|---|---|
| Aquatic plants: non-vascular vascular<br><br>(EPA Farm Pond and WPEZ[5], PFAM flooded field, and AgDRIFT to Aquatic Bins) | µg a.i./L | Impacts to Individuals: NE/MA: NOAEC or $IC_x$ associated with lowest $IC_{50}$ [1,2] | Impacts to Individuals: NE/MA/NLAA/LAA: lowest $IC_{50}$ |
| | | Impacts to Individuals: NLAA/LAA: Geometric mean of the lowest NOAEC and LOAEC, or ICx from $IC_{50}$ study[1, 2] | |
| | | Impacts to Populations: J/AM: lowest $IC_{50}$ and/or 5th Percentile from SSDs[3] | Impacts to Populations: J/AM: Consider all available $IC_{50}$ and/or 25th Percentile from SSDs[3] |
| Terrestrial and Wetland Plants: monocots, dicots, lichens, ferns, conifers and cycads<br><br>(TPEZ[5] and WPEZ[5],AgDRIFT) | lb a.i./A | Impacts to Individuals: NE/MA: NOAEC or $IC_x$ associated with lowest $IC_{25}$ [1, 2] | Impacts to Individuals: NE/MA/NLAA/LAA: lowest $IC_{25}$ |
| | | Impacts to Individuals: NLAA/LAA: Geometric mean of the lowest NOAEC and LOAEC, or ICx from $IC_{25}$ study[1, 2] | |
| | | Impacts to Populations: J/AM: lowest $IC_{25}$ and/or 5th Percentile from SSDs[4] | Impacts to Populations: J/AM: Consider all available $IC_{25}$ and/or 25th Percentile from SSDs[4] |

WPEZ=Wetland Plant Exposure Zone; TPEZ=Terrestrial Plant Exposure Zone; PFAM=Pesticides in Flooded Applications Model; a.i.=active ingredient; NE=No Effect; MA=May Affect; NLAA=Not Likely to Adversely Affect; LAA =Likely to Adversely Affect; J/AM=Jeopardy/Adverse Modification; NOAEC=No Observed Adverse Effect Concentration; LOAEC=Lowest Observed Adverse Effect Concentration; $IC_x$=concentration resulting in x% inhibition in plant growth; PBF=physical and biological feature; SSD=species sensitivity distribution

[1] In lieu of using NOAEC/LOAEC, the regression-based $IC_X$ values for aquatic and terrestrial plants can be used. In most risk assessments and Data Evaluation Records, the $IC_{05}$ is the regression-based endpoint that is available for use in lieu of a NOAEC value. If additional regression-based endpoints are available, the following can be used per EPA's analysis of the variability in terrestrial plant data (USEPA, 2020a; Appendix 1-5): vegetative vigor 850.4150 endpoints for dry weight ($IC_{15}$) and height ($IC_{10}$); seedling emergence 850.4100 endpoints for dry weight ($IC_{20}$) and height ($IC_{10}$); vascular and non-vascular aquatic plant studies and all plants survival-based endpoints ($IC_{05}$).

[2] If the toxicity endpoint for graminoid species (grasses, sedges, rushes) is substantially different than other monocots, the most sensitive graminoid endpoint should also be selected for determining the level of mitigation.

[3] The SSD used for determining the 5th or 25th percentile of the SSD for aquatic plants may separate vascular and nonvascular plants. The 5th and 25th percentile of SSDs represent the concentrations at which 95% and 75% (respectively) of species would have less than 25% reduction in growth, reproduction and/or survival.

[4] The SSD used for determining the 5th or 25th percentile of the SSD for terrestrial and wetland plants may separate monocots and dicots. The most sensitive of these should be used to represent lichens, ferns, conifers, and cycads. The 5th and 25th percentile of SSDs represent the concentrations at which 95% and 75% (respectively) of species would have less than 25% reduction in growth, reproduction and/or survival.

[5] WPEZ = Wetland Plant Exposure Zone; TPEZ = Terrestrial Plant Exposure Zone; See Plant Assessment Tool user guide for more description (USEPA, 2023).

## 3.3 Defining the Magnitude of Effect and Magnitude of Difference for Potential Population-Level Impacts and to Identify the Level of Mitigation

### 3.3.1 Magnitude of Difference (MoD)

A key concept in the analysis in the Strategy is the calculation of the exposure to toxicity ratio, which this document refers to as the magnitude of difference (MoD). The MoD is analogous to the risk quotients (RQs) that EPA calculates and compares to regulatory Levels of Concern in FIFRA assessments. RQs and MoDs are similar in that they both involve a ratio of exposure to toxicity; however, they differ by the toxicity endpoint. In this case, EPA is using the term "MoD" instead of "RQ" because EPA is using toxicity information to represent plant population or community level impacts, whereas the RQ relies upon toxicity information representing the individual. EPA is not using the standard Level of Concern, which also relates to impacts to an individual of a species (USEPA, 2004).

As the Strategy is focused on reducing the likelihood of potential population-level impacts, EPA calculates MoDs using toxicity endpoints that are protective of a population of a single species or a community of species. The draft Strategy uses the ratio of EECs to the population toxicity endpoints (e.g., 5$^{th}$ percentile of the SSD; see **Table 3-2**) to classify the magnitude of effect (MoE) as well as setting the mitigation category. EPA generated ratios for aquatic vascular and non-vascular plants, terrestrial/wetland monocots and dicots, and designated critical habitats. EPA relies on these ratios to determine the potential for population-level impacts and to reduce the potential for impacts to individuals, populations of individuals, or communities made up by multiple species. Additional information on this approach is included in the **Strategy Framework**.

When calculating the MoDs, EPA uses conservative estimates of exposures that represent an upper bound of a distribution of exposures, and EPA relies upon the most sensitive plant toxicity endpoint (e.g., plant height) from the most sensitive study (e.g., vegetative vigor). This conservatism is particularly appropriate for ESA analyses when determining if a chemical may affect an individual of a listed species. This conservatism is intentional and ensures protection in the face of uncertainty with regard to the sensitivity of listed species to an herbicide. However, when evaluating if there a potential population-level impact, the variability, assumptions, and distribution of both toxicity and exposure estimates play a role and are each discussed in the sections below.

In the analysis below, EPA describes the variability in standard model EECs. This variability may be attributed to different areas across the landscape or range of species, and provides different frequencies of exceedance of toxicity endpoints through the modeling years based on climatic data. EPA also describes the variability in standard toxicity endpoints used to represent impacts to plants and considerations for different life stages of plants that may impact interpretation of population-level impacts. Collectively, these sources of variability inform the level of precision of the ratio of EECs to effects endpoints.

There are many other assumptions and uncertainties common to ecological risk assessments that impact the potential for impacts to populations that EPA did not evaluate in these case studies. For example, the EECs do not consider the impact of field sizes, water flow rates, dilution and habitat sizes on wetland and aquatic EECs. Nor do the EECs consider differences in applicator practices and lower of application rates. For drift, the draft Strategy does not consider different application equipment, weather, nor interception by adjacent structures or vegetation, all of which are factors that could reduce drift related exposure. On the toxicity side, EPA did not consider the relative differences in sensitivity of greenhouse/laboratory toxicity studies versus studies conducted in the field, effects of exposures at different life stages outside of the seed (seedling emergence) through young growth (vegetative vigor) life-stages, nor cumulative effects of multiple herbicides.

From the analyses provided below, EPA concluded that the ratios of EECs to population-level plant toxicity endpoints are discernable when they differ by an order of magnitude. The evidence supporting this conclusion is discussed in **Section 3.3.2**.

### 3.3.2 Consideration of the Variability in the Exposure Estimate

In this section, EPA describes the variability in standard model spray drift and runoff/erosion EECs that may represent different areas across the landscape or range of species.

#### *3.3.2.1 Spray drift exposure*

AgDRIFT simulates spray drift deposition using a mechanistic approach for aerial spray and empirical data for ground and airblast applications. This inherently makes the analysis non-chemical specific, and therefore is applicable to all pesticides evaluated, and only becomes chemical specific when comparisons are made to the toxicity endpoints for a pesticide. While the drift curves represent high-end estimates for distance, a higher deposition may occur to a plant closer to the field if the plant obstructs the deposition that would have been deposited over a much larger distance (e.g., drift captured by a windbreak). In the Tier 1 aerial model, EPA used standard default parameters that it regularly uses in risk assessment for application equipment, and application practices and environmental conditions to generate an upper-bound estimate of deposition. In a sensitivity analysis of the model, ±10% change in default parameters (e.g., wind speed, release height, nozzle, aircraft) resulted in 60-70% less drift leaving the treated field (Teske *et al.* 2002). This demonstrates that for aerial drift estimation, the difference between EECs generated under default assumptions and applications under field application conditions could be on an order of magnitude scale. For the Tier 1 ground model, median ($50^{th}$ percentile) deposition curves are available. These median deposition curves are approximately 30-50% lower compared to most of the $90^{th}$ percentile curves (>50 ft from the edge of the field; **Figure 3-1**). Based on this information, ground spray $90^{th}$ percentile Tier I spray drift deposition estimates from AgDRIFT are approximately 2x higher than the median deposition estimates. Use of the $90^{th}$ percentile value (and its overprediction when compared

to central tendencies) is consistent with EPA guidance which dictates exposure should be assessed based on the upper range of an exposure distribution, but to avoid estimates that are beyond the true distribution (i.e., high-end risk). High-end risk is intended to estimate the risks that are expected to occur in small but definable high-end segments of the subject population (USEPA, 1992[17]).

[17] https://www.epa.gov/sites/default/files/2014-11/documents/guidelines_exp_assessment.pdf

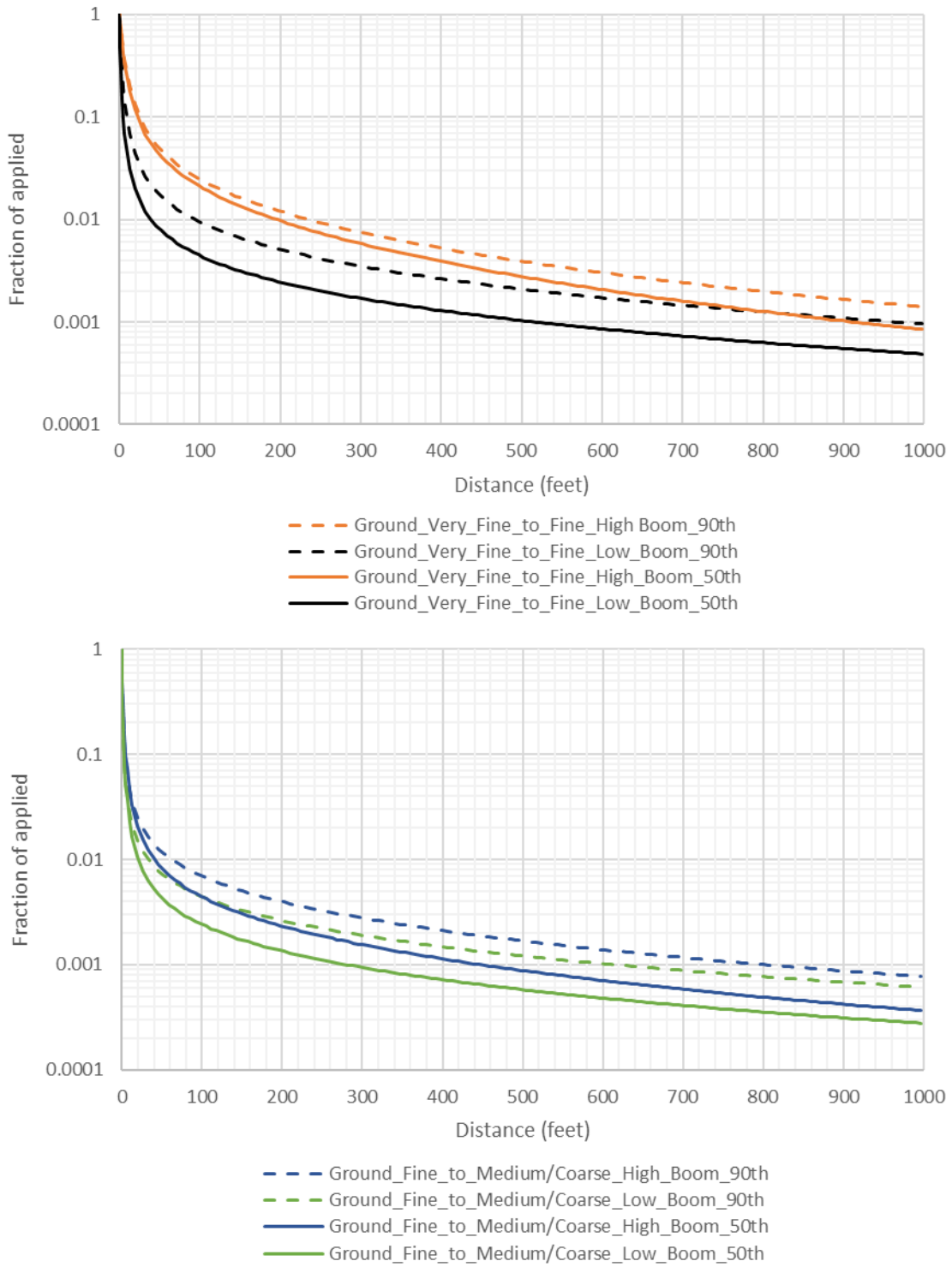


**Figure 3-1. Difference between median and 90th percentile spray drift deposition calculated using AgDRIFT Tier 1 ground model. Differences vary for different droplet sizes, boom sprayer release heights (high ~ 48 inches; low ~ 24 inches) and distances.**

AgDRIFT generates estimates of point deposition, but it does not provide confidence intervals associated with those point estimates. When considering the empirical studies used to generate the Tier 1 ground models, standard deviations were 10-20% of mean deposition. This means that point estimates of 1 lb ai/A would be 0.9-1.1 lb/A. Other embedded assumptions in the estimation of spray drift EECs include: 1) constant wind speed at highest allowable max windspeed (e.g., 10 or 15 mph); 2) affected species are always downwind, 3) little to no spray drift interception along the deposition distance. These factors when individually or collectively considered against the estimation assumptions, would reduce exposures. The draft Strategy does not include these factors when estimating exposure with the model, however they are considered when determining if drift depositions are likely to result in potential population-level impacts for the individual case studies. Additional discussion of spray drift (e.g., differences in wind speed, wind direction, humidity, temperature, canopy interception) are provided in the Technical Document, and includes discussion of the mitigation options and how they are related to the factors described in this section.

#### *3.3.2.2 Runoff/erosion transport*

EPA uses PWC and PAT to estimate runoff and soil erosion transport from treated sites to non-target terrestrial, wetland and aquatic habitats. These models rely upon high end scenarios that represent parameters that result in high-end exposures from runoff and erosion (e.g., curve numbers, soil) across the landscape for a given crop. For example, for corn, there are several scenarios representing different areas of the country with different weather. For a single scenario, EPA estimates daily concentrations in receiving habitats. EPA uses the highest concentration that occurs every 1-in-10 years to calculate the difference between EECs and endpoints. **Figure 3-2** depicts annual maximum values in a wetland that EPA estimated using its standard corn, cotton and soybean scenarios for Enlist applications (2,4-D; USEPA 2022). From year to year, the maximum exposure may vary by as much as an order of magnitude. In this example, when comparing exposures across scenarios (locations), 95$^{th}$ percentile estimates of exposure (comparable to the estimated 1-in-10 year EECs) vary by approximately 40% for most of the corn scenarios but vary by as much as 70% for the most extreme cases for corn (MS corn and NC corn) among scenarios representing the same crop. In addition to this within model variability, the variability in the environment, across agricultural practices, application timing, weather, soil, slope, and more, add that to the total variability and are substantial relative to the modeling.

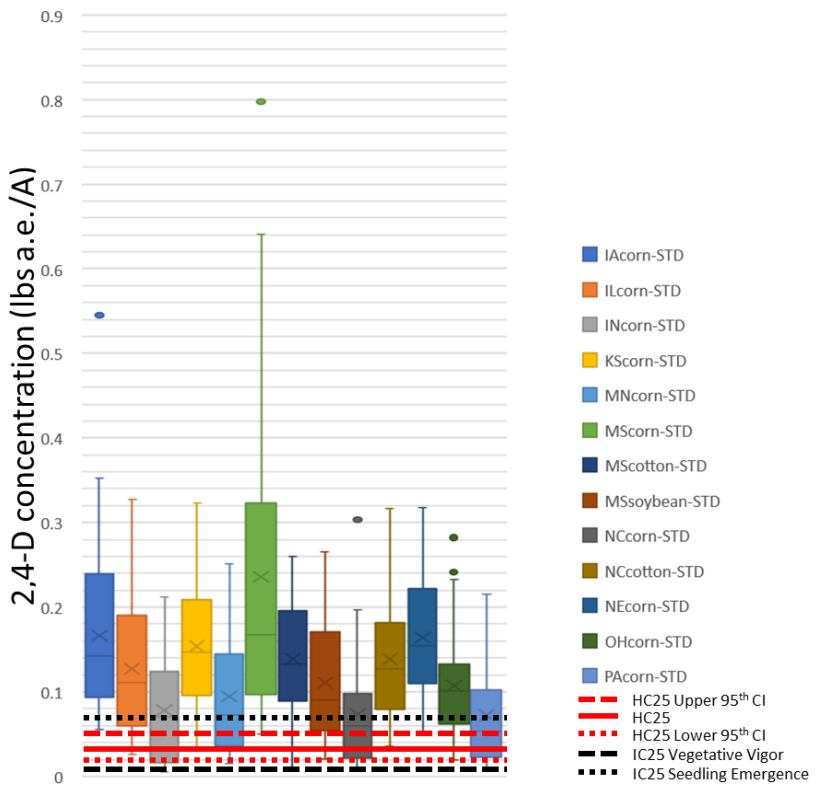


**Figure 3-2. Distributions of maximum annual concentrations of 2,4-D for individual scenarios (e.g., IAcorn, ILcorn) in PAT wetland habitat based on 30 years of modeling (From USEPA 2022). [boxplots: shaded boxes represent first quartile to the third quartile, "x" represents the mean, horizontal bar is the median, whiskers extend out to the 95th percentiles, outliers are dots above the whiskers]**

In April 2023, EPA began using new PWC scenarios to generate EECs for ecological risk assessments. These scenarios represent all of the Hydrologic Unit 2 (HUC2) watersheds in CONUS. The 1-in-10 year EECs for the new corn scenarios (**Figure 3-3**) show similar variability and magnitude across sites that EPA observed in the data depicted in **Figure 3-2** based on the older scenarios.

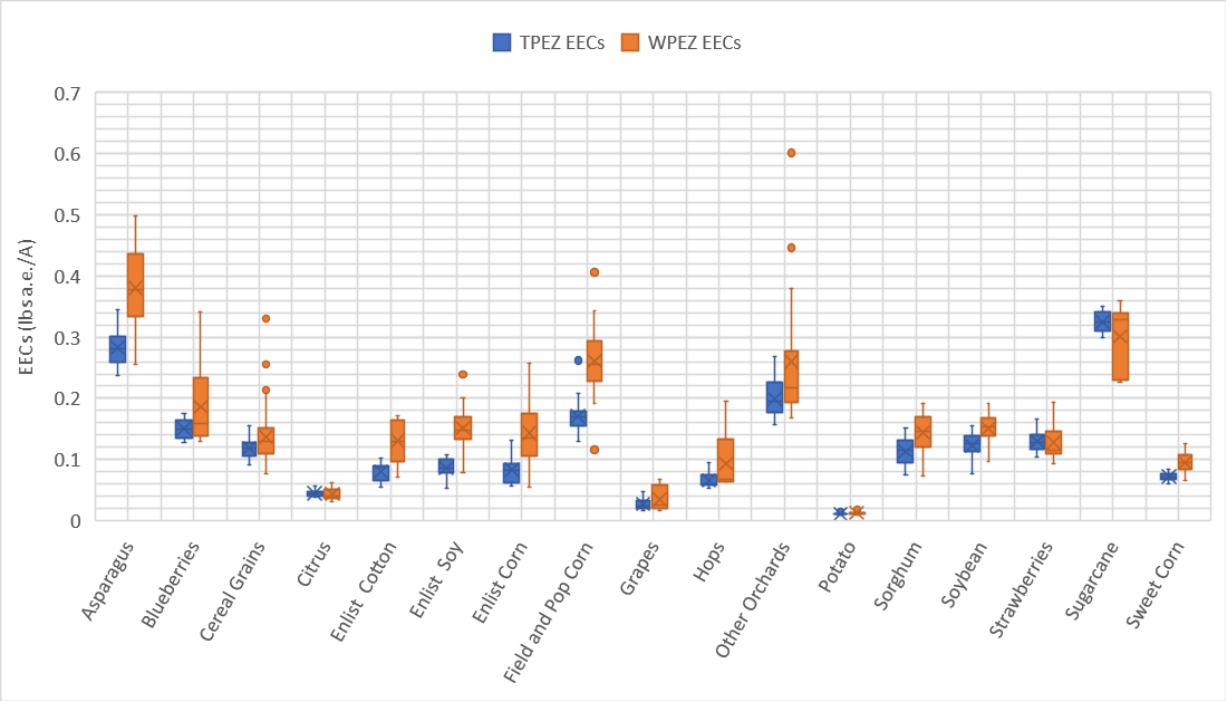


**Figure 3-3. 2,4-D 1-in-10 year EECs for Terrestrial (TPEZ) and Wetland (WPEZ) plants as modeled using the new ecological scenarios in the Pesticides in Water Calculator (PWC v. 2.001) and the Plant Assessment Tool (PAT v. 2.8). [boxplots: shaded boxes represent first quartile to the third quartile, "x" represents the mean, horizontal bar is the median, whiskers extend out to the 95th percentiles, outliers are dots above the whiskers]. Note: Enlist crops have mitigations required on the label however these were not included in this modeling exercise, therefore these modeled estimates are not reflective of the Enlist EECs after the mitigations are applied.**

#### *3.3.2.3 Toxicity*

Terrestrial Plants: Monocots and Dicots

EPA calculates the Magnitude of Difference (MOD) ratios for listed plants using either the most sensitive $IC_{25}$ values for monocots and dicots or the 5th percentile of the species sensitivity distribution (SSD) of IC25 values (*i.e.,* the endpoint is a 25% growth effect or more to 5% of species). For impacts to listed animals from declines in plants that represent diet or habitat, EPA uses the 25th percentile of the SSD (i.e., the endpoint represents 25% growth effect or more to 25% of plant species).

As discussed in **Section 3.2**, there are two types of toxicity data available for terrestrial plants, seedling emergence (SE) and vegetative vigor (VV) that are required to include 4 monocots and 6 dicots. EPA also uses other reliable toxicity endpoints from the scientific literature when available, but these typically fall into the same growth stages of the SE and VV studies. Seedling emergence studies begin at the seed germination growth stages and continue into early

seedling development. Vegetative vigor studies are conducted when plants are 2-3 weeks old seedlings and are carried out for 28 days after exposure. These growth stages of plants are considered sensitive to herbicides, such that the establishment of endpoints based on this early exposure has been shown to be protective of effects observed at later growth stages and for reproductive effects (USEPA 2020b; USEPA 2022). In the landscape, exposure to plants may occur at different times, meaning that different plant life stages may be exposed. EPA uses the most sensitive of these endpoints and assumes that exposure occurs at the relevant life stage for the assessed plants. Since plants grow over the course of the season and herbicides are applied at different times, it is important to consider that herbicide exposures could occur during less sensitive plant life stages, and vice versa.

When comparing most sensitive $IC_{25}$ endpoints, most SE and VV $IC_{25}$ endpoints are within the same order of magnitude (**Table 3-3**); however, a few of the representative pesticides have either a monocot or dicot endpoint that is greater than an order of magnitude different from the other (e.g., dicamba, diuron, paraquat, thiobencarb). In these comparisons, the species and timing of year when a study was conducted is not kept constant (the comparison is between the most sensitive endpoints). When a difference of greater than 10x is observed between the most sensitive endpoints, this indicates a difference that would likely be reflected in different conclusions in a risk assessment. Across the case studies included here, only vegetative vigor based studies showed greater than 10x differences.

**Table 3-3. Most sensitive[1] monocot and dicot 25% Inhibition Concentration ($IC_{25}$) values (lb ai/A) for seedling emergence (SE) and vegetative vigor (VV).**

| Herbicide | Monocot | | | Dicot | | |
|---|---|---|---|---|---|---|
| | SE $IC_{25}$ | VV $IC_{25}$ | Factor difference | SE $IC_{25}$ | VV $IC_{25}$ | Factor difference |
| 2,4-D and its amines/acids/salt | 0.026 | 0.0075 | 3.5 | 0.026 | 0.0038 | 6.8 |
| Dicamba and its salts | 0.34 | 0.092 | 3.7 | 0.036 | 0.00051 | 70 |
| Diuron | 0.086 | 0.021 | 4.1 | 0.075 | 0.0017 | 44 |
| MCPA and its salts and esters | 0.028 | 0.092 | 3.3 | 0.008 | 0.003 | 2.7 |
| Metolachlor, S-Metolachor | 0.0048 | 0.016 | 3.3 | 0.0055 | 0.0041 | 1.3 |
| Metribuzin | 0.01 | 0.017 | 1.7 | 0.01 | 0.002 | 5.0 |
| Oxyfluorfen | 0.063 | 0.27 | 4.3 | 0.0072 | 0.0078 | 1.1 |
| Paraquat | 0.64 | 0.021 | 31 | 0.67 | 0.022 | 31 |
| Pendimethalin | 0.02 | 0.034 | 1.7 | 0.09 | 0.1 | 1.1 |
| Propanil | 1.4 | 0.13 | 11 | 0.54 | 0.09 | 6.0 |
| Thiobencarb | 0.019 | 0.073 | 3.8 | 0.082 | 1.2 | 15 |
| Trifluralin | 0.0399 | 0.841 | 21 | 0.19 | 0.80 | 4.2 |

[1] Species is not kept constant in these comparisons.

This difference between studies is more apparent when considering a broader evaluation of endpoints and species. As discussed in **Section 3.2**, EPA developed SSDs for all applicable data. The SSDs were entirely made up of plants that are short lived (e.g., annuals or biennials) and did

not include the tested plants that had $IC_{25}$s greater than the highest tested concentrations, therefore they represent the most sensitive of all tested species. **Table 3-4** and **Table 3-5** provide the 5th and 25th percentiles from the SSDs developed for each endpoint from the SE and VV studies. Using the metolachlor case study as an example, when comparing the 5th percentile values from SSDs for metolachlor, the median estimate of the 5th percentile for SE is an order of magnitude more sensitive than the 5th percentile for VV. In the oxyfluorfen example, the SE (weight) and VV (weight) median 5th percentiles are on the same order of magnitude. By relying upon the most sensitive endpoints, the draft Strategy is protective of the sensitive life stages. Another finding of these SSDs, is that the confidence intervals for the 5th percentiles are often overlapping, suggesting that while central estimates are numerically different the variability around them infers that they likely are not different. This can be seen with the metolachlor example where the most sensitive 5th percentile upper CI (0.040) reaches concentrations higher than that of the SE height, VV weight and is nearly at the VV height. This order of magnitude variability in the endpoint estimate is an important consideration for determining the Magnitude of Effect, and is a consideration made on a pesticide-by-pesticide basis (see the case study chemicals for additional examples).

**Table 3-4. Fifth percentile values (95% confidence intervals) from species sensitivity distributions based on $IC_{25}$ toxicity endpoints from seedling emergence (SE) and vegetative vigor (VV) studies.**

| Herbicide | VV weight | VV height | SE weight | SE height |
|---|---|---|---|---|
| Metolachlor | 0.035 (0.012-0.13) [n=14] | 0.045 (0.0062-0.34) [n=13] | **0.0037** (0.00033-0.040) [n=14] | 0.016 (0.0026-0.099) [n=14] |
| Oxyfluorfen | 0.0035 (0.00083-0.022) [n=9] | 0.027 (0.0030-0.24) [n=6] | 0.0048 (0.0022-0.017) [n=10] | 0.0058 (0.0015-0.029) [n=9] |
| Pendimethalin | 0.039 (0.0097-0.23) [n=8] | N/A | 0.12 (0.033-0.56) [n=12] | 0.33 (0.19-0.67) [n=12] |
| Dicamba | 0.00041 (0.000037-0.0052) [n=15] | 0.00078 (0.000076-0.0081) [n=15] | N/A | N/A |
| Diuron | 0.0091 (0.0056-0.021) [n=10] | 0.023 (0.012-0.066) [n=9] | 0.014 (0.0011-0.22) [n=8] | 0.12 (0.051-0.53) [n=7] |
| MCPA | 0.0064 (0.0023-0.023) [n=14] | 0.013 (0.0038-0.042) [n=14] | 0.010 (0.0076-0.017) [n=10] | 0.0085 (0.0041-0.020) [n=11] |
| | | | Survival 0.062 (0.021-0.29) [n=9] | |
| Metribuzin | 0.0026 (0.0011-0.0073) [n=15] | N/A | 0.0096 (0.0072-0.015) [n=14] | 0.013 (0.010-0.020) [n=19] |
| | | | Survival 0.0063 (0.0036-0.0128) [n=13] | |
| Paraquat | 0.017 (0.012-0.026) [n=12] | 0.017 (0.011-0.039) [n=7] | N/A | N/A |
| Trifluralin | N/A | N/A | 0.066 (0.013-0.29) [n=10] | N/A |
| 2,4-D | 0.0038 (0.0015-0.010) [n=19] | N/A | 0.0098 (0.0032-0.038) [n=15] | N/A |

When considering impacts to habitat or prey of listed animals, EPA uses the 25th percentile of the SSD (see discussion in **Section 3.2**). For the case study chemicals, the SE and VV HC25 values are generally similar (within a factor of 2-5x). This suggests that timing of the life stage may not be as significant of a variable for impacts to animals that depend upon plants compared to when the 5th percentile is used to represent toxicity to listed plants.

**Table 3-5. Twenty-Fifth percentile values (95% confidence intervals) from species sensitivity distributions for seedling emergence (SE) and vegetative vigor (VV) studies.**

| Herbicide | VV weight | VV height | SE weight | SE height |
|---|---|---|---|---|
| Metolachlor | 0.15 (0.065-0.37) [n=14] | 0.45 (0.14-1.37) [n=13] | 0.064 (0.014-0.25) [n=14] | 0.13 (0.043-0.36) [n=14] |
| Oxyfluorfen | 0.017 (0.0056-0.064) [n=9] | 0.17 (0.045-0.58) [n=6] | 0.013 (0.0064-0.038) [n=10] | 0.024 (0.0087-0.077) [n=9] |
| Pendimethalin | 0.17 (0.058-0.60) [n=8] | N/A | 0.58 (0.26-1.4) [n=12] | 0.71 (0.45-1.2) [n=12] |
| Dicamba | 0.0082 (0.0021-0.034) [n=15] | 0.015 (0.0036-0.055) [n=15] | N/A | N/A |
| Diuron | 0.018 (0.012-0.036) [n=10] | 0.053 (0.031-0.14) [n=9] | 0.21 (0.040-0.88) [n=8] | 0.33 (0.16-1.13) [n=7] |
| MCPA | 0.025 (0.012-0.061) [n=14] | 0.058 (0.023-0.15) [n=14] | 0.016 (0.012-0.024) [n=10] | 0.02 (0.011-0.038) [n=11] |
| | | | Survival 0.22 (0.096-0.66) [n=9] | |
| Metribuzin | 0.0085 (0.0045-0.019) [n=15] | N/A | 0.015 (0.012-0.022) [n=14] | 0.019 (0.015-0.027) [n=9] |
| | | | Survival 0.0128 (0.0085-0.0207) [n=13] | |
| Paraquat | 0.026 (0.020-0.038) [n=12] | 0.029 (0.020-0.055) [n=7] | N/A | N/A |
| Trifluralin | N/A | N/A | 0.30 (0.12-0.69) [n=10] | N/A |
| 2,4-D | 0.014 (0.0077-0.028) [n=19] | N/A | 0.047 (0.020-0.13) [n=15] | N/A |

To illustrate the variability across studies and endpoints further, the metolachlor (**Figure 3-4**) and 2,4-D (**Figure 3-5**) SSDs are provided. As seen when comparing the percentiles above, the SSDs are fairly similar across the SSDs for SE height and weight, and VV weight, with a shift to less sensitive for the VV height SSD. The similarity across endpoints suggests that, while there is expected to be more of an impact on early plant development (seed germination through young plant) less of an impact on plants in the VV growth stages. The upper and lower confidence levels around the SE weight SSD provide some understanding of the variability in the toxicity relationship. Importantly, that the upper confidence level around the 5th percentile is within an order of magnitude of and is equivalent to that of the 25th percentile. These same patterns are observed in the 2,4-D SSDs (**Figure 3-5**).

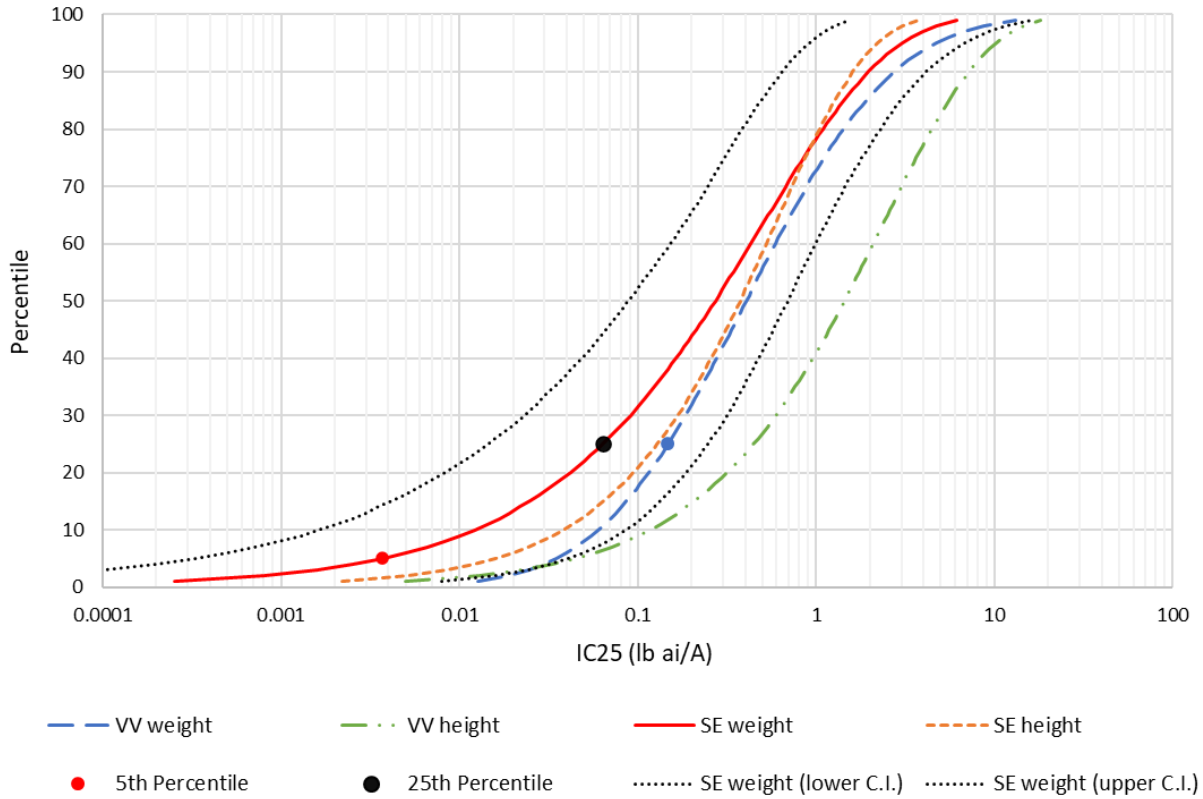


**Figure 3-4. Metolachlor Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs The assessment selected the 5th and 25th percentiles from the SE weight distribution. Upper and lower confidence intervals are provided for the SE weight SSD.**

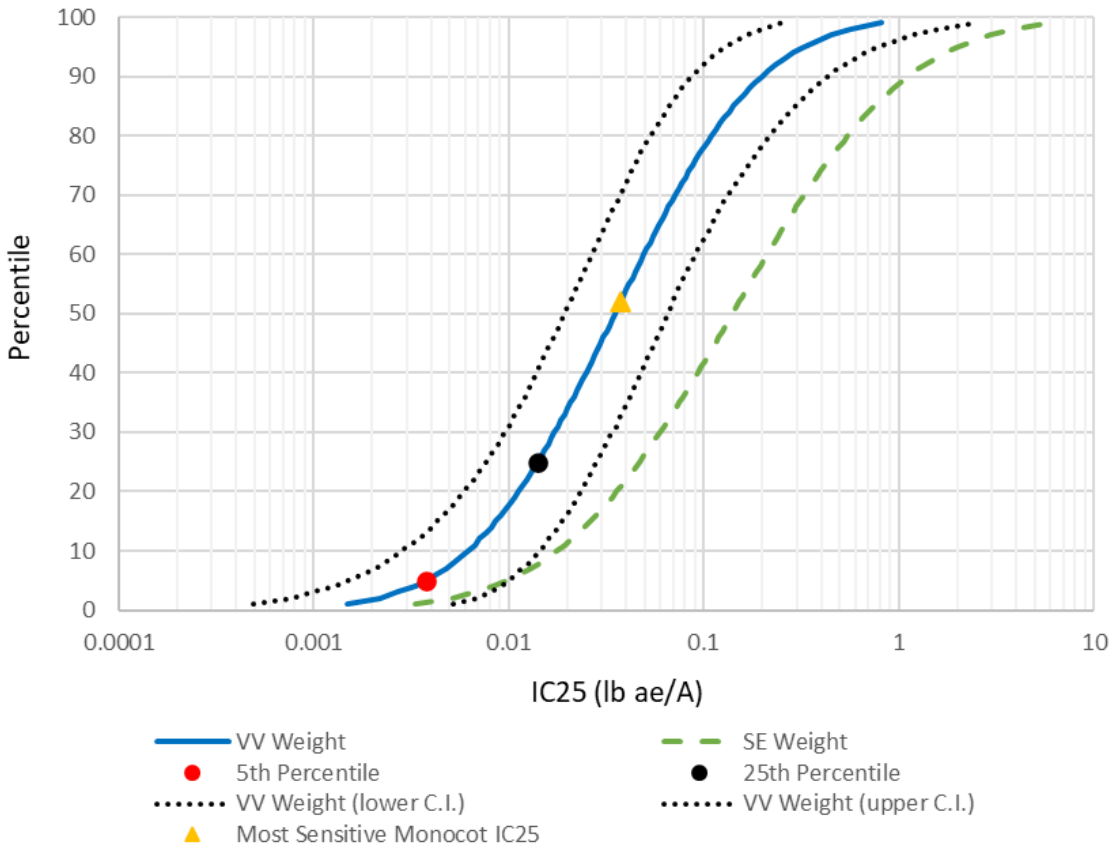


**Figure 3-5. 2,4-D Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs The assessment selected the 5th and 25th percentiles from the VV weight distribution, Upper and lower confidence intervals are provided for the VV weight SSD.**

One source of variability associated with the standard toxicity data is the timing of the year when studies were conducted. Boutin et al. 2010 compared $IC_{25}$ values for greenhouse studies conducted with atrazine and glyphosate. $IC_{25}$ values for the same species varied by as much as 1-2 orders of magnitude among studies conducted in spring, summer, fall and winter (**Table 3-6** and **Table 3-7**). These patterns of seasonal variability are likely present within the datasets that are submitted for registering pesticides. Therefore, endpoints from these studies can vary by approximately an order of magnitude as well. This supports the use of SSDs for the purpose of developing endpoints for the Herbicide Strategy, because not all species showed a consistent pattern between seasons, and not all species were affected by this seasonal differentiation. The incorporation of multiple studies into an SSD will strengthen the analysis and accounting for this variability will be reflective of the likely seasonal differentiation of sensitivity under field conditions as well.

**Table 3-6. $IC_{25}$ values (95% confidence intervals) for atrazine conducted at different times of the year by same laboratory (from Boutin et al 2010).**

| Test species (common name) | Spring | Summer | Fall | Winter | Maximum factor difference[1] |
|---|---|---|---|---|---|
| *Lycopus americanus* (American water-horehound) | 57.6 (42.3-78.3) | NA | 36.5 (10.5-121.5) | 136.4 (94.1-197.6) | 2.4 |
| *Geum canadense* (white avens) | 210.4 (159.3-276.9) | 88.3 (39.1-198.5) | NA | NA | 2.4 |
| *Chrysanthemum leucanthemum* (ox-eye daisy) | 273.2 (122.3-608.5) | NA | 11.3 (7.3-19.0) | 624.2 (131.6-1088.9) | 55 |
| *Rudbeckia hirta* (black-eyed susan) | 166.1 (98.8-279.5) | NA | 5.3 (3.9-334.4) | NA | 31 |
| *Triticum aestivum* (wheat)* | >1296 | NA | NA | 510.7 (382.7-681.3) | >2.5 |
| *Lactuca sativa* (lettuce)* | 4 (3.5-4.6) | 99.9 (82.0-118.9) | NA | 33.3 (29.3-121.5) | 25 |
| *Solanum lycopersicon* (tomato)* | NA | NA | 100.4 (64.5-156.0) | 5.2 (1.1-6.2) | 19 |

NA = not available

*Standard test species for seedling emergence and vegetative vigor studies.

[1] Maximum factor difference is the highest endpoint divided by the lowest endpoint for any season.

**Table 3-7. IC25 values (95% confidence intervals) for glyphosate conducted at different times of the year by same laboratory (from Boutin et al 2010).**

| Test species (common name) | Spring | Summer | Fall | Winter | Maximum factor difference[1] |
|---|---|---|---|---|---|
| *Lycopus americanus* (American water-horehound) | 141.2 (99.9-199.4) | NA | 86.9 (52.7-142.6) | 57.7 (35.5-93.6) | 2.4 |
| *Geum canadense* (white avens) | 449.8 (409.2-740.3) | 42.1 (9.5-152.0) | NA | NA | 11 |
| *Chrysanthemum leucanthemum* (ox-eye daisy) | 965.1 (692.4-1344.9) | NA | 113 (42.8-296.2) | 821.3 (630.0-1073.0) | 8.5 |
| *Rudbeckia hirta* (black-eyed susan) | 536 (280.8-1022.3) | NA | 54.96 (3.9-248.5) | NA | 9.8 |
| *Triticum aestivum* (wheat)* | >2136 | NA | NA | >2136 | NA |
| *Lactuca sativa* (lettuce)* | 7.2 (4.6-16.1) | 3.2 (3.0-3.4) | NA | 403.6 (313.8-519.0) | 130 |
| *Solanum lycopersicon* (tomato)* | NA | 32.7 (22.1-48.0) | NA | 4.4 (3.7-5.2) | 7.4 |

NA = not available

*Standard test species for seedling emergence and vegetative vigor studies.

[1] Maximum factor difference is the highest endpoint divided by the lowest endpoint for any season.

EPA uses the most sensitive test species (based on the $IC_{25}$) or the 5th percentile of the SSD to represent potential direct impacts to listed plants. When considering available species sensitivities for plants exposed to herbicides or the same species exposed at different growth stages or times of year, responses between species may vary by orders of magnitude (Boutine and Rogers 2000; Fletcher et al. 1990). One source of uncertainty is the relative sensitivity of the most sensitive test species and other species. Boutine and Rogers (2000) generated separate SSDs for 10 herbicides using $IC_{25}$s from EPA's standard test data and all available data (including their own data generated for native plant species). In this analysis, for 9 herbicides, the 5th percentile generated with EPA's standard test species were similar to 5th percentile SSD values (*i.e.*, within a factor of 5) based on larger plant toxicity data sets. This suggests that use of the most sensitive test species or the 5th percentile of an SSD from standard data submitted to EPA will still be protective for non-tested species. Use of the most sensitive test species or 5th percentile of the SSD is conservative for the majority of species; however, EPA does not know where specific listed species fall on the SSD. Therefore, to consider the potential for population-level impacts to listed plants that may be anywhere on the SSD, EPA used the most sensitive test species or 5th percentile to identify when mitigation is needed.

EPA uses median estimates of toxicity endpoints. When considering confidence interval around these estimates, standard deviations are often 35-50% of mean exposure (Boutine *et al.* 2010; see **Table 3-6** and **Table 3-7**). This means that median $IC_{25}$ estimates of 1 lb ai/A would be 0.75-1.25 lb/A. In addition, when SSDs are used, there is often an order of magnitude confidence associated with the 5th and 25th percentile $IC_{25}$ value (**Table 3-4**). The confidence intervals and other sources of variability in toxicity data are discussed below when determining the appropriate level of precision for identifying potential impacts to listed species and a need for mitigation.

Aquatic plants

EPA is not using aquatic plant toxicity endpoints to represent direct impacts to currently listed plants. EPA assesses those impacts using the monocot and dicot endpoints used above. All of the currently listed plants that may occur in aquatic habitats also occur in wetlands and are more taxonomically and structurally relevant to the monocot and dicot endpoints. EPA used aquatic plant toxicity data to evaluate the potential impacts to habitat and diet for listed animals.

For aquatic plants, a minimum of 5 test species is generally available for herbicides. This amount of data may not be sufficient to derive an SSD. Instead, EPA is using the most sensitive $EC_{50}$ from available aquatic toxicity data. In 2011, EPA compared the most sensitive of the typical test species submitted under FIFRA to SSDs generated using available aquatic plant toxicity data. In general, the most sensitive test species is similar to or lower than the 25th percentile of the SSD. For example, for metolachlor, the lowest FIFRA endpoint is approximately equivalent to the 13th percentile of the SSD. Diuron's lowest FIFRA endpoint approximates the 31st percentile on the SSD (**Table 3-8**). This supports the use of the most sensitive aquatic plant toxicity endpoint as representing an approximate plant community level of impact; however, in

some cases, the endpoint may be more conservative than the 25th percentile and in others it may be somewhat less conservative.

**Table 3-8. Lowest EC50 values from standard FIFRA test species and their relative positions (*i.e.,* percentiles) on the SSD generated from Combined Open Literature and FIFRA data sets (from USEPA 2011).**

| Chemical | Lowest EC50 from standard FIFRA test species (µg/L) | Corresponding Percentile of SSD | Number of test species in SSD |
|---|---|---|---|
| Prometryn | 1.0 | 4 | 13 |
| Metribuzin | 8.09 | 6 | 18 |
| Irgarol | 0.1 | 8 | 38 |
| Metolachlor | 61 | 13 | 17 |
| Diquat | 4 | 17 | 13 |
| Atrazine | 31.46 | 19 | 54 |
| Metsulfuron | 0.41 | 25 | 19 |
| Diuron | 7.09 | 31 | 32 |
| Linuron | 13.7 | 31 | 10 |

#### *3.3.2.4 Combining exposure and toxicity variability and uncertainty*

The variability around the exposure and toxicity endpoints were discussed separately above. This section provides a description of how the draft Strategy is considering these lines of evidence when setting the Magnitude of Effect[18] categories and interpreting the Magnitude of Difference.

When considering spray drift deposition estimated using AgDRIFT, central estimates of exposure in non-target habitats are generally 2x lower than the model's 90th percentile values. When considering variability in point deposition at the same location, exposures may vary by 1.5x (see **Section 3.3.2.1**). For runoff, estimated exposure from site to site (based on standard scenarios) may vary by roughly 2x, with 10x variability from year to year at the same site due primarily to weather (see **Section 3.3.2.2)**.

For toxicity to monocots and dicots, if the test species is kept constant, there is 2-3x variability around each height or weight $IC_{25}$ endpoint, 1 order of magnitude confidence surrounding 5th percentile SSD estimates, ~1-2 orders of magnitude in variability in response due to time of year

[18] The MoE determines the potential for population level effects based on a low, medium, high, and very high classification. This is determined based on the MoD and lines of evidence (*e.g.*, consideration of the empirical fate and toxicity data and reported incidents and monitoring data).

when the study was conducted and 1.1-70x variability in response due to life stage exposure (for seedling emergence vs vegetative vigor; see **Section 3.3.2.3**).

In considering the variability that is inherent in EPA's exposure models when representing a distribution of exposures across sites (e.g., different PWC scenarios and difference in upper bound and median estimates from AgDRIFT), times (exposures vary from year to year in PWC scenarios) and toxicity endpoints and some of the conservative assumptions EPA has built into both, EPA has less confidence that potential impacts at the relevant EECs would rise to population-level impacts when EECs are within an order of magnitude of the plant effects endpoint. This is demonstrated using the metolachlor and 2,4-D examples again, **Figure 3-6** and **Figure 3-7** demonstrate the overlap of 1-in-10 year EECs generated for all of the crop scenarios with the available SSDs. The range in EECs across all modeled uses is approximately 1 order of magnitude for the wetland (WPEZ) and terrestrial (TPEZ) plant habitats. In the metolachlor example, **Figure 3-6**, the 1-in-10 year EECs exceed both the 5$^{th}$ and 25$^{th}$ percentiles, and cross the SE Weight SSD between the 35$^{th}$ to 40$^{th}$ percentile and 90$^{th}$ percentile. This means that more than 90 to 35 percent of sensitive species might experience a 25% or greater reduction in growth (weight). Based on the Magnitude of Difference calculation for listed species of plant (also for animals that have an obligate relationship with plants) the 5$^{th}$ percentile-based ratios range from 1 to 2 orders of magnitude for wetlands and terrestrial habitats. These EECs represent the 1-in-10 year estimates, considered to be an uncommon event. However, consideration of the maximum EECs for each year of modeling (30-years of weather data) all maximum annual concentrations estimated across these years result in exceedances of the 5$^{th}$ and 25$^{th}$ percentiles and for all modeled scenarios. These lines of evidence support the conclusion that there is a likelihood of population level impacts to plants in terrestrial and wetland areas as a result of runoff and drift from these potential use sites.

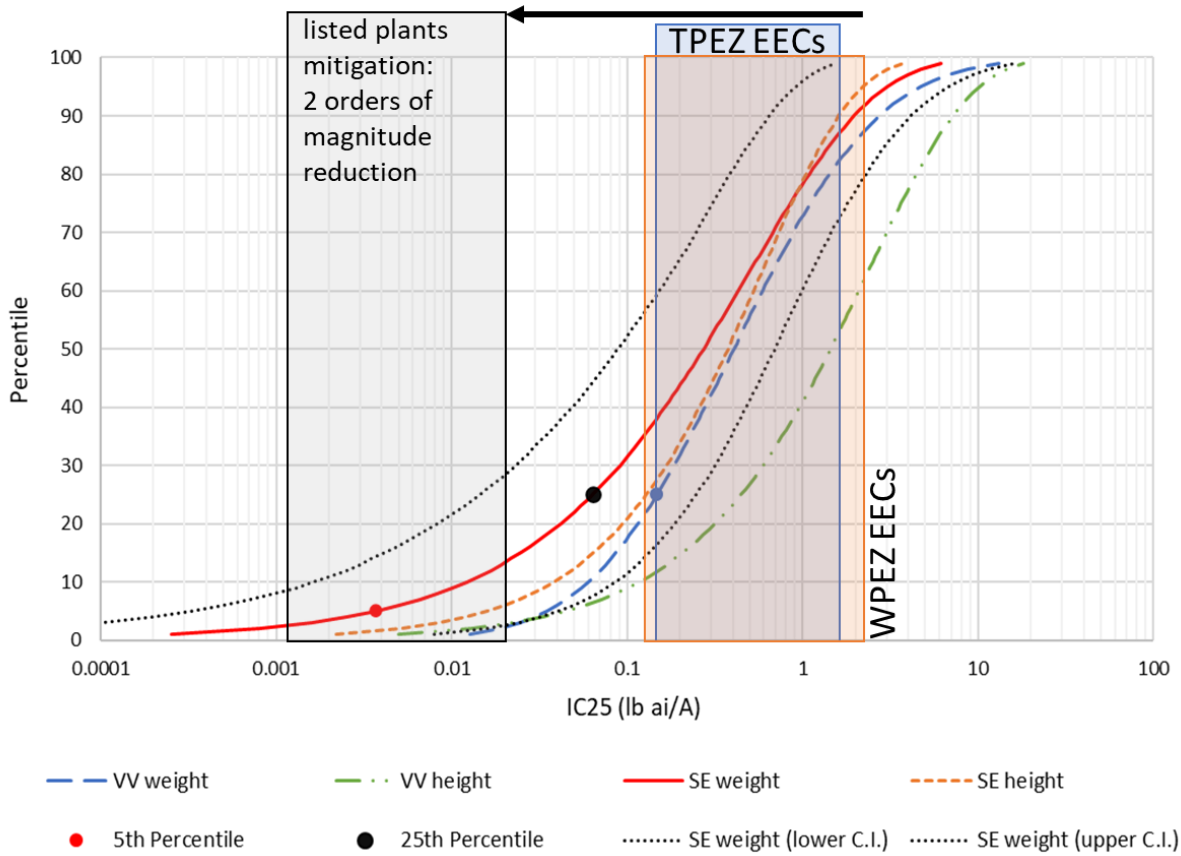


**Figure 3-6. Metolachlor Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs Compared to the Terrestrial (TPEZ) and Wetland (WPEZ) EECs for all use patterns (see Metolachlor Example Worksheet for more details). The assessment selected the 5th and 25th percentiles from the SE weight distribution, Upper and lower confidence intervals are provided for the SE weight SSD.**

For the 2,4-D example, **Figure 3-7**, only weight-based SSDs are available. These two SSDs show the roughly 1.5-2 orders of magnitude of EECs exceeding the $IC_{05}$ and $IC_{25}$. As was demonstrated with the metolachlor example, a significant portion of the SSDs are exceeded by these 1 in 10 year EECs increasing the likelihood that less sensitive species may be impacted by the exposures and that broader impacts to plant populations and the animals that depend on them could result from these uses.

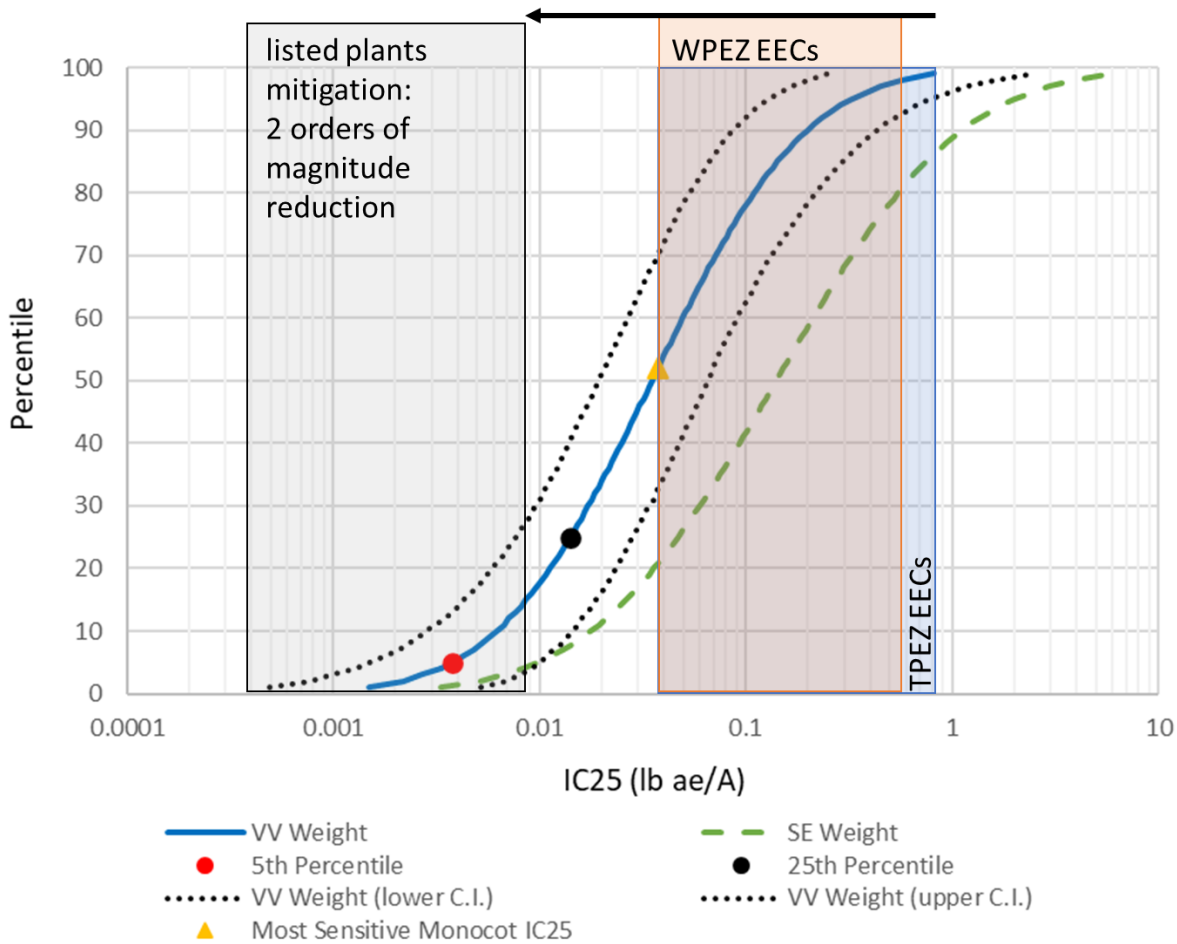


**Figure 3-7. 2,4-D Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs Compared to the Terrestrial (TPEZ) and Wetland (WPEZ) EECs for all use patterns (see 2,4-D Example Worksheet for more details). The assessment selected the 5th and 25th percentiles from the VV weight distribution, Upper and lower confidence intervals are provided for the VV weight SSD.**

When EECs are an order of magnitude or more above the population-based endpoint (e.g., 5th percentile of the SSD), there may still be some overlap in variability in exposure across different scenarios and overlap in variability associated with the toxicity endpoints. When exposures are two orders of magnitude above the toxicity endpoints, despite the model variability, exposures are above the levels where population impacts are likely to occur based on the most sensitive species and given the variability described above. These cases also signify a need for greater mitigation. Given the variability in exposure and effects, which is generally around an order of magnitude for each the EEC and the endpoint, EPA concludes that the level of precision around the ratios used for predicting population-level impacts is an order of magnitude. Therefore, the Magnitude of Difference is set at levels representing ratios that are on an order of magnitude scale such that for ratios 10 to <100 these herbicides would receive less mitigation compared to herbicides with ratios that are 100 to <1000.

### 3.3.3 Magnitude of Effect (MoE)

EPA assigned a low, medium, high, or very high MoE classification to each species based on the species taxonomy, life history, the ratio of the EECs to the relevant population level plant toxicity endpoint, and other lines of evidence such as incidents (as explained further below). **Table 3-9** provides the MoE low, medium, high categories as they relate to the Magnitude of Difference. While an exceedance of the endpoint may represent a risk of concern for individual organisms, it may be unreasonably conservative for estimating effects to populations. When the EECs fall below the endpoint, EPA concludes that there are no direct population impacts of concern for species in that taxon (and for those taxa for which it may serve as a surrogate), and no further refinement or mitigation is necessary within that taxon.

When assigning the MoE based on the Magnitude of Difference, EPA considers the type of effects observed in the plant toxicity studies (e.g., effects on growth vs. survival), the variability in the endpoints across endpoints and studies (e.g., vegetative vigor vs. seedling emergence), the proportion of the SSD exceeded by the EEC, the persistence of the pesticide, and evidence from reported chemical incidents. When the EECs exceed the toxicity endpoint by an order of magnitude or more, the MoE is medium or higher and there is greater likelihood that impacts to a population could occur if a use overlaps with the species. As discussed further in **Sections 5** and **5.6**, EPA also considers species and CH percent overlap with agriculture, species life history characteristics and risk modifiers in the prediction of likelihood of J/AM.

**Table 3-9. Magnitude of Difference using the Population-based Toxicity Endpoints and the Relationship to Magnitude of Effect, Potential Population Level Impacts, and Identified Mitigations.**

| Magnitude of Difference (MoD) using Population-based Toxicity Endpoint | Magnitude of Effect (MoE) | Population Level Impacts | Mitigation Category (Identified Mitigations to Reduce Exposure Estimates[1]) |
|---|---|---|---|
| <1 | Low | Not Likely | None |
| 1 to <10 | Low or Medium | Not likely or likely | Low (1 to 10 times reduction) |
| 10 to <100 | Medium or High | Likely | Medium (10 to 100 times reduction) |
| 100 to <1000 | High or Very High | | High (100 to 1000 times reduction) |
| 1000 or higher | | | Very High (>1,000 times reduction) |

[1] This is the amount of reduction identified to reduce exposure to levels that are not expected to result in potential population-level impacts.

# 4 Methods Used in Framework Step 2: Identify Type and Level of Mitigation Measures

The Magnitude of Difference (MoD) also provides the best available science with regard to the measure of mitigation needed to reduce the potential for population-level impacts. Based on the premise that the magnitude of effect is only discernably different at an order of magnitude scale, mitigation categories were assigned to each order of magnitude (**Table 3-9**).

The targeted mitigation level based on the MoD is illustrated using the metolachlor and 2,4-D examples. For both of these herbicides and their uses, the EECs were approximately 2 orders of magnitude above the 5$^{th}$ percentiles of the most sensitive SSDs. The MoDs would then be classified as "high" and mitigation would be required to reduce the EECs by two orders of magnitude. If runoff mitigation targeted 2 orders of magnitude for terrestrial and wetland plants, the resulting exceedances would drop to within an order of magnitude of the 5$^{th}$ percentile and there would be no exceedances of the 25$^{th}$ percentile (**Figure 4-1** and **Figure 4-2**). Based on the lines of evidence, certain proposed mitigation would be likely to be necessary to address the potential for population-level impacts.

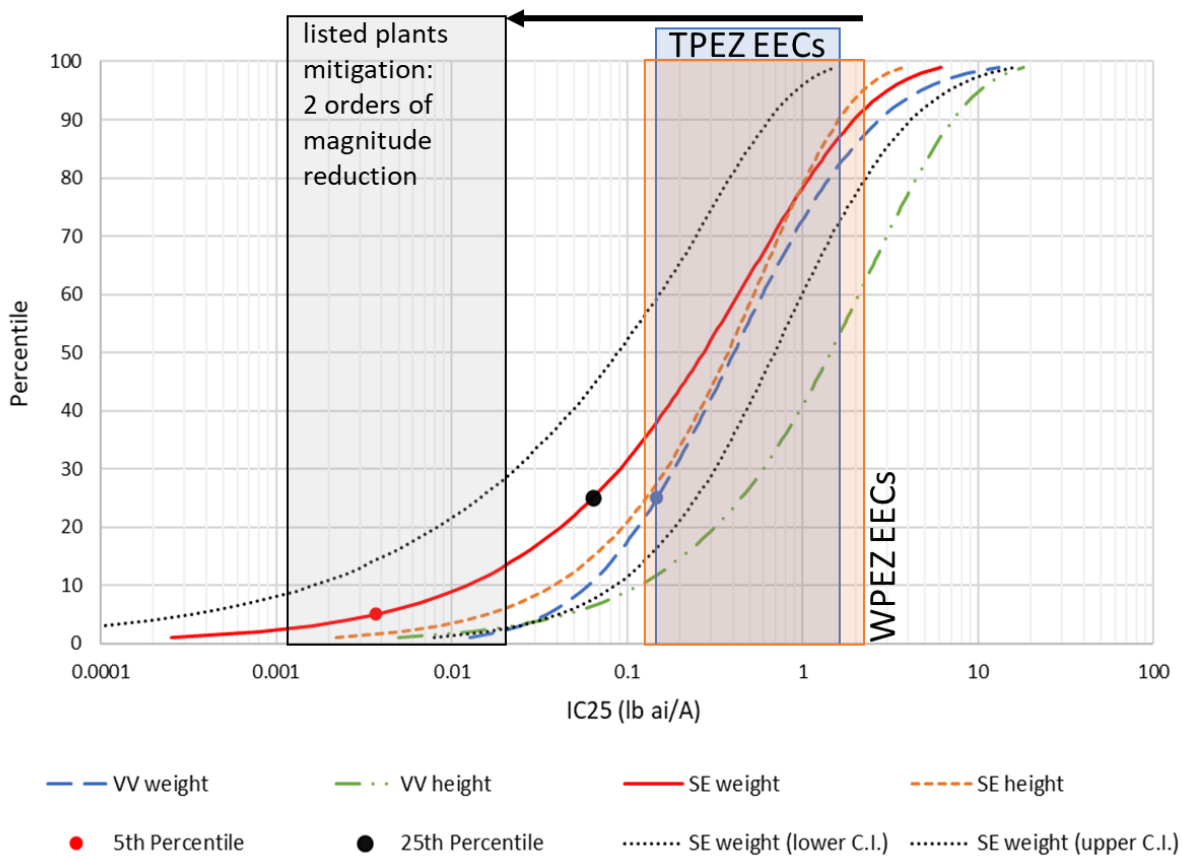


**Figure 4-1. Metolachlor Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs Compared to the Terrestrial (TPEZ) and Wetland (WPEZ) 1 in 10 year EECs for all use patterns (see Metolachlor Example Worksheet for more details). The assessment selected the 5$^{th}$ percentile (represents listed plants and animals with obligate relationships to plants) and the 25$^{th}$**

**percentile (represents generalists and CH) from the SE weight. Upper and lower confidence intervals (C.I.) are provided for the SE weight SSD.**

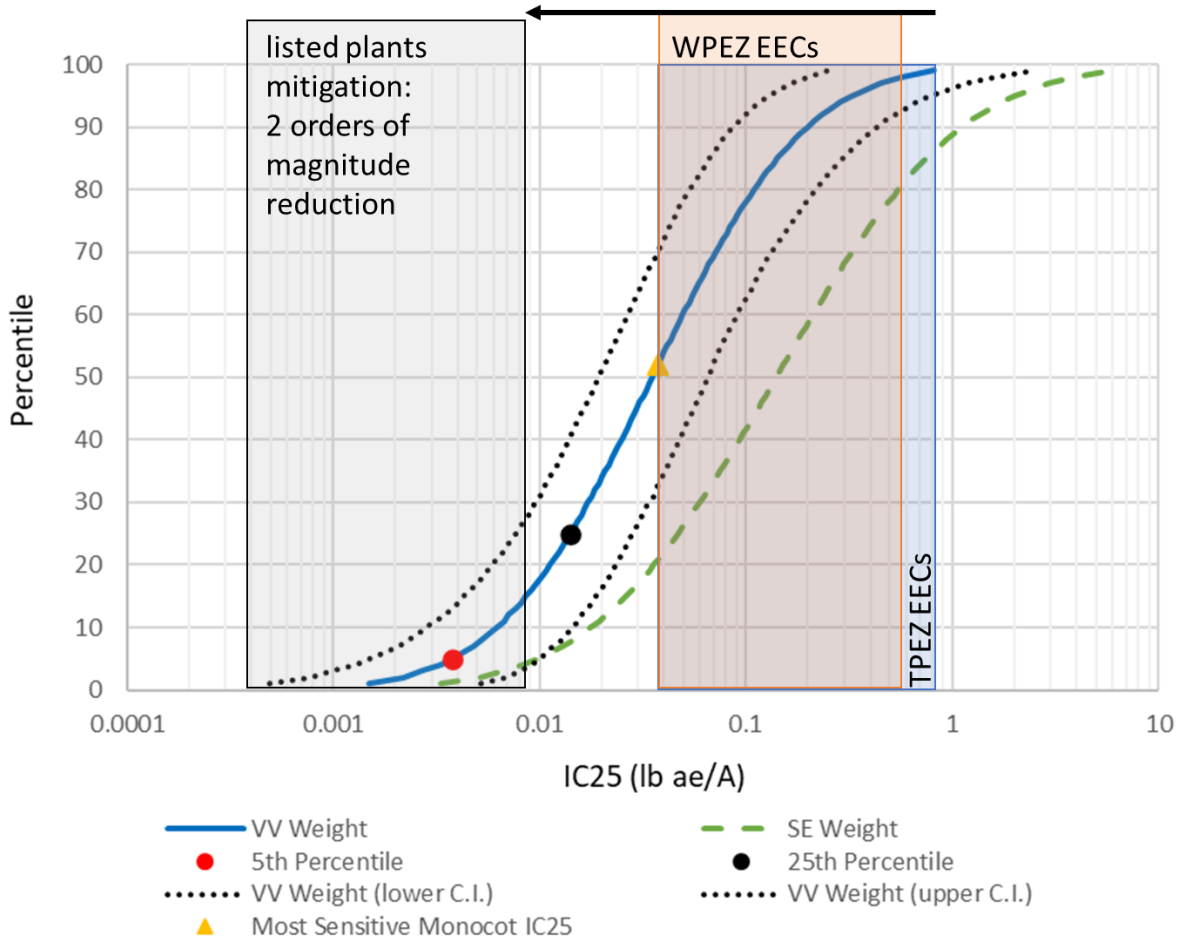


**Figure 4-2. 2,4-D Vegetative Vigor (VV) and Seedling Emergence (SE) SSDs Compared to the Terrestrial (TPEZ) and Wetland (WPEZ) EECs for all use patterns (see 2,4-D Example Worksheet for more details). The assessment selected the 5th percentile (represents listed plants and animals with obligate relationships to plants) and the 25th percentile (represents generalists and CH) from the VV weight distribution, Upper and lower confidence intervals (C.I.) are provided for the VV weight SSD.**

Based on the variability in the MoD estimation process, EPA expected there would be cases in which the MoDs for a single use (e.g., corn) span more than one of the mitigation categories (e.g., medium and high categories). When this occurred in the case studies, EPA completed a closer examination of the MoDs across modeled scenarios. If a higher mitigation category was identified for only a few modeled scenarios (*e.g.,* <20% of modeled scenarios) and/or MoDs were near the thresholds of the categories, EPA concluded the mitigation need as the lower category. As an example, if a use had 2 of 23 scenarios with high mitigation need (*i.e.,* MoD > 100), and all other scenarios were medium mitigation category (*i.e.,* 10 ≤ MoD < 100), EPA re-visited the mitigation category. If the two highest MoDs were close to the threshold for high mitigation (*i.e.,* 100), then EPA assigned that use a mitigation category of medium overall. If the

MoDs were not near the threshold (e.g., >200) then EPA generally scored the use as a high mitigation category. Within the case study documents, justification is provided for each of these situations when the mitigation category decision falls to the lower of the two categories identified by the MoDs. More discussion on **Step 2** is provide in the **Strategy Framework**.

# 5 Framework Step 3: Spatial Overlap Analysis for Species Locations and Potential Exposure Areas

EPA used a general spatial overlap analysis to establish the potential geographic extents of the proposed mitigation practices incorporated in the draft Strategy Framework (see discussions in **Section 7** and **Appendix C** of the **Strategy Framework**). EPA also used this analysis to assess whether there could be population-level impacts for listed species and CHs when taking into account agricultural uses of herbicides within CONUS.

The spatial overlap considers co-occurrence between potential pesticide exposure areas and listed species locations. The percent overlap is described by the potential geographic space where exposure can occur through runoff and/or spray drift, based on current and/or proposed labeled uses, and a given listed species range or its designated CH. EPA develops Off-field exposure areas for each potential agricultural use site or groups of sites based on the estimated drift and runoff/erosion distances. EPA uses species specific life history information to determine the off-site transport areas (based on species habitat type; i.e., terrestrial, wetland and/or aquatic) and likelihood that the species will occur on cultivated lands. As described in more detail below, EPA obtained species location information from FWS and based cultivated land locations on represented using geographic information system (GIS) layers developed from USDA's Cropland Data Layer[19] (CDL). When overlap is low (<5%), EPA concludes that there is a low likelihood of potential population level impacts. The exception to this approach is for the listed species that are incorporated into the vulnerable species[20] project, which are not considered further in the draft Strategy. The subsections below describe the spatial data and assumptions EPA used in the overlap analysis and how it interpreted the overlap.

## 5.1 Species and Critical Habitat Location Data

EPA used spatial data representing the listed species range and designated CH locations provided by the FWS as of February 16, 2022 (USFWS, 2022). These data are considered the best available species location data because they come from FWS, who has authority over the species considered in the draft Strategy. The listed species and CH location data helped inform the mitigation in the draft Strategy Framework and the potential for population-level impacts.

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[19] Available at USDA's National Agricultural Statistic Survey website: https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php

[20] https://www.epa.gov/endangered-species/implementing-epas-workplan-protect-endangered-and-threatened-species-pesticides#species

Updates to species ranges are expected, and EPA will continue to rely upon the most recent distributions provided by FWS.

To better understand how species range data may change and impact on the draft Strategy, EPA explored the updates to listed plant species ranges made between 2020 and 2022. During this timeframe, FWS updated the ranges for approximately 135 listed plants in CONUS (approximately 30% of listed plants within CONUS). These changes accounted for 75 species ranges that decreased by more than 10%, and 34 species ranges that increased by >10% in area. These changes may influence the individual species conclusions in terms of potential overlap with agriculture, and the potential for population-level impacts for these species as a result of herbicide use. Because the ranges are updated on a rolling basis, EPA plans to periodically update the species range data.

The species and CH range data do not typically include information on distributions of individuals within the range. Consistent with FWS's approach used in the malathion biological opinion (BiOp), EPA assumes that individuals are uniformly distributed within the range or CH, meaning the species is assumed to be present in all sections of the range and CH at all times of the year. Since many species are expected to have non-uniform distributions or animals may migrate to different locations within their ranges at different seasons, the uniform distribution assumption is an uncertainty in the overlap analysis that could under or overestimate the proportion of a listed species population that may be exposed to an herbicide. For animal species with general dependencies on plants, this assumption is not impactful when mitigation is needed because the draft Strategy Framework identifies mitigations that would be applicable throughout CONUS (regardless of the location of individuals within a population).

## 5.2 Geographic Locations of Use Sites

Since the draft Strategy is focused on agricultural uses within CONUS, EPA used available spatial data that represent potential application sites for specific crops or groups of crops. EPA also used an aggregated landcover layer that represents all cultivated lands. These spatial data are referred to as Use Data Layers (UDLs) and were generated by EPA by combining multiple years (2013-2017) of the CDLs and may represent multiple crops. In the future, EPA plans to update the UDLs with more recent CDL years. The 2017 cultivated layer identifies cultivated land cover for the CONUS and is based on land cover information derived from the 2013 through 2017 CDL (Boryan et al, 2011; USDA, 2017). EPA generated the individual agricultural UDLs through a temporal aggregation of multiple years of the CDL into the UDLs to account for changing agricultural practices from year to year (e.g., crop rotation). Also, EPA compared the total area of the temporally aggregated UDL to the reported area found in the Census of Agriculture, accounting for some of the error/difficulty in identifying minor crops. EPA used this approach to account for any area where a crop or crop group could occur over a 5-year period. The resulting UDLs provide a more protective land cover estimate for the purposes of assessing impacts to

listed species. Each UDL overestimates the spatial extent of the use sites within any single year and is especially conservative for the UDLs comprised of multiple crops. However, in the context of how the overlap is considered for population-level impacts this is intentionally conservative to ensure the process captures all of the potential species and CH that are closely associated with agricultural use sites as they change throughout years (e.g., crop rotation; crop expansion). Using a single year would underestimate the spatial extent of the use. Currently EPA uses 13 UDLs to represent different crops or groups of crops as outlined in **Table 5-1**Error! Reference source not found.. Generally, EPA targets at least 85% of accuracy[21] while generating UDLs from the CDLs. The following UDLs have accuracy values ranging from ~85 to 97%: corn, cotton, grapes/other vineyards, rice, soybeans, wheat, alfalfa/other agricultural grasses, citrus, other crops, other orchards, and vegetables and ground fruit. Two UDLs (i.e., other crops and other grains) did not meet an 85% accuracy for user's and producer's accuracy; however, the accuracies were close at 82 and 84%.

**Table 5-1. Agricultural Uses and the Corresponding UDL used by EPA in Spatial Analyses for ESA Assessments.**

| Uses (From Label/Risk Assessment) | Corresponding CONUS UDL[1] |
|---|---|
| Cultivated Lands (inclusive of all agricultural uses listed for the UDLs below except some non-alfalfa hay, e.g., switchgrass (USDA, 2017; Boryan et al,2011)) | Cultivated |
| Alfalfa, Vetch, Switchgrass | Alfalfa |
| Citrus (other), Grapefruit, Kumquat, Lemon, Lime, Orange, Tangelo, Tangerine | Citrus |
| Corn (grain), Corn (silage), Corn (traditional/Indian) | Corn |
| Cotton | Cotton |
| Grapes | Grapes |
| Field Crops (other), Fallow (other), Flaxseed, Grasses & Legumes (other, seed), Bahia Grass (seed), Bentgrass (seed), Bermuda Grass (seed), Kentucky Bluegrass (seed), Bromegrass (seed), Fescue (seed), Orchardgrass (seed), Ryegrass (seed), Sudangrass (seed), Timothy (seed), Wheatgrass (seed), Jojoba, Alfalfa (seed), Birdsfoot Trefoil (seed), Crimson Clover (seed), Red Clover (seed), White Clover (seed), Lespedeza (seed), Vetch (seed), Mustard (seed), Sesame | Other Crops |
| Barley, Buckwheat, Canola, Emmer & Spelt, Proso Millet, Oats, Rapeseed, Rye, Safflower, Sorghum (grain), Sorghum (silage), Sorghum (syrup), Sugarcane (seed), Sugarcane (sugar), Triticale | Other Grains |
| Almond, Apricot, Avocado, Banana, Cherimoya, Sweet Cherry, Tart Cherry, Chestnut, Coffee, Date, Fig, Apple, Guava, Hazelnut, Macadamia, Mango, Nectarine, Other Non-Citrus (excluding berries), Olive, Papaya, Passion Fruit, Peach, Pear, Pear, Persimmon, Pistachio, Plum-Apricot Hybrids (including plumcots & pluots), Plum & Prune, Pomegranate, Other Tree Nuts, English Walnut | Other Orchards |
| Hops, Peanut, Sugar Beet, Sunflower, Tobacco | Other Row Crops |
| Rice, Wild Rice | Rice |
| Soybean | Soybeans |

[21] Accuracy assessments provide a measure of correctness for the data layer.

| Uses (From Label/Risk Assessment) | Corresponding CONUS UDL[1] |
|---|---|
| Aronia Berry, Artichoke, Asparagus, Dry Edible Bean (excluding chickpeas & lima), Dry Edible Lima Bean, Green Lima Bean, Snap Bean, Beet, Other Berries, Blackberry (including dewberry &marionberry), Tame Blueberry, Wild Blueberry, Boysenberry, Broccoli, Brussel Sprout, Chinese Cabbage, Head Cabbage, Mustard Cabbage, Camelina, Carrot, Cauliflower, Celery, Chickpea, Chicory, Cranberry, Cucumber, Currant, Daikon, Dill (oil), Eggplant, Elderberry, Escarole & Endive, Garlic, Ginger Root, Ginseng, Collard Greens, Kale, Mustard Greens, Turnip Greens, Guar, Dry Herbs, Fresh Cut Herbs, Horseradish, Kiwifruit, Lentil, Lettuce, Loganberry, Cantaloupe, Honeydew Melon, Watermelon, Mint (oil), Mint Tea Leaves, Okra, Dry Onions, Green Onions, Parsley, Austrian Winter Pea, Chinese Pea (sugar & snow), Dry Edible Pea, Dry Southern Pea (cowpea), Green Pea (excluding Southern), Green Southern Pea (cowpea), Bell Pepper, Chile Pepper, Pineapple, Shelled Popcorn, Potato, Pumpkin, Radish, Raspberry, Rhubarb, Spinach, Squash, Strawberry, Sweet Corn, Sweet Potato, Taro, Tomato, Turnip, Other Vegetables, Watercress | Vegetables and Ground Fruit |
| Wheat | Wheat |

[1] CONUS UDL = Conterminous United States Use Data Layer

## 5.3 Determining the Off-Site Exposure Area for use in the Overlap Analysis

For the overlap analysis, EPA focuses on off-site exposure areas to where spray drift and runoff/erosion is possible to transport herbicides. EPA calculates the distances to where spray drift and runoff/erosion are possible to cause a population-level effect to listed plants or to animals through loss of diet or habitat. EPA buffered the 13 crop UDLs and the cultivated UDL in all directions to account for off-site transport. Because the UDLs are raster-based data that are composed of 30 m pixels (30 m x 30 m area, approximately 0.22 acre), the buffers are in increments of 30 m. As discussed below, the maximum buffer EPA used in the proposed Strategy to assess whether there could be a potential for population-level impacts is 300 m; however, the distance may be lower based on chemical specific use, fate, or toxicity characteristics.

As described in the **Strategy Framework**, EPA calculated spray drift buffers for each habitat, and used the habitat assignments for each species to select the appropriate overlap distance. Runoff buffers differ by the habitat type used by individual species, being broadly categorized as: terrestrial, wetland or aquatic (many species inhabit multiple categories). EPA assigned species to each of these habitats based on the information provided in publicly available FWS documents (https://ecos.fws.gov/ecp/). Species specific habitat information may be revised through future discussions with FWS.

EPA estimated spray drift distances using AgDRIFT™ (see section 3.1.4). The distance for spray drift in the overlap analysis is based on the toxicity thresholds (Section 3.2) and the application assumptions as defined on chemical specific labels (Section **3.1** and **3.3.2**). The overlap distance is defined by the distance within which the MoD is <1 or the level at which MoE switches to "low". With some chemicals, the distance to a MoD of "low" may extend beyond 300 m (~1000 ft). In these cases, EPA's default assumption was to rely upon the overlap at 300 m because this

is considered the farthest extent where EPA would expect the potential for population-level impacts from spray drift. This buffering approach is conservative approach as it assumes that spray drift occurs from all sides of treated areas, not just the downwind areas.

For runoff and erosion, distances vary by different habitats. For terrestrial habitats, EPA assumes that runoff occurs from overland flow or sheet-flow. Sheet-flow is over plane surfaces usually less than one inch deep. The PAT model (TPEZ) defines the distance of sheet-flow (overland flow) for terrestrial habitats out to an extent of 30 m (100ft; USEPA, 2023). Therefore, EPA is using 30 m as the buffer distance for runoff exposure from cultivated lands to non-target terrestrial areas potentially inhabited by listed species. For wetland plants, EPA assumes that runoff and erosion occurs from channelized or concentrated flow. This occurs when the flow from rills, gullies, and swales combines in natural or manmade conveyances. An overlap distance of 300 m (1000 ft) was used for channelized flow. The recommended maximum length for shallow concentrated flow will vary for different watersheds and waterbodies but has been assumed to be 300 m to 366 m (1200 ft; TXDOT, 2019; USDA, 2010; VADEQ, 1992). For species in terrestrial and wetland habitats, EPA based the overlap between species range or CH on the off-field untreated but potential exposure zones for runoff and drift. This buffering approach is conservative approach as it assumes that runoff occurs from all sides of treated areas, not just the down slope areas.

The overlap approach for aquatic habitats (represented by the EPA Farm Pond; see **Section 3.1)** is conceptually different compared to terrestrial and wetland habitats. EPA expanded FWS ranges of listed aquatic species to represent the entire watershed inhabited by the species (not just the stream reach or body of water where the species is known to occur). Therefore, EPA calculated the overlap by estimating the amount of potential use sites (UDLs) that occur within the watershed of the species. EPA also buffers out the UDLs in all directions to account for 30 m runoff area. This is a conservative approach as it assumes that: (1) Any use site within the treated area contributes exposure to the waterbodies inhabited by the species; (2) Concentrations are not diluted by untreated areas; and (3) Runoff occurs from all sides of treated areas, not just the down slope areas.

## 5.4 Overlap tool used in analysis

EPA used the UDL Overlap Tool[22], to post-process the percentage of overlap data with the exposure area (based on off-site transport areas discussed in previous section) for each UDL and each species range or CH. The overlap tool contains preprocessed overlap results using the species (Range) and designated CH data EPA obtained from FWS on February 16, 2022 and the 2013-2017 CDL derived UDLs. This tool generates outputs for species ranges and designated critical habitats separately, with the resulting percent overlaps summarized by use and off-site

[22] The Use Data Layer Overlap Tool can be found at: https://www.epa.gov/endangered-species/provisional-models-and-tools-used-epas-pesticide-endangered-species-biological

distance. For the case studies, EPA calculated the overlap percentages generated for 30m increments to represent different off-field exposure areas. EPA then incorporated overlaps into the range and CH likelihood of J/AM calculators for each case study chemical (see **Section 5.5**; and see individual case study documents) where chemical-specific off-field distances for drift and runoff (exposure area estimates) can be considered. The potential for population-level impacts are discussed further in **Section 3.5**.

## 5.5 Interpreting Overlap Analysis Results

Similar to the approach used by FWS in the malathion BiOp, when overlap is low (<5%), EPA concludes that there is a low potential for population-level impacts for the majority of species (excluding vulnerable species). For considering population-level impacts, EPA included species with >5% overlap. This approach likely captures more species finding that there could be population-level impacts because it does not consider some refinements that could be incorporated in the future. Discussed below are some of the assumptions of the overlap approach and how they may be conservative or under predictive for listed species.

### 5.5.1 Determinative species information refinements

There may be other considerations relevant to listed species that EPA could have used when interpreting the relevance of the overlap results. For example, there may be modifiers related to the species habitat that would limit the likelihood of exposure from spray drift and/or runoff/erosion, such as species location at elevation above agricultural sites or species on cliffs. In the current case studies, EPA did not incorporate these types of modifiers for all species. EPA expects to work with FWS in the future to identify species specific modifiers that may impact the interpretation of the overlap results.

### 5.5.2 UDLs and Use data

When assessing whether there could be population-level impacts for the case studies, EPA considered the overlap with individual UDLs that represent the registered uses of the specific chemicals. Given the categorical and temporal aggregations of UDLs (*i.e.*, the UDLs may contain more than one crop and are based on 5-years of data from 2013-2017), a single place (acre) could be accounted for in several UDLs. This is referred to as “redundancy” in the UDLs. Buffering the UDLs to account for off-site exposure area further compounds the redundancy because a single location will be found within the exposure area of multiple UDLs. Because of this redundancy and that it is not possible for a single site to simultaneously be multiple uses simultaneously, EPA does not add overlaps for a species or CH generated from multiple UDLs when assessing whether there could be a potential for population-level impacts. Given the redundancy across UDLs, the sum of the individual UDLs would dramatically overestimate the total percent overlap. While in single site cannot be multiple uses at one point in time, multiple UDLs could result in species overlap with potential exposure areas. If each UDL is evaluated

independently the problem of multiple counting is eliminated and we know if a species overlaps for each of the UDLs. This helps to identify which uses could potentially have population-level impacts.

### 5.5.3 Use and UDL considerations of geographic need for mitigation.

In the estimation of percent overlap for UDLs that include groups of crops, EPA did not consider specific crop distributions for refinement of the UDLs. Therefore, EPA also assessing whether there could be a potential for population-level impacts without consideration of more precise crop location within UDLs. This would appear to be a conservative assumption for assessing the potential for population-level impacts for specific species. EPA could refine this approach using available census of agriculture data (CoA); however, this type of refinement would not impact the level of mitigation because the magnitude of mitigation is defined based on the Magnitude of Difference (see **Section 4**) not the overlap, and those would only be required if using the chemical on the crop. As discussed in **Section 5.1**, if EPA finds that use of an herbicide has a potential to impact plants that could result in the potential for population-level impacts for listed animals with a generalist relationship to plants, proposed mitigation would be applicable throughout CONUS.

The difference between the actual and potential scale of mitigation can be explained with a specific crop example (artichokes) for oxyfluorfen. For artichokes, EPA identified the proposed mitigation based upon the UDL for Vegetables and Ground Fruit, the potential that there could be population-level impacts is based upon the species overlap with the UDL ($\geq$5%) and the relationship to plants (e.g., animal obligates; plants), habitat type (e.g., wetlands) and the Magnitude of Effect on plants in these habitats (Magnitude of Difference $\geq$10) based on the labeled application to artichokes. The proposed mitigation would be applicable to the habitat/species group combinations and the magnitude is based upon the Magnitude of Difference. If only considering the UDL, it would appear that the proposed mitigations would be applicable for large landscapes of agriculture. However, the Census of Agriculture reported very few counties that have artichoke acres grown, and the majority of these were concentrated over the coastal counties of central California from Marin County to Santa Barbara County, with approximately half of all artichokes being produced in Monterey County (**Figure 5-1**).

As mentioned above, the vegetable and ground fruit UDL is repetitive of many crops that are also registered for oxyfluorfen (in addition to artichokes). EPA identified mitigation for each of these crops based upon the labeled application rate and method and resulting EECs from modeling. Reliance on the UDL approach allows EPA to identify the mitigation for each of these uses such that the impacts are only to those locations where the crop is being grown and the herbicide is being used. The UDL approach is comprehensive to allow for adjustments to the distribution of use as it changes over time without requiring additional analyses to support expansion of crops into new areas within the UDL.

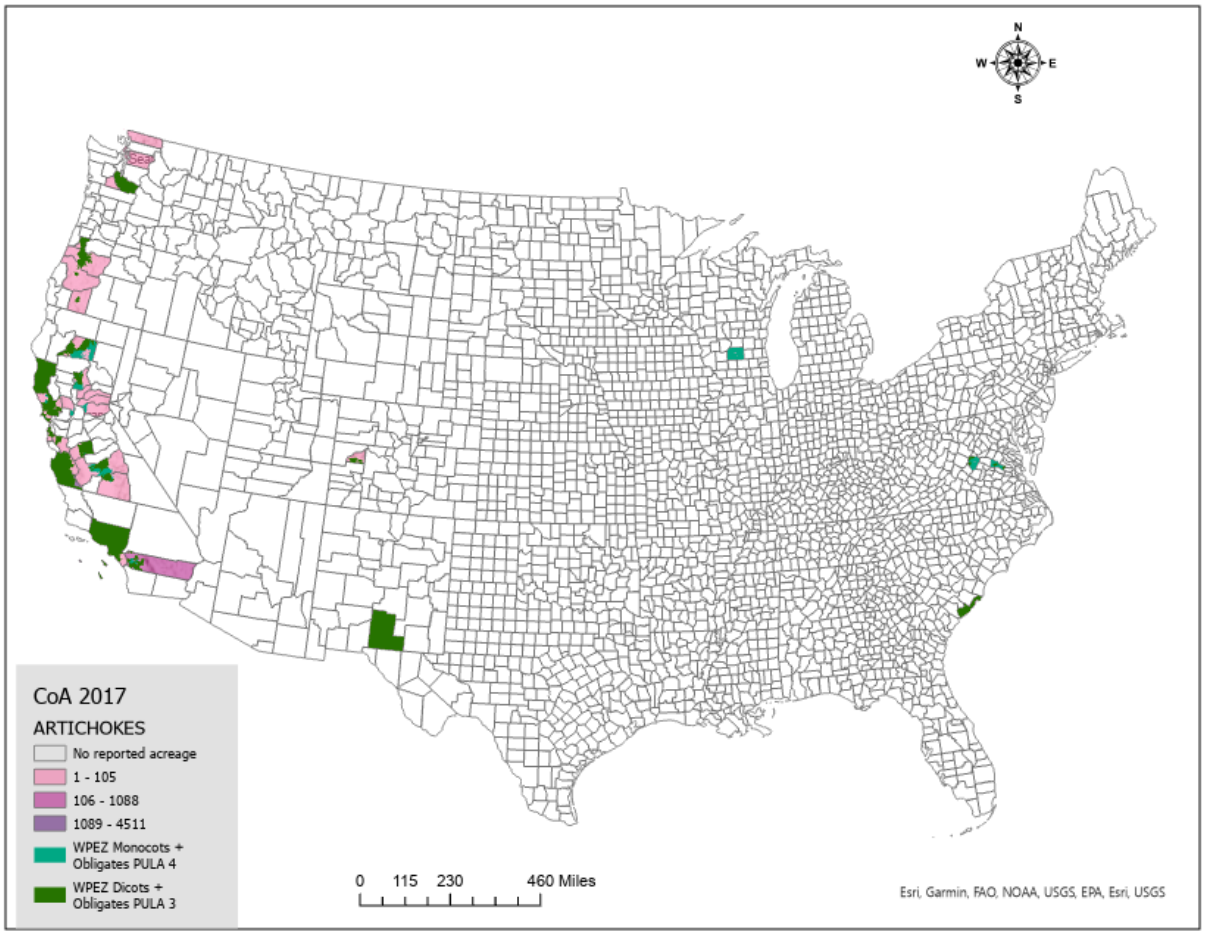


**Figure 5-1. Geographic Extent of Mitigation Identified for Oxyfluorfen Use on Artichoke with CoA (2017) reported acreage. Artichoke cropland is limited almost exclusively to western coast**

### 5.5.4 Usage data

In EPA's recent insecticide BEs[23] and the FWS malathion BiOp, percent crop treated data were used to refine the extent of overlap by accounting for the amount of overlap due to treated acres. Available census of agriculture data indicate herbicides are frequently used on cultivated lands, such that when considering the use of herbicides, there is not much refinement of the potential application area because of the widespread usage. In order to realize efficiencies and simplify the assessment process, EPA is not proposing to include usage data in the Herbicide Strategy. In cases where mitigation practices are needed on labels to address potential concerns due to loss of diet or habitat for listed animals with a generalist relationship to plants, consideration of the extent of usage will not impact the need for mitigation as it will be applied anywhere there is usage.

[23] https://www.epa.gov/pesticides/epa-takes-next-step-endangered-species-act-review-three-neonicotinoids

### 5.5.5 Accuracy and precision

*C*ommonly known and related sources of uncertainty for GIS data generally relate to accuracy, data resolution and precision. Accuracy can be defined as how well information on a map matches the values in the real world (e.g., is "corn" on the map really corn?). Data resolution is also related to accuracy, and is defined as size of the smallest difference between features that could be recorded as imaged pixels (e.g., can two objects be defined independently at 30m scale?). Precision relates to how well the description of the data used for mapping matches reality, based on closeness of repeated sets of measurements. The more precise the data, the more likely additional measurement or calculation will show the same result (*i.e.,* a measure of confidence related to how repeatable and predictable a mappable element is, based on the accuracy, data resolution and multiple measurements). Some sources of inaccuracy and imprecision in GIS data are obvious while others are difficult to identify. It is important to consider these sources of uncertainty as GIS software can make it appear that data are accurate and precise beyond the limits of the data. When conducting this spatial analysis to assess the relationship between the species range and agricultural location, EPA made assumptions related to the accuracy and precision of the available data (e.g., using a 30 m resolution for the overlap process). These assumptions impact the uncertainty of the relationship, and generally may overestimate the overlap between of species range and agricultural locations.

To address classification accuracy and positional accuracy of the agricultural GIS data used, EPA combines multiple years of the USDA cropland data layer (CDL) into a Use Data Layer (UDL) for each crop to represent anywhere the crop could be found. The CDL has a resolution of 30 meters. A raster data set can be re-sampled into smaller increments, but this does not improve the resolution or accuracy of the dataset. For this reason, values cannot be established with a higher level of resolution than 30 meters for the UDLs, and only values that are multiples of 30 can be determined (e.g., 30 m, 60 m, 90 m are distances in the dataset; 50 m is not).

Precision errors can be introduced when formatting data for processing. Formatting changes can include changes to scale, re-projections of data, and data format conversions (raster to vector or vice versa). Sources of errors that are not as obvious can include those originating from the initial measurements, digitizing of data and using different versions of a dataset. These types of precision error may introduce an edge effect, or a misaligned dataset when conducting the spatial analysis. For example, borders following the general shape of the county boundaries that do not align exactly with range information could result in this type of precision error.

These uncertainties in accuracy and precision impact the relationship between the agricultural areas and species locations. EPA's spatial analysis makes conservative assumptions to err on the side of overestimating the potential for species exposure when assessing the relationship of the species range to agricultural land. EPA uses five years of crop information in constructing the UDLs representing the agricultural land, so that the UDLs include every location where the crop was grown during those five years. Due to normal agricultural practices (e.g., crop rotations), this is more land than expected in a given year. The overlap between the species and the agricultural land may be overestimated when the range is larger than the actual area occupied

by the species, and when the additional area includes agricultural use areas or areas where edge effects were introduced. When considering the species location data, all areas may be occupied by the species at the time the pesticide is used. Species ranges occasionally use county or state boundaries as a conservative estimate for species range, but species and natural habitats are not expected to follow man-made boundaries. When the species locations have not been refined beyond these man-made boundaries, underestimates of the percentage of overlap between species range and agricultural use can occur. While this underestimation is possible, EPA makes several conservative assumptions for agricultural land and species life history to account for this possibility. For example, for agricultural land, use of UDLs that represent multiple years of cropping patterns expands the agricultural footprint beyond what is expected in a given year. In addition to these assumptions, EPA uses the best available species location information from the species experts at FWS. Overlaying the UDL and species range distributions requires combining two datasets that are collected using very different methods with different and varying degrees of both precision and accuracy. For the overlap calculations, EPA relies upon the UDL dataset that has the least amount of precision, therefore minimizing this possibility of underestimating a potential concern for listed species.

## 5.6 Predicting Potential Likelihood of Population Level Impacts and/or Impacts to Habitat

EPA's assessment for these case studies is similar to the analysis the Agency uses when it makes effects determinations. However, these cases studies are not effects determinations. For all species and CHs with ≥1% overlap of their locations with the CONUS Cultivated UDL exposure area when buffered to 300 m, EPA considered the potential for direct and/or PPHD effects, and, if relevant, EPA considered them further in the analysis to consider potential for population-level impacts. The Cultivated UDL comprises the geographic footprint of all agricultural lands (e.g., orchards, hay, beans, corn, cucumbers) within the conterminous United States. Therefore, any species or CH that has an overlap less than 1% or no overlap, is reasonably expected to not be impacted at a population or habitat level by agricultural pesticide use. Overall, as part of the case studies for the Herbicide Strategy, EPA considered the 432 listed plants, 530 listed animals, 103 designated CHs for listed plants, and 255 designated CHs for listed animals in CONUS—all of which have overlap >0.00% with the CONUS Cultivated UDL (see "Species + CH_Overlap&Characteristics.xlsx").

There is a subset of species that are known to be particularly "vulnerable"[24] and for which any overlap and take of a single individual may result in potential jeopardy to the population. EPA proposed mitigations for a subset of these species in its draft Vulnerable Species pilot (June 2023). As such, EPA did not include these species in the development of the draft Strategy.

[24] https://www.epa.gov/newsreleases/epa-marks-national-pollinator-week-proposing-protections-27-most-vulnerable-endangered

For each species and CH, EPA used the very high, high, medium or low Magnitude of Effect classification and the percent overlap for determining the potential likelihood of population level impacts. EPA assigned plant-based Magnitude of Difference ratios to the terrestrial, wetland, and aquatic habitats. For each individual use, if the Magnitude of Difference correlates to medium, high, or very high Magnitude of Effect (see **Section 3.3.3**), EPA considered the exceedances sufficient to cause potential population-level impacts. Modeling often provided multiple scenarios for an individual use (different scenario locations, application methods, application rates) and often multiple uses for an individual UDL (e.g., tomato, pepper, carrot all within Vegetables and Ground Fruit UDL). EPA relied upon the highest Magnitude of Difference ratios for each group of plants estimated for a UDL (e.g., dicots; monocots; aquatic plants). For any UDL with a Magnitude of Effect "medium" or "high", EPA considered the type of plant (e.g., monocot; dicot), type of habitat (e.g., terrestrial; wetland) and specific dependencies on plants (e.g., obligate to dicots). Generally, EPA predicted no likelihood population level impacts for one or more of the following conditions:

- if overlap was considered low (<5%),
- if the species was not a plant or and was not dependent upon plants
- if the specific plant type (e.g., monocots) or habitat (e.g., aquatic) did not have Magnitude of Effect of "medium", "high", or "very high".

Using the results from the analysis, EPA pulled the Entity IDs (i.e., unique numeric code representing a specific listed species) for all species and CH with potential likelihood of population impacts. These maps informed the geospatial extent of mitigation potentially needed across the agricultural landscape (for example the corn UDL for metolachlor **Figure 5-2**)

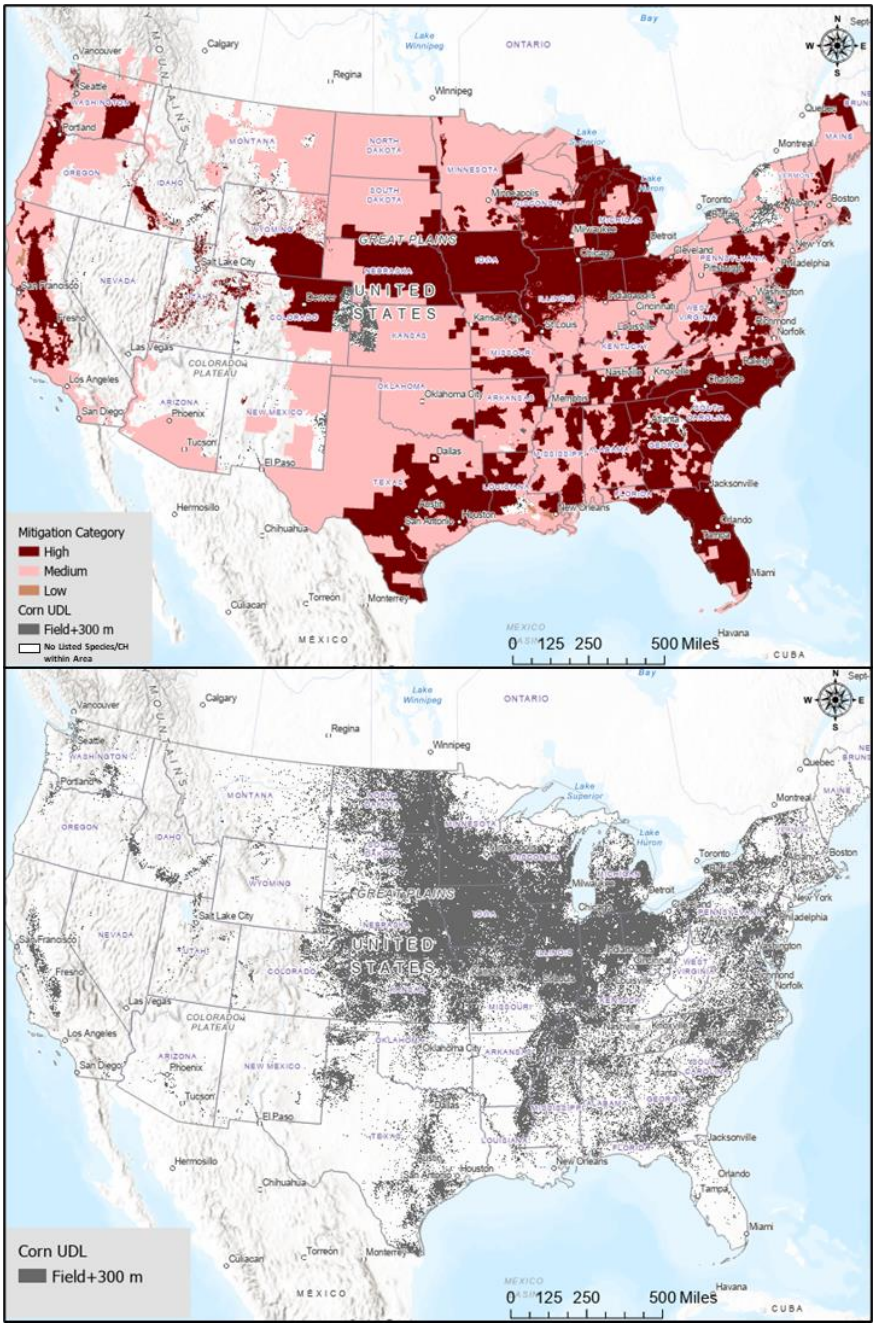


**Figure 5-2. Top Panel: Geographic Extent and Magnitude of Runoff Mitigation for Metolachlor Use on Corn. Bottom Panel: Distribution of Corn Acres (Corn UDL), highest densities of acres in darker grey areas.**

## 5.7 Determining Mitigation to Reduce the Potential Likelihood of Population Level Impacts

After completing the analyses discussed in **Section 5.6**, EPA then revisited the Magnitude of Difference (MoD) and determined how much mitigation is needed to result in a low likelihood of potential population level impacts for each of the case studies. In this evaluation, EPA considered both the spray drift pathway of exposure as well as the runoff/erosion pathway. Each of these pathways and the mitigation process to reduce the EECs are discussed in **Sections 4** and **6** of the **Strategy Framework**.

# 6 2,4-D Case Study Example (PC Codes 030001, 030004, 030016, 030025, 030019, 030035, 030053, 030063, 030066, 051505)

## 6.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 6.2 Use Information

2,4-D is a plant growth regulator (synthetic auxin herbicide) in the phenoxyacetic acid family that is most commonly used post-emergence for selective control of broadleaf weeds[25]. There are currently 10 forms of 2,4-D (collectively referred to as '2,4-D' in this example) with active EPA registrations: 2,4-dichlorophenoxyacetic acid (acid; PC Code 030001), 2,4-D dimethylamine salt (DMA; PC Code 030019), 2,4-D 2-ethylhexyl ester (EHE; PC Code 030063), 2,4-D butoxyethyl ester (BEE; PC Code 030053), 2,4-D triisopropanolamine salt (TIPA; PC Code 030035), 2,4-D isopropylamine salt (IPA; PC Code 030025), 2,4-D diethanolamine salt (DEA; PC Code 030016), 2,4-D sodium salt (Na; PC Code 030004), 2,4-D isopropyl ester (IPE; PC Code 030066), and 2,4-D choline salt (choline; PC Code 051505). Under most environmental conditions, 2,4-D ester and

[25] Broadleaf weeds are typically dicotyledonous flowering plants (or dicots). Because the target weed is a dicot, 2,4-D is more toxic to dicots than to monocots. See **Section 6.3.1** for information about 2,4-D's toxicity.

2,4-D salt formulations rapidly dissociate to 2,4-D acid. The mobility of ionized 2,4-D will depend on pH conditions and dissolved cations and metals present in the environment; overall, 2,4-D does have the potential to move into surface water via runoff and erosion. 2,4-D is not stable in aerobic aquatic environments nor in aerobic soil, but is moderately persistent to persistent in anaerobic conditions. 2,4-D may dissipate via volatilization, but volatilization is not considered in this example case study. However, important exposure pathways that are limited to a small number of pesticides such as volatilization or bioaccumulation will still be considered and addressed if appropriate on a case-by-case basis during chemical specific regulatory evaluations or individual consultations for that pesticide.

2,4-D is registered for a large number of agricultural and non-agricultural uses including aquatic weed control, potatoes, berries, tree nuts, turf, pastures, forest sites, cereal grains, corn, soybeans, sugarcane, rice, pome fruits, stone fruits, and citrus. As is consistent with previous assessments, all toxicity and fate data included in this example are considered on an "acid equivalent" (a.e.) basis. 2,4-D application rates range from 0.1 to 4 lb a.e./A for a single application and the primary application methods include aerial spray and ground spray.

**Table 6-1** includes the use information from the 2016 Draft Risk Assessment (DRA; DP424054) for Registration Review. EPA only included the non-GMO agricultural uses[26] which were evaluated in this DRA in the draft Strategy. As this is an illustrative example of how the draft Strategy would be implemented for 2,4-D, changes to the registered labels and uses since this addendum are not considered at this time but would be considered when EPA conducts assessments for 2,4-D for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the most recent assessment. **Table 6-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 6.6**. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on field corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5.**

EPA estimated exposures using the selected[27] uses and application information provided in **Table 6-1**. **Table 6-1** presents all 2,4-D application rates in acid equivalents (a.e.) to allow for comparison, in common units, across application rates for the various 2,4-D chemical forms. The selected uses do not necessarily represent all registered uses of 2,4-D and instead include large acreage uses sites (e.g., corn) and the agricultural use sites where 2,4-D usage is most

[26] 2,4-D choline is an active ingredient in Enlist One and Enlist Duo products, which are registered for use on genetically modified organism (GMO) Enlist corn, cotton, and soybean. These uses are not included in this case study example as EPA conducted a biological evaluation and included mitigations to reduce any potential effects to listed species and their critical habitat in that registration.

[27] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2016 Draft Risk Assessment (DRA; DP424054) for Registration Review for 2,4-D. Any uses not evaluated in the 2016 assessment (and 2022 addendum) and any new uses since this assessment are not included in this example case study for the proposed Herbicide Strategy.

common. As explained earlier, this evaluation excludes the Enlist One and Enlist Duo product uses on Enlist Corn, Enlist Soybean, and Enlist Cotton. Additionally, EPA did not include use of 2,4-D on flooded crops such as cranberries and rice to identify mitigations for such uses in this document at this time, but would consider these uses when the Herbicide Strategy is implemented for 2,4-D in the future. The selected uses are examples to illustrate the draft Strategy framework; however, this case study is not intended to be an ESA effects determination that would assess all use patterns. For the draft Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of 2,4-D as this application method represents the greatest source of potential offsite movement. Although granular formulations of 2,4-D are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

**Table 6-1. Summary of the Selected Agricultural Use Patterns Labeled for 2,4-D (2022 Addendum to the 2016 Draft Risk Assessment for Registration Review, DP453685)[1]**

| Use Site | Application Method | Max Single Application Rate, lb a.e./A (Application Timing) | Max # of Applications/year | Max Annual Application Rate, lb a.e./A/yr | MRI [2] (d) | 2,4-D Chemical Forms |
|---|---|---|---|---|---|---|
| **Wheat Use Data Layer** | | | | | | |
| Wheat | A, G broadcast | 1.25 (post-emergence)<br>0.5 (pre-harvest) | 1 post-emergence<br>1 pre-harvest | 1.75 | (12) | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| **Other Grains Use Data Layer** | | | | | | |
| Cereal Grains (barley, millet, oat, rye and tiff) | A, G broadcast | 1.25 (post-emergence)<br>0.5 (pre-harvest) | 1 post-emergence<br>1 pre-harvest | 1.75 | (12) | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| Sorghum | A, G broadcast or directed band | 1 (acid, amines, salt)<br>0.5 (esters) | 1 | NA | NA | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| Sugarcane | A, G broadcast | 2 (pre-plant)<br>2 (post-emergence) | 1 per crop stage | 4 | (12) | Acid, DMA, TIPA, IPA, DEA, Na, Choline |
| **Corn Use Data Layer** | | | | | | |
| Field corn | A, G broadcast or directed band | 1 (pre-plant or pre-emergence)<br>0.5 (post-emergence)<br>1.5 (pre-harvest) | 1 per crop stage | 3 | (12) | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | |
| Pop corn | A, G broadcast or directed band | 1 (pre-plant or pre-emergence)<br>0.5 (post-emergence)<br>1.5 (pre-harvest) | 1 per crop stage | 3 | (12) | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| Sweet corn | A, G broadcast or directed band | 1 (pre-plant or pre-emergence)<br>0.5 (post-emergence) | 1 per crop stage | 1.5 | 21 | Acid, DMA, EHE, BEE, TIPA, IPA, DEA, Na, Choline |
| Potato | A, G broadcast | 0.07 | 2 | 0.14 | 10 | Acid, DMA, EHE, BEE, TIPA, IPA, DEA |
| Asparagus | A, G broadcast | 2 | 2 | 4 | 30 | Acid, DMA, TIPA, IPA, DEA |
| Strawberries | A, G broadcast | 1.5 | 1 | 1.5 | NA | Acid, DMA, TIPA, IPA, DEA, Na |

| Use Site | Application Method | Max Single Application Rate, lb a.e./A (Application Timing) | Max # of Applications/year | Max Annual Application Rate, lb a.e./A/yr | MRI [2] (d) | 2,4-D Chemical Forms |
|---|---|---|---|---|---|---|
| Low bush blueberries | Directed, ground wipe or spot treatment | Wiper Solution 0.0375 lb/gal (post-emergence)<br><br>1 lb a.e./10 gal (post-harvest)<br><br>(1.4 lb a.e/A) | 1 per crop stage | (2.8) | (12) | Acid, DMA, TIPA, IPA, DEA |
| High bush blueberries | Directed, ground wipe or spot treatment | 1.4 (post-emergence and post-harvest) | 1 per crop stage | 2.8 | (12) | Acid, DMA, TIPA, IPA, DEA, Na |
| Cranberries[3] | Ground granule broadcast (esters)<br><br>Ground wipe or spot treatment (acid, amine, and salt) | 4 - dormant (esters)<br><br>1.2 post-emergence (acid, amine, salt) | 1 (ester)<br><br>2 (acid, amine, salt) | 4 (esters)<br><br>2.4 (acid, amine, salt) | (12) | Acid, DMA, EHE, BEE, TIPA, IPA, DEA, Na |
| **Soybean Use Data Layer** | | | | | | |
| Soybean | A, G broadcast | 1 | 1 pre-plant or pre-emergence | 1 | NA | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| **Rice Use Data Layer** | | | | | | |
| Rice[3] | A, G broadcast, band, or spot treatment | 1 (pre-plant)<br>1.5 (post-emergence) | 1 per crop stage | 1.5 | (12) | Acid, DMA, TIPA, IPA, DEA, Na, Choline |
| Wild Rice | A, G broadcast, band, or spot treatment | 0.25 | 1 | 0.25 | NA | Acid, DMA, TIPA, IPA, DEA, Na |
| **Other Crops Use Data Layer** | | | | | | |
| Fallow and Crop Stubble | A, G broadcast | 2 | 2 | 4 | 30 | Acid, DMA, EHE, BEE, EMPE, TIPA, IPA, DEA, Na, Choline |
| **Other Orchards Use Data Layer** | | | | | | |
| Pome Fruit, Stone Fruit | A, G broadcast or spot treatment | 2 | 2 | 4 | 75 | Acid, DMA, TIPA, IPA, DEA, Na, Choline |
| Nut orchards, pistachio | A, G broadcast or spot treatment | 2 | 2 | 4 | 30 | Acid, DMA, TIPA, IPA, DEA, Na, Choline |

| Use Site | Application Method | Max Single Application Rate, lb a.e./A (Application Timing) | Max # of Applications/year | Max Annual Application Rate, lb a.e./A/yr | MRI [2] (d) | 2,4-D Chemical Forms |
|---|---|---|---|---|---|---|
| Filberts | Spot Treatment | 1 lb a.e./100 gal (assume 2 lb a.e/A) | 4 | (12) | 30 | Acid, DMA, TIPA, IPA, DEA, Na |
| **Other Row Crops Use Data Layer** | | | | | | |
| Hops | A, G broadcast | 0.5 | 3 | 1.5 | 30 | Acid, DMA, TIPA, IPA, DEA |
| **Grapes Use Data Layer** | | | | | | |
| Grapes | Ground directed | 1.36 | 1 | 1.36 | NA | Acid, DMA, TIPA, IPA, DEA, Na |
| **Citrus Use Data Layer** | | | | | | |
| Citrus | A, G broadcast or directed | 0.1 | 1 | 0.1 | NA | IPE |

a.e.=acid equivalent; MRI = Minimum retreatment interval; d=day; A=aerial; G=ground; Acid=2,4-dichlorophenoxyacetic acid; DMA=2,4-D dimethylamine salt; EHE=2,4-D 2-ethylhexyl ester; BEE=2,4-D butoxyethyl ester; EMPE=2-ethyl-4-methylpentyl ester; TIPA=2,4-D triisopropanolamine salt; IPA=2,4-D isopropylamine salt; DEA=2,4-D diethanolamine salt; Na=2,4-D sodium salt; IPE=2,4-D isopropyl ester; Choline=2,4-D choline.

[1] The use information presented in this table is identical to the agricultural uses included in the 2016 Draft Risk Assessment (DRA) for Registration Review (DP424054).

[2] Values in parenthesis were estimated in the 2022 addendum (DP453685) to the DRA based on other information provided on the label. These values are not on the label.

[3] Although cranberries and rice are registered uses of 2,4-D, EPA did not calculate EECs using the Pesticides in Flooded Applications Model for these uses for the Herbicide Strategy at this time. EPA would consider these uses for potential impacts to listed species when the draft Strategy is implemented for 2,4-D.

## 6.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of 2,4-D (**Section 6.3.1**), reported incidents (**Section 6.3.2**), and the EECs to calculate magnitude of difference values (**Section 6.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 6.3.1 Toxicity Information

**Table 6-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for 2,4-D. The available plant toxicity data include all forms of 2,4-D. Because the ester forms of 2,4-D result in similar terrestrial plant toxicity endpoints as the non-ester forms and the ester degrades rapidly to acid in water, the most sensitive toxicity endpoints (**Table 6-2**) are focused on toxicity data for 2,4-D salts, acids, and amines, not ester forms of 2,4-D.

**Table 6-2. Summary of the Most Sensitive Toxicity Endpoints for 2,4-D (As Summarized in the 2016 Draft Risk Assessment for Registration Review (DP424054) and its 2022 Addendum (DP453685))**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Onion (*Allium cepa*) | NOAEC = 0.091 lb a.e./A<br>$IC_{25}$ = 0.097 lb a.e./A | 47106001 Acceptable | Test with 2,4-D DMA; Based on effects on dry weight |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.020 lb a.e./A<br>$IC_{25}$ = 0.026 lb a.e./A | | Test with 2,4-D DMA; Based on effects on dry weight |
| Vegetative Vigor | Monocot: Onion (*Allium cepa*) | NOAEC = 0.01 lb a.e./A<br>**$IC_{25}$ = 0.037 lb a.e./A** | 42609102 Acceptable | Test with 2,4-D DEA; Based on effects on fresh weight |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.0017 lb a.e./A<br>$IC_{25}$ = 0.0038 lb a.e./A | 47106002 Acceptable | Test with 2,4-D DMA; Based on effects on dry weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 47.6 µg a.e./L<br>**$IC_{50}$ = 299.2 µg a.e./L** | 42712204 Acceptable | Test with 2,4-D DEA; Based on effects on frond number and plant number |
| Aquatic Nonvascular Plant | Freshwater diatom (*Navicula pelliculosa*) | NOAEC = 1,410 µg a.e./L<br>**$IC_{50}$ = 3,880 µg a.e./L** | 41505903 Acceptable | Test with 2,4-D DMA; Based on effects on growth |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}/_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.e.=acid equivalents; DMA=2,4-D dimethylamine salt (PC Code 030019); DEA=2,4-D diethanolamine salt (PC Code 030016)

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots and listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all dicot species, EPA generated Species Sensitivity Distributions (SSDs) using results for all dicot terrestrial plant test species (*i.e.,* not only the most sensitive) and for all tested terrestrial plants from the 2,4-D vegetative vigor tests. See **Table 6-3** and **Figure 6-1** for these SSD results. EPA used the most sensitive $IC_{25}$ value for vegetative vigor across all tested monocots to calculate the magnitude of difference for monocots (see **Table 6-4**).

As explained below, EPA calculated Species Sensitivity Distributions (SSDs) separately for vegetative vigor and seedling emergence plant weight endpoints. EPA did not calculate SSDs for the height data, because the data are too few. See **Sections 6.7** and **6.8** for the process for calculating the SSDs.

Monocots and dicots do not appear to be substantially different in sensitivity based on all of the submitted seedling emergence toxicity data for plant weight for 2,4-D. The ranges of growth endpoints (*i.e.,* the concentrations resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot weights from the seedling emergence studies overlap when considering all definitive values available (summarized in **Section 6.7**). Additionally, the mean and median $IC_{25}$ values for monocot and dicot weights only differ by a factor of 4 when considering all of the seedling emergence studies. Therefore, EPA did not create separate SSDs for monocots and dicots for the seedling emergence weight data.

For 2,4-D, the vegetative vigor weight data were more sensitive than the seedling emergence weight data. Although the ranges of $IC_{25}$ values for the weight data overlap for monocots and dicots when considering all definitive values available from the vegetative vigor studies, monocots and dicots differ in sensitivity. Specifically, the monocot and dicot mean and median $IC_{25}$ values for weight differ by a factor of 12 with lower weights measured for dicots. Therefore, an SSD was generated using only the dicot weight data from the vegetative vigor studies. However, as explained below, EPA did not choose the dicot weight SSD for determining the magnitude of difference between the EECs and dicot toxicity endpoints.

The $5^{th}$ percentile of the SSDs is equivalent for the vegetative vigor weight data regardless of whether the SSD includes only the dicot data or both the dicot and monocot data (0.0037 vs. 0.0038 lb a.e./A, respectively). Therefore, conclusions for listed plants and animals with an obligate relationship to plants would not differ between the two SSD approaches. EPA selected the SSD based on the combined monocot and dicot weight data because the fit of the SSD to the empirical data at the upper percentiles (*i.e.,* $\geq 50^{th}$ percentile) is better when the monocot data are included in the SSD (as shown in **Section 6.8**) and because the $25^{th}$ percentile of the SSD is used to estimate community-level impacts to generalist animals that rely on both monocots and dicots. This SSD is shown in **Figure 6-1**.

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 6.3.3**). Overall, the magnitude of difference between the endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot,

dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship[28]).

EPA calculated the magnitude of difference for terrestrial and wetland dicots and animals that obligately depend on dicots as a ratio of the EEC to the 5$^{th}$ percentile of the SSD with the combined weight data (**Table 6-3** and **Table 6-4;** see **Section 6.3.3)**. EPA did not generate an SSD for the monocot data because the available vegetative vigor studies only tested five monocot species. Therefore in lieu of an SSD, given that monocots are less sensitive to 2,4-D than dicots, EPA calculated the magnitude of difference between the EECs and toxicity endpoint using the most sensitive $IC_{25}$ value for monocots. These magnitude of difference ratios are applicable for monocots and animals that obligately depend on monocots. The most sensitive monocot $IC_{25}$ value from **Table 6-2** (0.037 lb a.e./A) is 10 times greater than the 5$^{th}$ percentile value (0.0038 lb a.e./A) from the selected SSD based on the combined weight data (as shown by comparing the yellow triangle to the red dot in ), which further supports the decision to analyze dicots and monocots separately for 2,4-D.

For animals that generally rely upon terrestrial or wetland plants for diet or habitat and for designated critical habitats (CH), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated CHs is the ratio of the EEC to the 25$^{th}$ percentile of the SSD based on the combined weight data (**Table 6-3** and **Table 6-4**; see **Section 6.3.3**).

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[29] are available to evaluate potential impacts of 2,4-D on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 6-2** and **Table 6-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[30].

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[28] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend. Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

[29] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[30] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

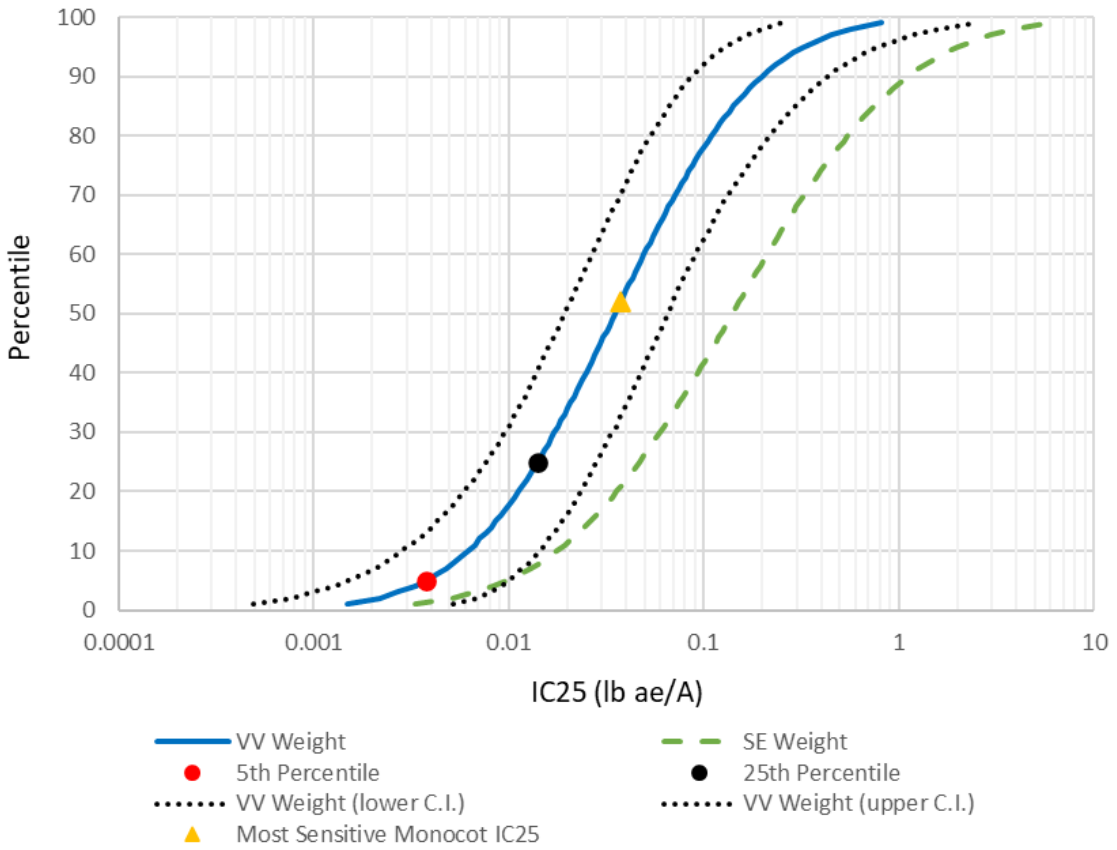


**Figure 6-1. Vegetative Vigor (VV) and Seedling Emergence (SE) Study Species Sensitivity Distributions (SSD) representing the Distributions of the Plant Weight IC25s for 2,4-D. The Upper and Lower Confidence Intervals (C.I.) are plotted for the VV Plant Weight SSD. Also shown is where the most sensitive monocot VV weight $IC_{25}$ is located on the SSD.**

**Table 6-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for 2,4-D**

| Percentile (x) | Seedling Emergence Test | Vegetative Vigor Test | |
|---|---|---|---|
| | Monocots and Dicots Combined | Monocots and Dicots Combined | Dicots Only |
| | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A |
| 5 | 0.0083 (0.0025 – 0.035) | **0.0038** (0.0015 – 0.010) | 0.0037 (0.0015 – 0.010) |
| 25 | 0.045 (0.019 – 0.13) | **0.014** (0.0077 – 0.028) | 0.011 (0.0064 – 0.019) |
| 50 | 0.13 (0.056 – 0.31) | 0.035 (0.019 – 0.066) | 0.019 (0.012 – 0.028) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed dicots, animals that obligately depend on dicots, and animals that generally depend on monocots/dicots. For listed monocots and animals that obligately depend on monocots, the most sensitive $IC_{25}$ value was used (shown in **Table 6-2** and **Table 6-4**).

**Table 6-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for 2,4-D[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | Monocots: 0.037 lb a.e./A<br>Dicots: 0.0038 lb a.e./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | Monocots: 0.037 lb a.e./A<br>Dicots: 0.0038 lb a.e./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | Monocots: 0.037 lb a.e./A<br>Dicots: 0.0038 lb a.e./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | Monocots: 0.037 lb a.e./A<br>Dicots: 0.0038 lb a.e./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | Monocots: 0.037 lb a.e./A<br>Dicots: 0.0038 lb a.e./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.014 lb a.e./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 0.014 lb a.e./A |
| | | Based on aquatic plant endpoints: 299.2 µg a.e./L (Vascular)<br>3880 µg a.e./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 299.2 µg a.e./L<br>Nonvascular: 3880 µg a.e./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Strategy. In this case study for 2,4-D, EPA calculated eight sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.e./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.e./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.e./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 6.3.2 Incidents

The incident information from the 2013 revised Problem Formulation for Registration Review (DP402410) and the 2016 Draft Risk Assessment for Registration Review (DP424054) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[31] (as discussed in **Section 6.3.3.3**), which informs the potential population-level impacts (**Section 6.6**), and to identify the proposed level of mitigation (see **Section 6.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 6.3.3.3**).[32] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

Per the revised 2013 Problem Formulation, a search of the Ecological Incident Information System database (EIIS) on August 6, 2012 returned more than 400 incidents for 2,4-D, ranging from 1949 to the 2012. The majority of these incidents were reported for 2,4-D acid and involved plants. Entries included both residential and agricultural use of 2,4-D products. Many of the plant incidents appeared to result from over-application of 2,4-D products to lawns or application of 2,4-D products to types of grass that are sensitive to 2,4-D. Other plant incidents were the result of spray drift in agricultural settings. A limited number of incidents with other organisms (fish, aquatic plants, birds, mammals, reptiles, and terrestrial insects) were also reported. In the Aggregate Incidents Report database (IDS), 13,798 minor plant incidents were reported from 1996 to June 2012.

Per the 2016 assessment, EPA searched the EIIS and IDS on December 22, 2015, focusing on incidents more recent than and/or not reported in the Problem Formulation (the search in the Problem Formulation was performed in June and August, 2012). In the EIIS database, 2,4-D was the “possible” or “probable” cause of 56 additional incidents since the Problem Formulation (incidents classified as “misuse”, “unlikely”, or “unrelated” are not reported). Similar to the

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[31] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[32] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

Problem Formulation, most incidents involved damage to plants. The majority of the incidents involved at least one other herbicide, making it difficult to attribute the plant damage to one specific chemical.

EPA searched the IDS again for 2,4-D incidents on June 21, 2022. The search focused on incidents more recent than the DRA (DP424054). This search excluded incidents classified as "unlikely", "unrelated" or "misuse" and only includes incidents with the certainty categories of "possible" or "probable". There were 233 reported incidents that were associated with 2,4-D between January 1, 2016, and June 21, 2022. Similar to previous assessments, the majority of the incidents involved damage to plants. Additionally, there were 4,480 aggregate incidents associated with 2,4-D between January 1, 2016, and June 21, 2022. Approximately 99% of the incidents involved damage to plants.

Previous assessments likely under-counted the number of reported ecological incidents associated with 2,4-D due to issues associated with uploading, coding, and displaying ecological incident data in IDS (as explained in the 2022 addendum (DP453685) to the 2016 risk assessment). EPA uncovered a backlog of incidents which includes many incidents involving 2,4-D. The 2022 addendum includes a summary of all ecological incidents currently in IDS and includes a summary of the numbers of incidents in the backlog that were retrieved and reported to be associated with 2,4-D use (as of August 2021).

The number of actual incidents associated with 2,4-D may be higher than what is reported to the Agency. Incidents may go unreported since side effects may not be immediately apparent or readily attributed to the use of a chemical. Although incident reporting is required under FIFRA Section 6(a)(2), the absence of reports in IDS does not indicate that the chemical has no impacts on wildlife; rather, it is possible that incidents are unnoticed and unreported.

The high number of incidents of direct impacts to plants off the treated field is one line of evidence that the magnitude of effect categories should be shifted to a lower magnitude of difference threshold for 2,4-D (**Section 6.3.3.3**). In other words, the 2,4-D incidents indicate that an unexpected level of off-field exposure may occur, and EPA considered this potential off-field exposure within this case study.

### 6.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *6.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the area, and the plant toxicity endpoint. **Table 6-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoints to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of 2,4-D ($5^{th}$ percentile of the SSD = 0.0038 lb a.e./A for dicots; most sensitive toxicity endpoint = 0.037 lb a.e./A for monocots). To estimate potential diet/habitat impacts to listed generalist animals, EPA selected the most sensitive endpoint applicable for generalists (*i.e.,* $25^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, in **Table 6-5**, EPA based the spray drift distances for generalist animals on the $25^{th}$ percentile of the SSD (0.014 lb a.e./A).

Within **Table 6-5**, the modeled application rates are representative of the maximum single application rate currently registered for 2,4-D on non-GMO agricultural uses (*e.g.,* sugarcane, pome fruit, etc.; 2.0 lb a.e./A) and reduced rates (1.5, 0.5, 0.07 lb a.e./A) representative of maximum single application rates for other uses (**Table 6-1**). **Table 6-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoints evaluated (*i.e.,* $5^{th}$ percentile of the SSD, monocot $IC_{25}$, or $25^{th}$ percentile of the SSD), and also the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size, as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 6.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 6.9**). This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 6-5. Spray Drift Distances to the Population-Level Impacts Endpoint for 2,4-D for Listed Terrestrial and Wetland Plants and Listed Animals that Depend on Plants, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| Application Rate (lb a.e./A) | | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|---|
| | | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Listed Monocots and Listed Animals that Obligately Depend on Monocots** | | | | | | | | |
| 2.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | 500 | 250 | 175 | 150 | 50 | 50 | 20 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.6** [300] | 0.8 [300] | 0.8 [200] | 0.7 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |
| 1.5 (maximum rate for use on corn and strawberries) | Distance to Medium MoE[2,3] (ft) | 375 | 200 | 150 | 100 | 50 | 20 | 20 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.2** [300] | 0.6 [300] | 0.6 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| 0.50 (maximum rate for multiple uses) | Distance to Medium MoE[2,3] (ft) | 125 | 75 | 50 | 50 | 20 | 10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.4 [300] | 0.2 [300] | 0.2 [200] | 0.2 [200] | 0.1 [100] | 0.1 [100] | 0.1 [100] |
| 0.07 (maximum rate for use on potato) | Distance to Medium MoE[2,3] (ft) | 0* | 0* | 0* | <10 | <10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.1 [300] | <0.1 [300] | <0.1 [200] | <0.1 [200] | <0.1 [100] | <0.1 [100] | <0.1 [100] |
| **Listed Dicots and Listed Animals that Obligately Depend on Dicots** | | | | | | | | |
| 2.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | >1000 | 650 | 450 | 425 | 300 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **16** [300] | **7.6** [300] | **7.9** [200] | **6.4** [200] | **5.1** [100] | **3.7** [100] | **2.4** [100] |
| 1.5 (maximum rate for use on corn and strawberries) | Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | >1000 | 525 | 400 | 325 | 225 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **12** [300] | **5.7** [300] | **5.9** [200] | **4.8** [200] | **3.8** [100] | **2.8** [100] | **1.8** [100] |

| Application Rate (lb a.e./A) | | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|---|
| | | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0.50 (maximum rate for multiple uses) | Distance to Medium MoE[2,3] (ft) | >1000 | 600 | 350 | 300 | 125 | 100 | 50 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **4.0** [300] | **1.9** [300] | **2.0** [200] | **1.6** [200] | **1.3** [100] | 0.9 [100] | 0.6 [100] |
| 0.07 (maximum rate for use on potato) | Distance to Medium MoE[2,3] (ft) | 175 | 125 | 75 | 50 | 20 | 10 | 10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |
| **Listed Generalist Animals** | | | | | | | | |
| 2.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | >1000 | 700 | 375 | 325 | 150 | 100 | 50 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **4.3** [300] | **2.1** [300] | **2.2** [200] | **1.7** [200] | **1.4** [100] | 1.0 [100] | 0.6 [100] |
| 1.5 (maximum rate for use on corn and strawberries) | Distance to Medium MoE[2,3] (ft) | >1000 | 450 | 275 | 250 | 100 | 75 | 50 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **3.3** [300] | **1.6** [300] | **1.6** [200] | **1.3** [200] | 1.0 [100] | 0.8 [100] | 0.5 [100] |
| 0.50 (maximum rate for multiple uses) | Distance to Medium MoE[2,3] (ft) | 325 | 175 | 125 | 100 | 50 | 20 | 10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.1** [300] | 0.5 [300] | 0.5 [200] | 0.4 [200] | 0.3 [100] | 0.3 [100] | 0.2 [100] |
| 0.07 (maximum rate for use on potato) | Distance to Medium MoE[2,3] (ft) | 50 | 20 | 20 | 20 | 10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.2 [300] | 0.1 [300] | 0.1 [200] | 0.1 [200] | <0.1 [100] | <0.1 [100] | <0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the vegetative vigor endpoint for monocots (0.037 lb a.e./A), the 5th percentile of the SSD for dicots (0.0038 lb a.e./A), and the 25th percentile of the SSD for generalist animals (0.014 lb a.e./A) are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For 2,4-D, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 6.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation practices in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25 ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 6.9** contains the full output of results.

*At 0 ft off the field, the magnitude of difference ratio is <1.0.

#### *6.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 6-6** through **Table 6-10** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, monocot $IC_{25}$, 5th or 25th percentile of the SSD).

**Table 6-6. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 4.8 – 24 | 0.02 – 0.08 | <0.01 – 0.01 |
| Field Corn and Popcorn | 7.4 – 46 | 0.02 – 0.15 | <0.01 – 0.01 |
| Sweet Corn | 3.3 – 17 | 0.01 – 0.06 | <0.01 |
| Soybean | 4.7 – 23 | 0.02 – 0.08 | <0.01 – 0.01 |
| Sorghum | 3.5 – 35 | 0.01 – 0.12 | <0.01 – 0.01 |
| Sugarcane | 13 – 56 | 0.04 – 0.19 | <0.01 – 0.01 |
| Potato | 0.52 – 2.6 | <0.01 – 0.01 | <0.01 |
| Asparagus | 13 – 64 | 0.04 – 0.21 | <0.01 – 0.02 |
| Hops | 4.7 – 13 | 0.02 – 0.04 | <0.01 |
| Strawberries | 5.3 – 21 | 0.02 – 0.07 | <0.01 – 0.01 |
| Blueberries | 9.6 – 18 | 0.03 – 0.06 | <0.01 |
| Citrus | 1.8 – 8.8 | 0.01 – 0.03 | <0.01 |
| Grapes | 1.0 – 5.1 | <0.01 – 0.02 | <0.01 |
| Pome, Nuts, Stone Fruit | 11 – 23 | 0.04 – 0.08 | <0.01 – 0.01 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for 2,4-D, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 6-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Monocots | Wetland Dicots | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.08 – 0.65 | 2.1 – 17 | 20 – 170 | 75 – 2200 | 0.25 – 7.4 | 0.02 – 0.57 |
| Field Corn and Popcorn | 0.12 – 0.72 | 3.1 – 19 | 31 – 190 | 190 – 3000 | 0.63 – 10 | 0.05 – 0.77 |
| Sweet Corn | 0.07 – 0.25 | 1.8 – 6.8 | 17 – 67 | 64 – 1100 | 0.21 – 3.8 | 0.02 – 0.29 |
| Soybean | 0.10 – 0.32 | 2.6 – 8.6 | 25 – 84 | 110 – 1500 | 0.35 – 4.9 | 0.03 – 0.38 |
| Sorghum | 0.07 – 0.28 | 2.0 – 7.5 | 19 – 73 | 87 – 1700 | 0.29 – 5.5 | 0.02 – 0.43 |
| Sugarcane | 0.23 – 0.64 | 6.1 – 17 | 60 – 170 | 240 – 3400 | 0.79 – 11 | 0.06 – 0.88 |
| Potato | <0.01 – 0.05 | 0.25 – 1.3 | 2.4 – 12 | 10 – 180 | 0.03 – 0.58 | <0.01 – 0.05 |
| Asparagus | 0.26 – 1.0 | 6.9 – 27 | 67 – 270 | 250 – 4100 | 0.85 – 14 | 0.07 – 1.1 |
| Hops | 0.06 – 0.39 | 1.7 – 11 | 17 – 100 | 57 – 1300 | 0.19 – 4.4 | 0.01 – 0.34 |
| Strawberries | 0.09 – 0.39 | 2.5 – 11 | 24 – 100 | 87 – 2300 | 0.29 – 7.7 | 0.02 – 0.59 |
| Blueberries | 0.13 – 0.34 | 3.5 – 9.2 | 34 – 90 | 100 – 1400 | 0.34 – 4.7 | 0.03 – 0.37 |
| Citrus | 0.03 – 0.06 | 0.84 – 1.7 | 8.2 – 16 | 24 – 350 | 0.08 – 1.2 | 0.01 – 0.09 |
| Grapes | 0.02 – 0.07 | 0.43 – 1.8 | 4.2 – 18 | 13 – 190 | 0.04 – 0.62 | <0.01 – 0.05 |
| Pome, Nuts, Stone Fruit | 0.17 – 0.60 | 4.5 – 16 | 44 – 160 | 200 – 1900 | 0.66 – 6.5 | 0.05 – 0.50 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 6-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Monocots and Dicots and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Monocots and/or Dicots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.08 – 0.65 | 5.5 – 46 |
| Field Corn and Popcorn | 0.12 – 0.72 | 8.3 – 51 |
| Sweet Corn | 0.07 – 0.25 | 4.7 – 18 |
| Soybean | 0.10 – 0.32 | 6.9 – 23 |
| Sorghum | 0.07 – 0.28 | 5.3 – 20 |
| Sugarcane | 0.23 – 0.64 | 16 – 46 |
| Potato | <0.01 – 0.05 | 0.66 – 3.3 |
| Asparagus | 0.26 – 1.0 | 18 – 72 |
| Hops | 0.06 – 0.39 | 4.5 – 28 |
| Strawberries | 0.09 – 0.39 | 6.6 – 28 |
| Blueberries | 0.13 – 0.34 | 9.3 – 24 |
| Citrus | 0.03 – 0.06 | 2.2 – 4.5 |
| Grapes | 0.02 – 0.07 | 1.1 – 4.9 |
| Pome, Nuts, Stone Fruit | 0.17 – 0.60 | 12 – 43 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 6-7**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] EPA did not use the results from the Species Sensitivity Distribution for monocots for 2,4-D. For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the 25$^{th}$ percentile of the SSD.

**Table 6-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Monocots | Terrestrial Dicots |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Range of Magnitude of Difference[2] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.09 – 0.35 | 2.5 – 9.3 | 24 – 91 |
| Field Corn and Popcorn | 0.13 – 0.52 | 3.5 – 14 | 34 – 140 |
| Sweet Corn | 0.06 – 0.17 | 1.6 – 4.7 | 16 – 46 |
| Soybean | 0.08 – 0.24 | 2.1 – 6.4 | 20 – 62 |
| Sorghum | 0.07 – 0.24 | 2.0 – 6.4 | 20 – 62 |
| Sugarcane | 0.30 – 0.70 | 8.1 – 19 | 79 – 180 |
| Potato | <0.01 – 0.03 | 0.26 – 0.82 | 2.6 – 8.0 |
| Asparagus | 0.24 – 0.70 | 6.4 – 19 | 63 – 180 |
| Hops | 0.05 – 0.26 | 1.5 – 6.9 | 14 – 67 |
| Strawberries | 0.11 – 0.28 | 2.8 – 7.5 | 28 – 73 |
| Blueberries | 0.13 – 0.18 | 3.4 – 4.7 | 33 – 46 |
| Citrus | 0.04 – 0.06 | 1.0 – 1.5 | 9.9 – 15 |
| Grapes | 0.02 – 0.05 | 0.44 – 1.3 | 4.2 – 12 |
| Pome, Nuts, Stone Fruit | 0.16 – 0.27 | 4.2 – 7.3 | 41 – 71 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
Mitigation measures

**Table 6-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Monocots and Dicots and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Monocots and/or Dicots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.09 – 0.35 | 6.5 – 25 |
| Field Corn and Popcorn | 0.13 – 0.52 | 9.3 – 37 |
| Sweet Corn | 0.06 – 0.17 | 4.3 – 12 |
| Soybean | 0.08 – 0.24 | 5.5 – 17 |
| Sorghum | 0.07 – 0.24 | 5.3 – 17 |
| Sugarcane | 0.30 – 0.70 | 21 – 50 |
| Potato | <0.01 – 0.03 | 0.70 – 2.2 |
| Asparagus | 0.24 – 0.70 | 17 – 50 |
| Hops | 0.05 – 0.26 | 3.9 – 18 |
| Strawberries | 0.11 – 0.28 | 7.5 – 20 |
| Blueberries | 0.13 – 0.18 | 9.1 – 13 |
| Citrus | 0.04 – 0.06 | 2.7 – 4.1 |
| Grapes | 0.02 – 0.05 | 1.2 – 3.4 |
| Pome, Nuts, Stone Fruit | 0.16 – 0.27 | 11 – 19 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] EPA did not use the results from the Species Sensitivity Distribution for monocots for 2,4-D. For animals that generally rely upon terrestrial plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in terrestrial habitats is the ratio of the EEC to the 25$^{th}$ percentile of the SSD.

#### *6.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 6-11**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 6.3.3.1** and **6.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 6.4**) and conducting a population-level impact analysis (**Section 6.6**).

For 2,4-D, given the toxicity profile (including only about a 4X difference between the 5$^{th}$ and 25$^{th}$ percentiles of the selected SSD with a relatively steep slope)[33] and given the high number of untreated area plant incidents (see **Section 6.3.2**), EPA assigned a low magnitude of effect in **Table 6-11** on a use basis to groups of listed species and critical habitats (CHs)[34] when the magnitude of difference is less than 1. For low magnitude of effect (when the magnitude of difference is <1), population-level impacts are not expected. EPA assigned a medium, high, or very high magnitude of effect in **Table 6-11** when the magnitude of difference is from 1 to 10, 10 up to 100, or greater than 100, respectively.

[33] See **Section 3.3** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[34] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

**Table 6-11. Use-Based Magnitude of Effect for 2,4-D.[1]**

| Use | Terrestrial | | | Wetland and Small Waterbodies[2] | | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | | Generalist Animals and CHs[4] | Plants and Obligate Animals | | Generalist Animals and CHs[4] | Plants[5], Obligate & Generalist Animals[6], CHs |
| | Monocots | Dicots | | Monocots | Dicots | | |
| Cereal Grains | Medium | High | High | Medium | High | High | Low |
| Field Corn and Popcorn | Medium | High | High | High | Very High | High | Low |
| Sweet Corn | Medium | High | High | Medium | High | High | Low |
| Soybean | Medium | High | High | Medium | High | High | Low |
| Sorghum | Medium | High | High | Medium | High | High | Low |
| Sugarcane | High | Very High | High | High | Very High | High | Low |
| Potato | Low | Medium | Medium | Low | Medium | Medium | Low |
| Asparagus | High | Very High | High | High | Very High | High | Low |
| Hops | Medium | High | High | Medium | High | High | Low |
| Strawberries | Medium | High | High | Medium | High | High | Low |
| Blueberries | Medium | High | High | Medium | High | High | Low |
| Citrus | Medium | High | Medium | Medium | High | Medium | Low |
| Grapes | Medium | High | Medium | Medium | High | Medium | Low |
| Pome, Nuts, Stone Fruit | Medium | High | High | Medium | High | High | Low |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 6.4**) and to conduct the population-level impacts analysis (**Section 6.6**). If the magnitude of effect is medium or higher for 2,4-D, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] For animals that generally rely upon terrestrial/wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots, and $IC_{50}$ for aquatic plants (applicable for wetlands and small waterbodies only)). The magnitude of effect in this table reflects the highest magnitude of difference calculated for generalists for each use, which is based on the 25$^{th}$ percentile of the SSD (see **Table 6-7, Table 6-8**, and **Table 6-10**).

[5] All listed aquatic plants are also found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[6] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. Therefore, the results for obligate and generalist animals in larger waterbodies are equivalent.

## 6.4 Framework Step 2: Identify Mitigation Measures

**Section 6.4** outlines the mitigation measures identified for 2,4-D for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 6.4.1**) and runoff/erosion (**Section 6.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 6.4.1 Spray Drift Mitigation Measures Identified

**Table 6-12** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland dicots and listed animals that obligately depend on these plants. Although EPA calculated spray drift buffer distances for listed monocots and animals obligately depending on monocots in **Table 6-5**, the spray drift buffer distances for listed monocots and animals obligately depending on monocots are shorter than the distances for generalist animals. This is because EPA used the 25$^{th}$ percentile of the SSD to calculate the buffer distances for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the SSD, EPA identified larger spray drift buffer distances for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the extent of the spray drift buffers, EPA grouped listed monocots and animals that obligately rely on monocots with generalist animals, and EPA relied upon the results based on the 25$^{th}$ percentile of the SSD to determine the spray drift buffer distances. **Table 6-13** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed monocots, animals that obligately rely on monocots, and animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 6-12. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Dicots and Animals that Obligately Depend on Dicots as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ae/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.0 | 300 + windbreak[3] | 300 [a,b,c] | 200 [a,b] | 200 [e,g,h] | 100 [e,g,h] | 100 [e,g,h] | 100 [e,f,g,h] |
| 1.5 | 300 + windbreak[3] | 300 [a,b,c] | 200 [a,b] | 200 [e,g,h] | 100 [e,g,h] | 100 [e,g,h] | 100 [e,f,g,h] |
| 0.50 | 300 [a,b,c] | 300 [a,b,c] | 200 [a,b] | 200 [e,g,h] | 100 [e,g,h] | 100 [e,g,h] | 50 [g,h] |
| 0.07 | 175 [a,b,d] | 125 [b,d] | 75 [b,d] | 50 [g,h] | 20 [i] | 10 [i] | 10 [i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft can be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft can be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 6-1**
[3] Additional mitigation measures (*e.g.,* windbreak, hedgerow) would apply for aerial applications of fine-medium droplets at application rates of 1.5 and 2.0 lb a.e./A because the magnitude of difference exceeds 10 at the maximum buffer distance. Use of additional mitigation measures do not result in reduced buffer distances.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 6-13. Spray Drift Mitigation Measures Identified for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1,2]**

| Single Maximum Application Rate (lb ae/A)[3] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.0 | 300 [a,b,c] | 300 [a,b,c] | 200 [a,b] | 200 [f,g,h] | 100 [f,g,h] | 100 [f,g,h] | 50 [g,h] |
| 1.5 | 300 [a,b,c] | 300 [a,b,c] | 200 [a,b] | 200 [f,g,h] | 100 [f,g,h] | 75 [g,h] | 50 [g,h] |
| 0.50 | 300 [a,b,c] | 175 [a,b,d] | 125 [b,d] | 100 [f,g,h] | 50 [g,h] | 20 [i] | 10 [i] |
| 0.07 | 50 [b] | 20 [e] | 20 [e] | 20 [i] | 10 [i] | None[4] | None[4] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[5] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour<br>[e] The applicator would achieve sufficient mitigation with a windbreak (release height below the top of the windbreak) alone without a buffer. | | | [f] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] EPA proposes to use the spray drift buffer distances in this table (based on the 25th percentile of the SSD) for listed monocots, animals obligately relying on monocots, and generalist animals. This is due to the differential sensitivity of monocots and dicots to 2,4-D and the shorter spray drift distances modeled for monocots than for generalist animals (due to the toxicity to dicots driving the spray drift distances for generalists; see **Table 6-5**).
[3] Single maximum label rates reflect the range of uses represented in **Table 6-1.**
[4] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is ≤0.5 at 10 ft off the treated field.
[5] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 6.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of the proposed runoff mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts differs across uses and, as shown in **Figure 6-2**, the level of mitigation is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed plants (5th percentile endpoint), generalists (25th percentile endpoint)). **Figure 6-2** visually represents the targeted reduction in EECs through the implementation of runoff mitigations for 2,4-D.

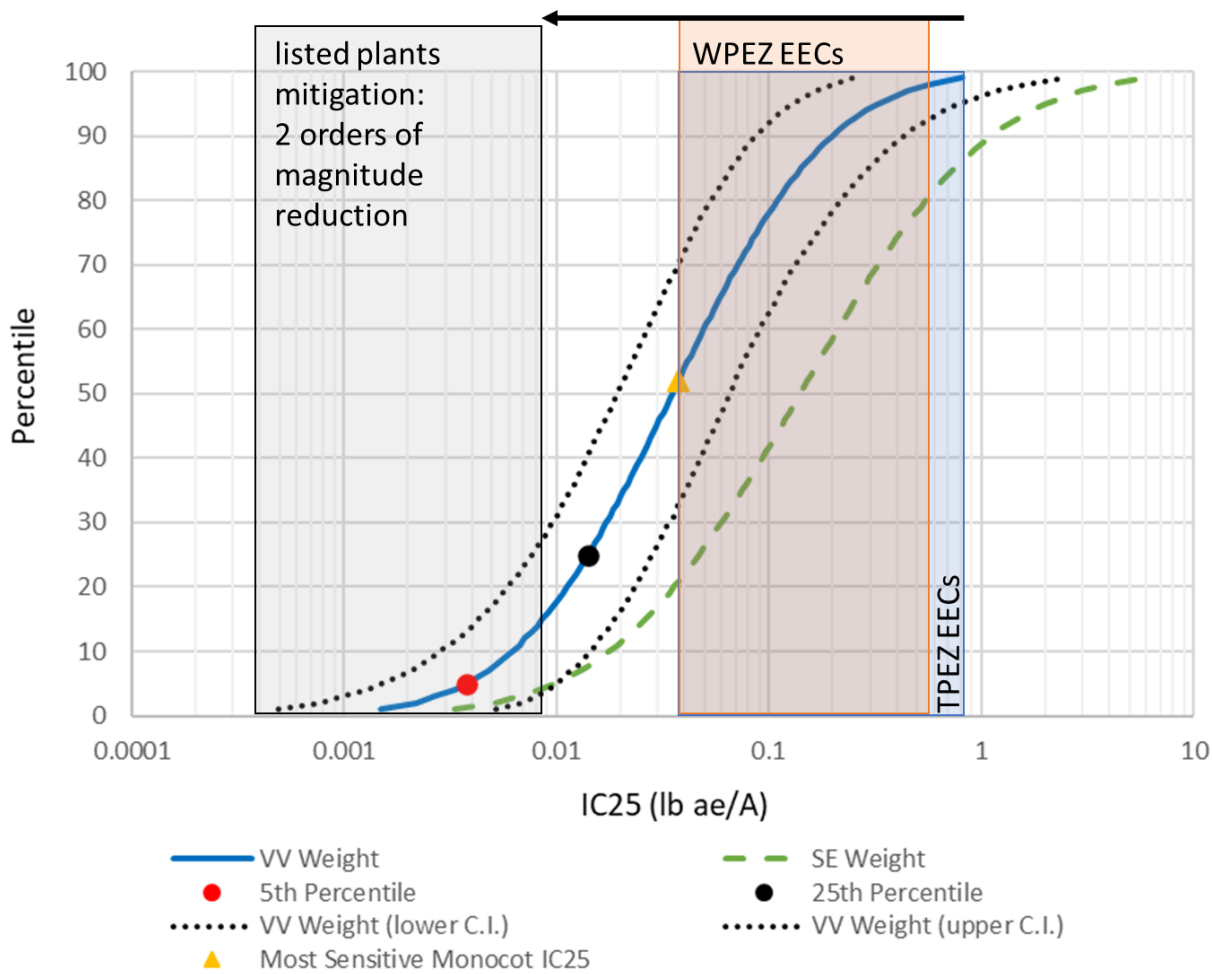


**Figure 6-2. 2,4-D Vegetative Vigor (VV) and Seedling Emergence (SE) Species Sensitivity Distributions (SSD) and the Most Sensitive Monocot Endpoint Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5th percentile (represents listed dicots and animals with obligate relationships to dicots) and the 25th percentile (represents generalists and designated critical habitats) from the VV weight SSD,**

**and the most sensitive monocot endpoint for direct impacts to monocots and animals with obligate relationships to monocots. Upper and lower confidence intervals (C.I.) are provided for the VV weight SSD.**

For 2,4-D, see **Section 6.3.3.2** for more details on the magnitude of difference between EECs and toxicity endpoints and the mitigation identification for each use separated by plant and animal groups. EPA assigns the mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in Section 5.2 in the Strategy Framework document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of 2,4-D is <1,000 L/kg-o.c. (mean $K_{OC}$ = 72 L/kg-o.c.), higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework**, EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation is identified. If the magnitude of difference is between 10 and 100, medium mitigation is identified, and if it is between 100 and 1,000, high mitigation is identified. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For 2,4-D, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for 2,4-D, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed aquatic plants and animals that depend on aquatic plants[35] and designated Critical Habitats in waterbodies similar in size to the EPA farm pond or larger[36], no mitigations are identified to reduce the likelihood of potential population-level impacts (**Table 6-14**).
- EPA identified no mitigation for semi-aquatic/wetland monocots and the animals that obligately depend on these plants[37], for use on potato (**Table 6-15**). EPA identified medium mitigation[38] for use on field corn, popcorn, sugarcane, and asparagus and low mitigation for all other uses (**Table 6-15**).
- For semi-aquatic/wetland dicots and the animals that obligately depend on these plants, EPA identified low mitigation for use on potato and high mitigation for use on field corn,

[35] None of the listed aquatic animals have obligate relationships to plants.
[36] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[37] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[38] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios ≥1000), High (ratios ≥100 but <1000), Medium (ratios ≥10 but <100), Low (ratios ≥1 but <10), No Mitigation (ratios <1).

popcorn, sugarcane, and asparagus (**Table 6-15**). EPA identified medium mitigation for all other uses (**Table 6-15**).

- For aquatic plants in wetlands or small waterbodies[39] and for animals that depend on these plants (both obligately and generally[40]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. Based on the aquatic vascular toxicity endpoint, EPA identified no mitigation for use on potato, citrus, and grape and low mitigation for all other uses (**Table 6-15**). EPA identified no mitigation based on the nonvascular plant endpoint for listed species wetlands or small waterbodies (**Table 6-15**).
- For animals that have a generalist relationship[40] to wetland plants, EPA identified low mitigation for use on citrus, grape, and potato and medium mitigation for all other use patterns (**Table 6-16**).
- For terrestrial monocots and the animals that obligately depend on these plants, EPA identified no mitigation for use on potato and medium mitigation for use on sugarcane and asparagus (**Table 6-17**). EPA identified low mitigation for all other uses (**Table 6-17**).
- For terrestrial dicots and the animals that obligately depend on these plants, EPA identified low mitigation for use on potato and high mitigation for use on sugarcane and asparagus (**Table 6-17**). EPA identified medium mitigation for the rest of the uses (**Table 6-17**).
- For animals that have a generalist relationship[40] to terrestrial plants, EPA identified low mitigation for use on potato, citrus, and grape and medium mitigation for all other use patterns (**Table 6-18**).

**Table 6-14. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 4.8 – 24 | 0.02 – 0.08 | No mitigation | <0.01 – 0.01 | No mitigation |
| Field Corn and Popcorn | 7.4 – 46 | 0.02 – 0.15 | No mitigation | <0.01 – 0.01 | No mitigation |
| Sweet Corn | 3.3 – 17 | 0.01 – 0.06 | No mitigation | <0.01 | No mitigation |
| Soybean | 4.7 – 23 | 0.02 – 0.08 | No mitigation | <0.01 – 0.01 | No mitigation |
| Sorghum | 3.5 – 35 | 0.01 – 0.12 | No mitigation | <0.01 – 0.01 | No mitigation |
| Sugarcane | 13 – 56 | 0.04 – 0.19 | No mitigation | <0.01 – 0.01 | No mitigation |
| Potato | 0.52 – 2.6 | <0.01 – 0.01 | No mitigation | <0.01 | No mitigation |
| Asparagus | 13 – 64 | 0.04 – 0.21 | No mitigation | <0.01 – 0.02 | No mitigation |

[39] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[40] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

| | | | | | |
|---|---|---|---|---|---|
| Hops | 4.7 – 13 | 0.02 – 0.04 | No mitigation | <0.01 | No mitigation |
| Strawberries | 5.3 – 21 | 0.02 – 0.07 | No mitigation | <0.01 – 0.01 | No mitigation |
| Blueberries | 9.6 – 18 | 0.03 – 0.06 | No mitigation | <0.01 | No mitigation |
| Citrus | 1.8 – 8.8 | 0.01 – 0.03 | No mitigation | <0.01 | No mitigation |
| Grapes | 1.0 – 5.1 | <0.01 – 0.02 | No mitigation | <0.01 | No mitigation |
| Pome, Nuts, Stone Fruit | 11 – 23 | 0.04 – 0.08 | No mitigation | <0.01 – 0.01 | No mitigation |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for 2,4-D, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 6-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Monocots | | Wetland Dicots | | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.08 – 0.65 | 2.1 – 17 | Low[6] | 20 – 170 | Medium[6] | 75 – 2200 | 0.25 – 7.4 | Low | 0.02 – 0.57 | No mitigation |
| Field Corn and Popcorn | 0.12 – 0.72 | 3.1 – 19 | Medium | 31 – 190 | High | 190 – 3000 | 0.63 – 10 | Low[6] | 0.05 – 0.77 | No mitigation |
| Sweet Corn | 0.07 – 0.25 | 1.8 – 6.8 | Low | 17 – 67 | Medium | 64 – 1100 | 0.21 – 3.8 | Low | 0.02 – 0.29 | No mitigation |
| Soybean | 0.10 – 0.32 | 2.6 – 8.6 | Low | 25 – 84 | Medium | 110 – 1500 | 0.35 – 4.9 | Low | 0.03 – 0.38 | No mitigation |
| Sorghum | 0.07 – 0.28 | 2.0 – 7.5 | Low | 19 – 73 | Medium | 87 – 1700 | 0.29 – 5.5 | Low | 0.02 – 0.43 | No mitigation |
| Sugarcane | 0.23 – 0.64 | 6.1 – 17 | Medium | 60 – 170 | High | 240 – 3400 | 0.79 – 11 | Low[6] | 0.06 – 0.88 | No mitigation |
| Potato | <0.01 – 0.05 | 0.25 – 1.3 | No mitigation[6] | 2.4 – 12 | Low[6] | 10 – 180 | 0.03 – 0.58 | No mitigation | <0.01 – 0.05 | No mitigation |
| Asparagus | 0.26 – 1.0 | 6.9 – 27 | Medium | 67 – 270 | High | 250 – 4100 | 0.85 – 14 | Low[6] | 0.07 – 1.1 | No mitigation[6] |
| Hops | 0.06 – 0.39 | 1.7 – 11 | Low[6] | 17 – 100 | Medium[6] | 57 – 1300 | 0.19 – 4.4 | Low | 0.01 – 0.34 | No mitigation |
| Strawberries | 0.09 – 0.39 | 2.5 – 11 | Low[6] | 24 – 100 | Medium[6] | 87 – 2300 | 0.29 – 7.7 | Low | 0.02 – 0.59 | No mitigation |
| Blueberries | 0.13 – 0.34 | 3.5 – 9.2 | Low | 34 – 90 | Medium | 100 – 1400 | 0.34 – 4.7 | Low | 0.03 – 0.37 | No mitigation |
| Citrus | 0.03 – 0.06 | 0.84 – 1.7 | Low | 8.2 – 16 | Medium | 24 – 350 | 0.08 – 1.2 | No mitigation[6] | 0.01 – 0.09 | No mitigation |
| Grapes | 0.02 – 0.07 | 0.43 – 1.8 | Low | 4.2 – 18 | Medium | 13 – 190 | 0.04 – 0.62 | No mitigation | <0.01 – 0.05 | No mitigation |

| Use | Range of EECs (lb a.e./A)[2] | Wetland Monocots | | Wetland Dicots | | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Pome, Nuts, Stone Fruit | 0.17 – 0.60 | 4.5 – 16 | Low[6] | 44 – 160 | Medium[6] | 200 – 1900 | 0.66 – 6.5 | Low | 0.05 – 0.50 | No mitigation |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

[5] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

[6] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

Mitigation measures

**Table 6-15** outlines the proposed mitigation categories identified for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[41]. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[42]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 4**. For 2,4-D, EPA determined that proposed mitigation categories presented in **Table 6-15** based on the weight of evidence discussed below, which is specifically relevant for use on cereal grains, field corn and popcorn, sugarcane, potato, asparagus, hops, strawberries, citrus, pome fruit, tree nuts, and stone fruit.

In **Table 6-15**, the magnitude of difference for wetland monocots ranges from 2.1 to 17 for use on cereal grains. Out of 154 wetland ratios of EEC to endpoint estimated for this use, only six ratios reached the medium mitigation category rating. Given that nearly all of the scenarios (96%) resulted in a magnitude of difference less than 10, EPA set the mitigation category as low to protect listed wetland monocots and animals obligately depending on these plants. Similarly for wetland dicots, the magnitude of difference ranges from 20 to 170 with only four of the 154 scenarios resulting in ratios that exceed 100. Because nearly all of the modeled scenarios (97%) indicated medium mitigation, EPA set the mitigation category for use on cereal grains as medium to protect listed wetland dicots and animals that obligately depend on these plants.

In **Table 6-15**, the magnitude of difference for aquatic vascular plants ranges from 0.63 to 10 for use on field corn and popcorn. Because the highest ratio is equivalent to, but does not exceed, the threshold for identifying medium mitigation (*i.e.,* 10), EPA identified only low mitigation for these uses when considering aquatic vascular plants.

For use on sugarcane, the magnitude of difference for aquatic vascular plants in wetlands or small waterbodies ranges from 0.79 to 11. Out of 12 wetland ratios of EEC to endpoint estimated for this use, only one result reached the medium mitigation category rating. Given that the overwhelming majority of the scenarios (92%) resulted in a magnitude of difference less than 10, EPA set the mitigation category as low when considering aquatic vascular plants.

For use on potato, the magnitude of difference ranges from 0.25 to 1.3 for wetland monocots and 2.4 to 12 for wetland dicots. Out of the 42 scenarios modeled for use on potato, only one results in a ratio exceeding 1.0 for monocots and 10.0 for dicots. Because almost all of the scenarios (98%) indicated lower mitigation than the maximum ratios for monocots and dicots, EPA identified no mitigation to protect listed wetland monocots and low mitigation to protect listed dicots.

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[41] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.e./A or µg a.e./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[42] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.1**.

For use on asparagus, the magnitude of difference ranges from 0.85 to 14 for aquatic vascular plants and 0.07 to 1.1 for aquatic nonvascular plants. Out of the 42 scenarios modeled for use on asparagus, only five scenarios result in a ratio exceeding 10 for vascular plants and one scenario has a ratio exceeding 1.0 for nonvascular plants. Because the overwhelming majority of the scenarios (88% for vascular plants, 98% for nonvascular plants) indicated lower mitigation than the maximum ratios for aquatic vascular and nonvascular plants, EPA determined that only low mitigation would apply for aquatic vascular plants and no mitigation is identified for aquatic nonvascular plants.

For use on hops, the magnitude of difference ranges from 1.7 to 11 for wetland monocots and 17 to 100 for wetland dicots. Out of the 22 scenarios modeled, only one results in a ratio exceeding 10 for monocots and 100 for dicots. Because almost all of the scenarios (95%) indicated lower mitigation than the maximum ratios for monocots and dicots, EPA determined that only low mitigation would apply to protect listed wetland monocots, and EPA identified medium mitigation to protect listed dicots.

For use on strawberries, the magnitude of difference ranges from 2.5 to 11 for wetland monocots and 24.3 to 100 for wetland dicots. Out of the 42 scenarios modeled, only one results in a ratio exceeding 10 for monocots and 100 for dicots. Because almost all of the scenarios (98%) indicated lower mitigation than the maximum ratios for monocots and dicots, EPA identified only low mitigation to protect listed wetland monocots and medium mitigation to protect listed dicots.

For use on citrus, the magnitude of difference ranges from 0.08 to 1.2 for aquatic vascular plants. Out of the 16 scenarios modeled for use on citrus, only two scenarios result in a ratio exceeding 1.0 for vascular plants. Because the overwhelming majority (88%) of the scenarios indicated lower mitigation than the maximum ratio for aquatic vascular plants, EPA set the mitigation category as no mitigation for aquatic vascular plants.

For use on pome fruit, tree nuts, and stone fruit, the magnitude of difference ranges from 4.5 to 16 for wetland monocots and 44 to 160 for wetland dicots. Out of the 21 scenarios modeled, only three scenarios result in a ratio exceeding 10 for monocots and two scenarios have ratios greater than 100 for dicots. Because almost all of the scenarios (86% for monocots, 90% for dicots) indicated lower mitigation than the maximum ratios, EPA identified only low mitigation to protect listed wetland monocots and medium mitigation to protect listed dicots.

**Table 6-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Monocots and/or Dicots[4] | |
|---|---|---|---|
| | | Range of Magnitude of Difference[5] | Mitigation Category |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.08 – 0.65 | 5.5 – 46 | Medium |
| Field Corn and Popcorn | 0.12 – 0.72 | 8.3 – 51 | Medium |
| Sweet Corn | 0.07 – 0.25 | 4.7 – 18 | Medium |
| Soybean | 0.10 – 0.32 | 6.9 – 23 | Medium |
| Sorghum | 0.07 – 0.28 | 5.3 – 20 | Medium |
| Sugarcane | 0.23 – 0.64 | 16 – 46 | Medium |
| Potato | <0.01 – 0.05 | 0.66 – 3.3 | Low |
| Asparagus | 0.26 – 1.0 | 18 – 72 | Medium |
| Hops | 0.06 – 0.39 | 4.5 – 28 | Medium |
| Strawberries | 0.09 – 0.39 | 6.6 – 29 | Medium |
| Blueberries | 0.13 – 0.34 | 9.3 – 24 | Medium |
| Citrus | 0.03 – 0.06 | 2.2 – 4.5 | Low |
| Grapes | 0.02 – 0.07 | 1.1 – 4.9 | Low |
| Pome, Nuts, Stone Fruit | 0.17 – 0.60 | 12 – 43 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 6-15**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] EPA did not use the results from the Species Sensitivity Distribution for monocots for 2,4-D. For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the 25$^{th}$ percentile of the SSD.

[5] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 6-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Monocots | | Terrestrial Dicots | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category[3] | Range of Magnitude of Difference[2] | Mitigation Category[3] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.09 – 0.35 | 2.5 – 9.3 | Low | 24 – 91 | Medium |
| Field Corn and Popcorn | 0.13 – 0.52 | 3.5 – 14 | Low[4] | 34 – 140 | Medium[4] |
| Sweet Corn | 0.06 – 0.17 | 1.6 – 4.7 | Low | 16 – 46 | Medium |
| Soybean | 0.08 – 0.24 | 2.1 – 6.4 | Low | 20 – 62 | Medium |
| Sorghum | 0.07 – 0.24 | 2.0 – 6.4 | Low | 20 – 62 | Medium |
| Sugarcane | 0.30 – 0.70 | 8.1 – 19 | Medium | 79 – 180 | High |
| Potato | <0.01 – 0.03 | 0.26 – 0.82 | No mitigation | 2.6 – 8.0 | Low |
| Asparagus | 0.24 – 0.70 | 6.4 – 19 | Medium | 63 – 180 | High |
| Hops | 0.05 – 0.26 | 1.5 – 6.9 | Low | 14 – 67 | Medium |
| Strawberries | 0.11 – 0.28 | 2.8 – 7.5 | Low | 28 – 73 | Medium |
| Blueberries | 0.13 – 0.18 | 3.4 – 4.7 | Low | 33 – 46 | Medium |
| Citrus | 0.04 – 0.06 | 1.0 – 1.5 | Low | 9.9 – 15 | Medium |
| Grapes | 0.02 – 0.05 | 0.44 – 1.3 | Low | 4.2 – 12 | Medium |
| Pome, Nuts, Stone Fruit | 0.16 – 0.27 | 4.2 – 7.3 | Low | 41 – 71 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Mitigations were identified whenever the magnitude of difference is >1.
[4] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.
Mitigation measures

**Table 6-17** outlines the proposed mitigation categories identified for listed terrestrial plants and animals that obligately rely on terrestrial plants. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 4**. For 2,4-D, EPA determined that proposed mitigation categories presented in **Table 6-17** based on the weight of evidence discussed below, which is specifically relevant for use on field corn and popcorn.

For use on field corn and popcorn, the magnitude of difference ranges from 3.5 to 14 for terrestrial monocots and 34 to 140 for terrestrial dicots. Out of 42 ratios of EEC to endpoint estimated for this use, only three ratios indicated medium mitigation for monocots and only one indicated high mitigation for dicots. Given that nearly all of the scenarios (93% for

monocots, 98% for dicots) indicated less mitigation than the maximum ratio, EPA identified only low mitigation for listed monocots and medium mitigation for listed dicots.

**Table 6-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Monocots and Dicots and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Monocots and/or Dicots[2] | |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 0.09 – 0.35 | 6.5 – 25 | Medium |
| Field Corn and Popcorn | 0.13 – 0.52 | 9.3 – 37 | Medium |
| Sweet Corn | 0.06 – 0.17 | 4.3 – 12 | Medium |
| Soybean | 0.08 – 0.24 | 5.5 – 17 | Medium |
| Sorghum | 0.07 – 0.24 | 5.3 – 17 | Medium |
| Sugarcane | 0.30 – 0.70 | 21 – 50 | Medium |
| Potato | <0.01 – 0.03 | 0.70 – 2.2 | Low |
| Asparagus | 0.24 – 0.70 | 17 – 50 | Medium |
| Hops | 0.05 – 0.26 | 3.9 – 18 | Medium |
| Strawberries | 0.11 – 0.28 | 7.5 – 20 | Medium |
| Blueberries | 0.13 – 0.18 | 9.1 – 13 | Medium |
| Citrus | 0.04 – 0.06 | 2.7 – 4.1 | Low |
| Grapes | 0.02 – 0.05 | 1.2 – 3.4 | Low |
| Pome, Nuts, Stone Fruit | 0.16 – 0.27 | 11 – 19 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] EPA did not use the results from the Species Sensitivity Distribution for monocots for 2,4-D. For animals that generally rely upon terrestrial plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the SSD or $IC_{25}$ for monocots) while considering the differential toxicity of 2,4-D to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in terrestrial habitats is the ratio of the EEC to the 25$^{th}$ percentile of the SSD.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 6-14** and **Table 6-15**) and wetland plants (**Table 6-15** and **Table 6-16**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the area is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation

category for each use for listed plants and obligate animals (**Table 6-17**) and for generalist animals (**Table 6-18**).

**Table 6-19** and **Table 6-20** provide the runoff mitigation points identified for each evaluated use of 2,4-D. Although EPA calculated the magnitude of difference values and determined the runoff mitigation categories for listed monocots and listed animals that obligately rely on monocots, these values are not presented in **Table 6-19** and **Table 6-20**. The mitigation categories and mitigation points identified for listed monocots and animals obligately depending on monocots are lower than the values for generalist animals. This is because EPA used the most sensitive monocot $IC_{25}$ to calculate the magnitude of difference for listed monocots but used the 25$^{th}$ percentile of the SSD to calculate the magnitude of difference for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the SSD, EPA identified higher mitigation levels for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the runoff mitigation levels for 2,4-D, EPA grouped listed monocots and animals that obligately rely on monocots with generalist animals.

**Table 6-19. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Dicots and Animals Obligately Relying on Dicots (Mitigation Points) | Listed Monocots, Animals Obligately Relying on Monocots, Generalist Animals, and CHs (Mitigation Points) |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | Medium (6 pts) | Medium (6 pts) |
| Field Corn and Popcorn | High (9 pts) | Medium (6 pts) |
| Sweet Corn | Medium (6 pts) | Medium (6 pts) |
| Soybean | Medium (6 pts) | Medium (6 pts) |
| Sorghum | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | Medium (6 pts) |
| Potato | Low (3 pts) | Low (3 pts) |
| Asparagus | High (9 pts) | Medium (6 pts) |
| Hops | Medium (6 pts) | Medium (6 pts) |
| Strawberries | Medium (6 pts) | Medium (6 pts) |
| Blueberries | Medium (6 pts) | Medium (6 pts) |
| Citrus | Medium (6 pts) | Low (3 pts) |
| Grapes | Medium (6 pts) | Low (3 pts) |
| Pome, Nuts, Stone Fruit | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 6-14** and **Table 6-15**), listed animals that obligately depend on aquatic

and wetland plants (**Table 6-14** and **Table 6-15**), and listed animals that generally depend on aquatic and wetland plants (**Table 6-14**, **Table 6-15**, and **Table 6-16**).

**Table 6-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | Dicots and Animals Obligately Relying on Dicots (Mitigation Points) | Listed Monocots, Animals Obligately Relying on Monocots, Generalist Animals, and CHs (Mitigation Points) |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | Medium (6 pts) | Medium (6 pts) |
| Field Corn and Popcorn | Medium (6 pts) | Medium (6 pts) |
| Sweet Corn | Medium (6 pts) | Medium (6 pts) |
| Soybean | Medium (6 pts) | Medium (6 pts) |
| Sorghum | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | Medium (6 pts) |
| Potato | Low (3 pts) | Low (3 pts) |
| Asparagus | High (9 pts) | Medium (6 pts) |
| Hops | Medium (6 pts) | Medium (6 pts) |
| Strawberries | Medium (6 pts) | Medium (6 pts) |
| Blueberries | Medium (6 pts) | Medium (6 pts) |
| Citrus | Medium (6 pts) | Low (3 pts) |
| Grapes | Medium (6 pts) | Low (3 pts) |
| Pome, Nuts, Stone Fruit | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See **Section 5.3** of the **Strategy Framework** document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 6-17**), listed animals that obligately depend on terrestrial plants (**Table 6-17**), and listed animals that generally depend on terrestrial plants (**Table 6-18**).

## 6.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the Strategy Framework, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for 2,4-D are discussed in this section.

2,4-D targets broadleaf weeds (which are typically dicots); therefore, 2,4-D is more toxic to dicots than monocots. Given the higher toxicity to dicots, EPA identified more restrictive mitigations for listed dicots and listed animals that obligately rely on dicots than for other listed species such as listed monocots, listed animals that obligately rely on listed monocots, and generalist animals. Although monocots are less sensitive than dicots, EPA used the 25$^{th}$ percentile of the SSD (instead of the most sensitive monocot $IC_{25}$) to calculate the magnitude of difference for generalist animals because generalist animals are assumed to rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the SSD, EPA identified higher mitigation levels for generalist animals than for listed monocots (as explained in **Sections 6.4.1** and **6.4.2**). However, listed monocots and animals obligately relying on monocots occur in areas where listed generalist animals occur. Therefore, for identifying the extent of mitigation measures, EPA sorted the listed species into two groups for differential mitigations: listed dicots and animals that obligately rely on dicots vs. listed monocots, animals that obligately rely on monocots, and generalist animals.

As indicated above, EPA would generate two different sets of spray drift mitigation measures for this example: one for listed dicots (**Table 6-12**) and one for listed monocots, animals that obligately depend on monocots, and generalist animals that depend on plants (**Table 6-13**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate spray drift mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are different for these two groups of species. For 2,4-D, the less restrictive mitigations relevant for listed monocots, listed animals obligately relying on monocots, and listed generalists animals that are depicted in **Table 6-13** would be applied to the general label because generalist animals are distributed widely across the United States and more restrictive mitigation is not needed for listed monocots nor animals that obligately depend on monocots. Listed monocots and animals that obligately rely on monocots occur in areas where generalist animals also occur; therefore, the higher mitigations based on the spray drift distances for generalists are needed in these areas. The more restrictive mitigations identified in **Table 6-12** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed dicots and listed obligate animals occur. Specifically, in this example, EPA identified that the dicot PULAs (PULAs 1 and 3) would be applicable for 2,4-D.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For 2,4-D, the runoff/erosion mitigation levels are identical for both of these habitat types for listed monocots, listed animals that obligately depend on monocots, and listed generalist animals. Like with the spray drift mitigations, there are different levels of runoff mitigations identified for listed dicots and animals obligately relying on dicots vs. listed monocots, animals obligately relying on monocots, and generalist animals (see **Table 6-19** and **Table 6-20**). **Table 6-21** summarizes the points identified for the different 2,4-D uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by two of the PULAs. PULAs 1 and 3 are not grouped because different mitigations would be applied to dicots in terrestrial habitats

compared in wetland and aquatic habitats for use on field and popcorn. The monocot PULAs (PULAs 2 and 4) are not needed for 2,4-D because the mitigations for listed monocots are grouped with generalist animals.

**Table 6-21. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | Geographically Specific Mitigation Points | |
|---|---|---|---|
| | Terrestrial, Wetland, and Aquatic Habitats | PULAs 1 and 3 (Terrestrial Habitats)[1] | PULA 3 (Aquatic and Wetland Habitats)[1] |
| Cereal Grains (Wheat, Barley, Millet, Oat, Rye and Tiff) | 6 | 6 | 6 |
| Field Corn and Popcorn | 6 | 6 | 9 |
| Sweet Corn | 6 | 6 | 6 |
| Soybean | 6 | 6 | 6 |
| Sorghum | 6 | 6 | 6 |
| Sugarcane | 6 | 9 | 9 |
| Potato | 3 | 3 | 3 |
| Asparagus | 6 | 9 | 9 |
| Hops | 6 | 6 | 6 |
| Strawberries | 6 | 6 | 6 |
| Blueberries | 6 | 6 | 6 |
| Citrus | 3 | 6 | 6 |
| Grapes | 3 | 6 | 6 |
| Pome, Nuts, Stone Fruit | 6 | 6 | 6 |

[1] Many of the listed wetland species that occur in PULA 3 also occur in terrestrial habitats. EPA proposes that if mitigations are applicable for terrestrial habitats (PULA 1 in this case), these mitigations for terrestrial habitats would also apply to areas covered by PULA 3. The result would be that PULA 3 would have two sets of mitigations—one set for terrestrial habitats and one for the wetland/aquatic habitats. See Section 7.2.2 in the Strategy Framework document for the full explanation of this proposal.

## 6.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in the **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 6.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of 2,4-D. For major crops (corn, wheat, citrus, and grapes), the crop-specific UDLs were selected. For other uses such as on asparagus and cereal grains, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). As indicated in **Section 6.2**, EPA did not include the flooded crop uses for rice and cranberry, which would be represented by the rice and

vegetables and ground fruit UDLs, respectively. EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential 2,4-D use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 6-11**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 6-22** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected 2,4-D UDLs[43] are considered. For illustrative purposes of the Herbicide Strategy, the Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for 2,4-D based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. However, for this illustrative example, EPA would only use two of the PULAs (PULAs 1 and 3). For the four PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For PULAs 1 and 3, EPA identified 338 listed dicots and animals obligately depending on dicots and 73 CHs as having >5% overlap with the cultivated landcover. For 2,4-D's UDLs, fewer species (306) and CHs (65) have >5% overlap. An important consideration for the purposes of this example is that EPA did not evaluate all registered uses of 2,4-D (see **Section 6.2**), so additional species could be identified in the future for 2,4-D. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of 2,4-D; however, the PULAs include some species and CHs that have <5% overlap with 2,4-D's potential exposure area for the considered uses.

[43] The selected use data layers (UDLs) do not represent every registered use of 2,4-D. See **Section 6.2** for more information on the selected uses evaluated in this example.

**Table 6-22. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for 2,4-D Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Wheat | 469 / 142 | 182 | 41 |
| Other Grains | | 236 | 51 |
| Corn | | 150 | 30 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Soybeans | | 88 | 9 |
| Other Row Crops | | 58 | 5 |
| Citrus | | 50 | 10 |
| Grapes | | 117 | 31 |
| Other Orchards | | 131 | 36 |
| Total across all UDLs above[2] | | 306 | 65 |
| Cultivated | | 383 | 85 |
| Dicot PULAs (PULAs 1 and 3) | | 338 | 73 |
| **Listed Animal Generalists** | | | |
| Wheat | 534 / 316 | 267 | 116 |
| Other Grains | | 255 | 118 |
| Corn | | 277 | 126 |
| Vegetables and Ground Fruit | | 152 | 74 |
| Soybeans | | 190 | 75 |
| Other Row Crops | | 94 | 38 |
| Citrus | | 32 | 5 |
| Grapes | | 52 | 29 |
| Other Orchards | | 122 | 70 |
| Total across all UDLs above[2] | | 356 | 172 |
| Cultivated | | 412 | 199 |

CH=designated critical habitat; PULA=pesticide use limitation area

[1] These values are based on EPA's analyses for example purposes for 2,4-D. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for 2,4-D (excluding the Cultivated UDL, which is summarized below this row).

## 6.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

Due to limited definitive endpoints[44], EPA was not able to generate SSDs for the height data for both the seedling emergence and vegetative vigor studies.

The ranges of $IC_{25}$ values for plant weight from the seedling emergence studies are 0.097 to 4.2 lb a.e./A (excluding non-definitive endpoints) for monocots and 0.0061 to 1.7 lb a.e./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 1.2 and 0.29 lb a.e./A, respectively. The ranges of $IC_{25}$ values for plant weight from the vegetative vigor studies are 0.037 to 1.3 lb a.e./A (excluding non-definitive endpoints) for monocots and 0.0021 to 0.19 lb a.e./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.34 and 0.028 lb a.e./A, respectively.

[44] Definitive endpoints are those where an IC25 is estimated (*e.g.,* $IC_{25}$ = 0.021 lb a.e./A). Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 4 lb a.e./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test. Non-definitive endpoints can also be expressed as lower than the lowest application rate tested (*e.g.,* $IC_{25}$ < 0.0075 lb a.e./A), because a 25% or greater inhibition in growth was detected at all tested application rates in the toxicity test.

## 6.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to 2,4-D. For 2,4-D, EPA only generated SSDs based on weight data since height data were too few to generate robust SSDs.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values were to derive SSDs. The data EPAused to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the 2,4-D data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

### *Distributions*

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA made comparison of the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### *Seedling Emergence Weight Data*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0098 | 0.6743 |
| 2 | logistic | ML | 0.0077 | 0.5415 |
| 3 | triangular | ML | 0.0132 | 0.4905 |
| 4 | gumbel | ML | 0.0144 | 0.8412 |
| 5 | weibull | ML | 0.0026 | 0.4316 |
| 6 | burr | ML | 0.0144 | 0.8182 |

Percentile of interest: 5

Model-averaged HCp: 0.011719

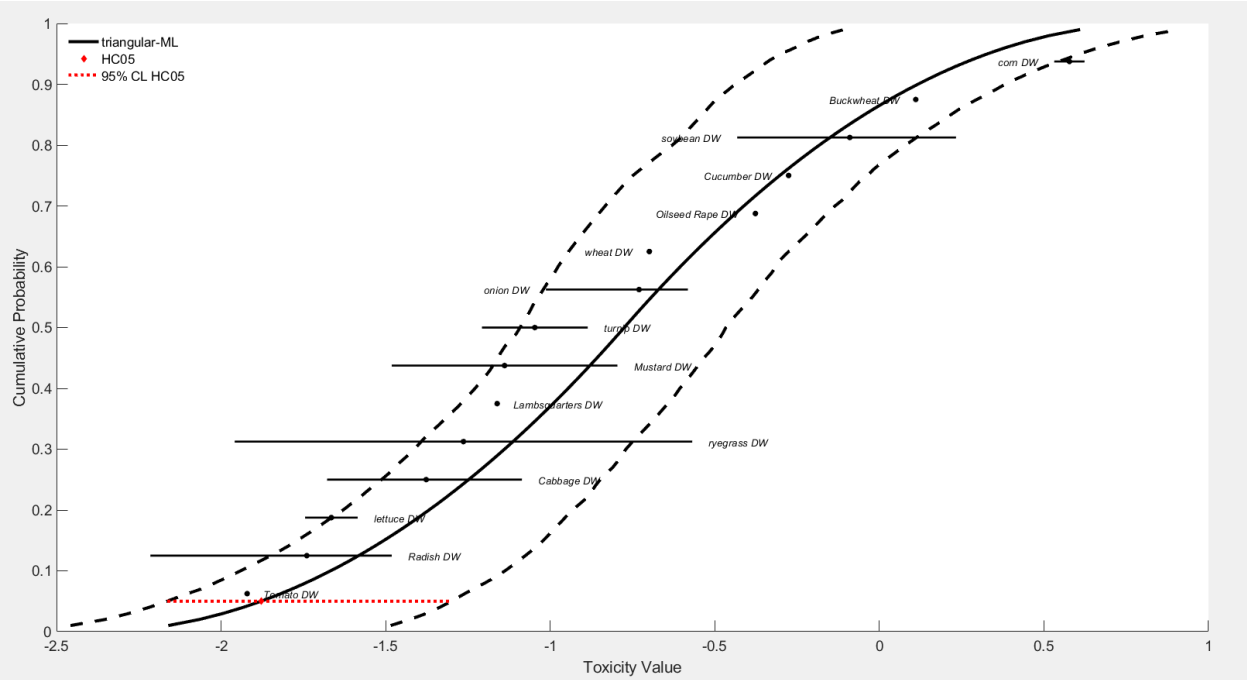
Model-averaged SE of HCp: 0.007330

CV of HCp: 0.6255

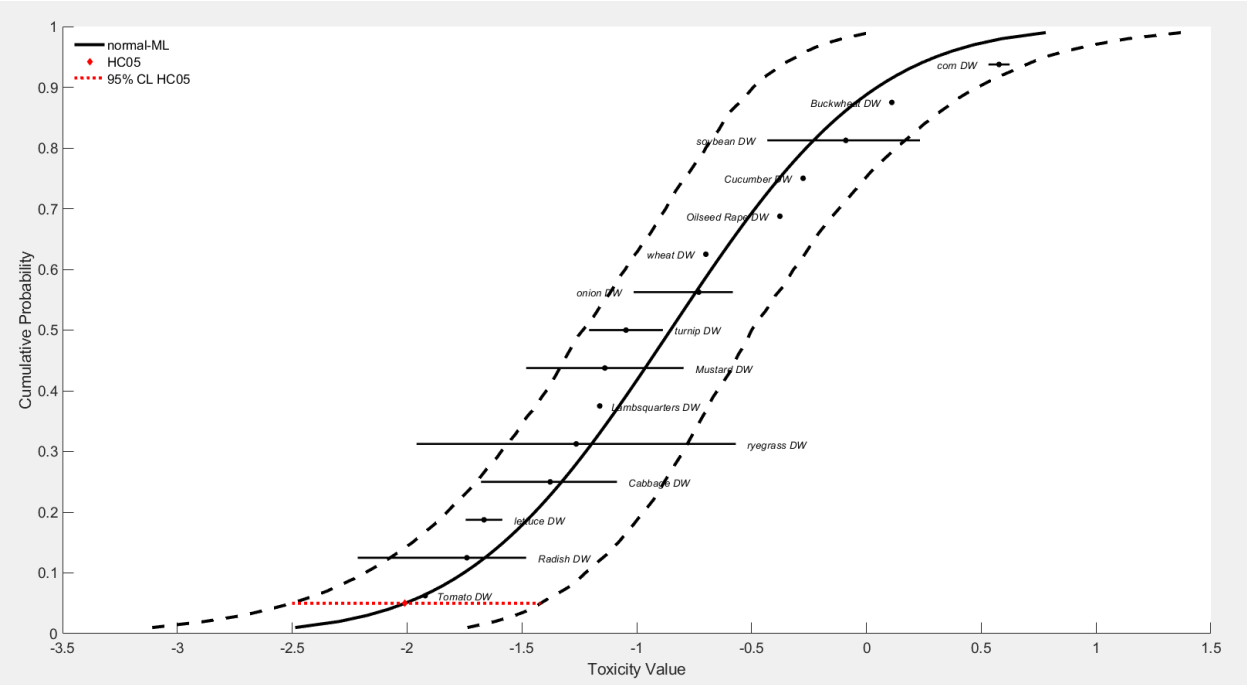
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 2.2311 | 0 | 0.3060 | 0.0132 | 0.0084 |
| 2 | gumbel | 2.5134 | 0.2823 | 0.2657 | 0.0144 | 0.0057 |
| 3 | normal | 3.0608 | 0.8297 | 0.2021 | 0.0098 | 0.0063 |
| 4 | logistic | 4.0015 | 1.7704 | 0.1263 | 0.0077 | 0.0056 |
| 5 | burr | 5.6967 | 3.4657 | 0.0541 | 0.0144 | 0.0057 |
| 6 | weibull | 6.0244 | 3.7933 | 0.0459 | 0.0026 | 0.0030 |

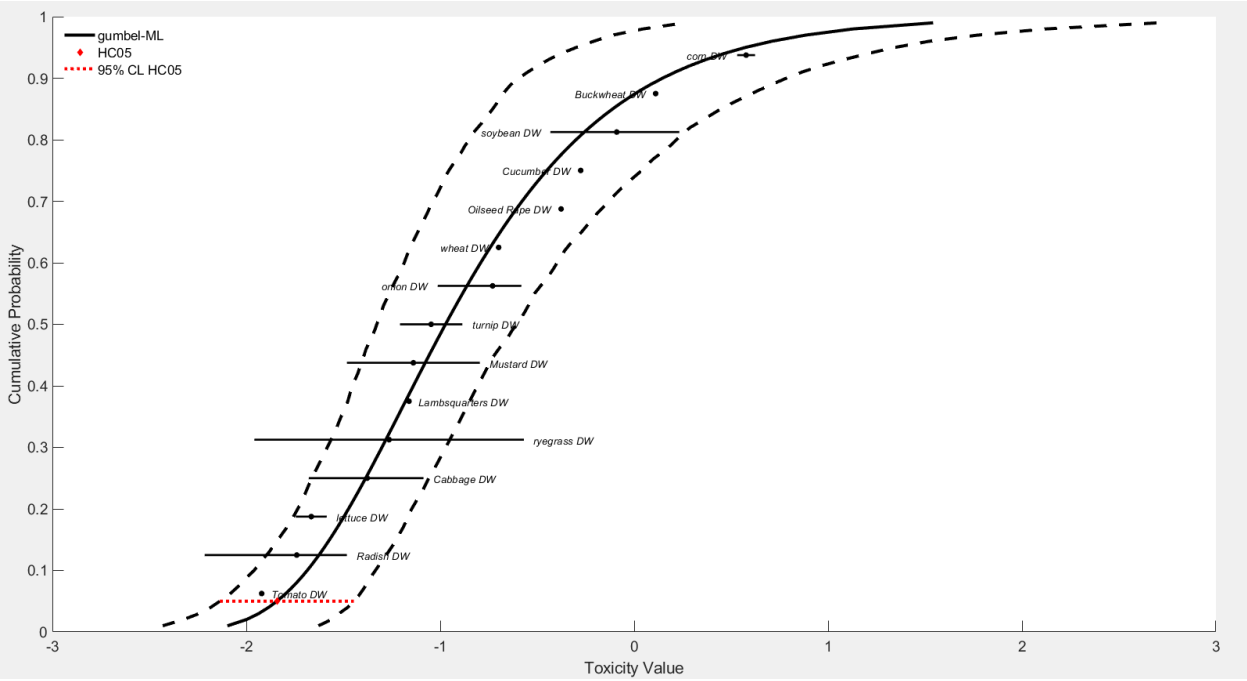
Based on the goodness of fit, EPA moved forward with the triangular, normal, and Gumbel distributions, and ultimately selected the normal distribution for the weight data from the seedling emergence toxicity tests.




Triangular




**Normal (selected distribution)**


gumbel-ML
HC05
95% CL HC05
corn DW
Buckwheat DW
soybean DW
Cucumber DW
Oilseed Rape DW
wheat DW
onion DW
turnip DW
Mustard DW
Lambsquarters DW
ryegrass DW
Cabbage DW
lettuce DW
Radish DW
Tomato DW
Cumulative Probability
Toxicity Value
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-3
-2
-1
0
1
2
3

Gumbel

*Vegetative Vigor Weight (Monocots + Dicots) Data*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0038 | 0.5185 |
| 2 | logistic | ML | 0.0032 | 0.4206 |
| 3 | triangular | ML | 0.0039 | 0.7692 |
| 4 | gumbel | ML | 0.0046 | 0.7552 |
| 5 | weibull | ML | 0.0015 | 0.0899 |
| 6 | burr | ML | 0.0043 | 0.6284 |

Percentile of interest: 5

Model-averaged HCp: 0.003781

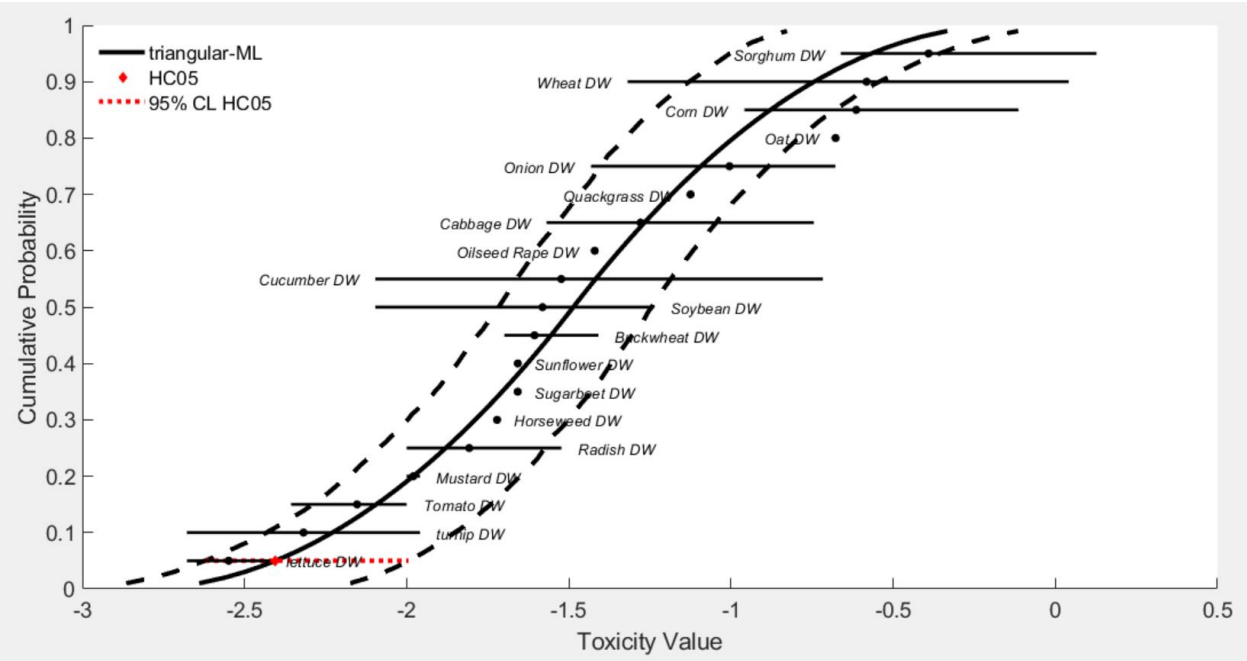
Model-averaged SE of HCp: 0.001821

CV of HCp: 0.48165

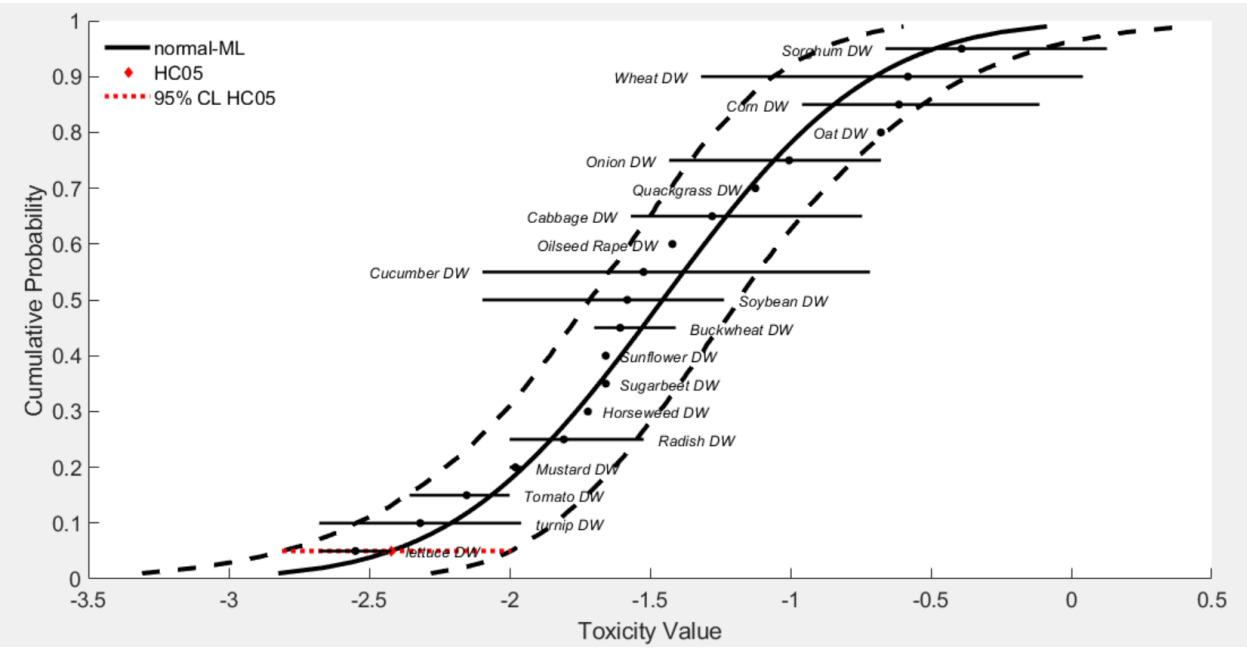
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -58.9387 | 0 | 0.4846 | 0.0039 | 0.0017 |
| 2 | normal | -57.1189 | 1.8198 | 0.1951 | 0.0038 | 0.0018 |
| 3 | logistic | -56.1208 | 2.8179 | 0.1184 | 0.0032 | 0.0017 |
| 4 | gumbel | -55.9901 | 2.9486 | 0.1109 | 0.0046 | 0.0015 |
| 5 | weibull | -54.5751 | 4.3637 | 0.0547 | 0.0015 | 0.0012 |
| 6 | burr | -53.7532 | 5.1855 | 0.0363 | 0.0043 | 0.0021 |

Based on the goodness of fit, EPA moved forward with the triangular and normal distributions, and ultimately selected the normal distribution for the weight data from the vegetative vigor toxicity tests when combining the monocot and dicot data.




Triangular




**Normal (selected distribution)**

*Vegetative Vigor Weight (Dicot Only) Data*

Goodness of fit:

Results:

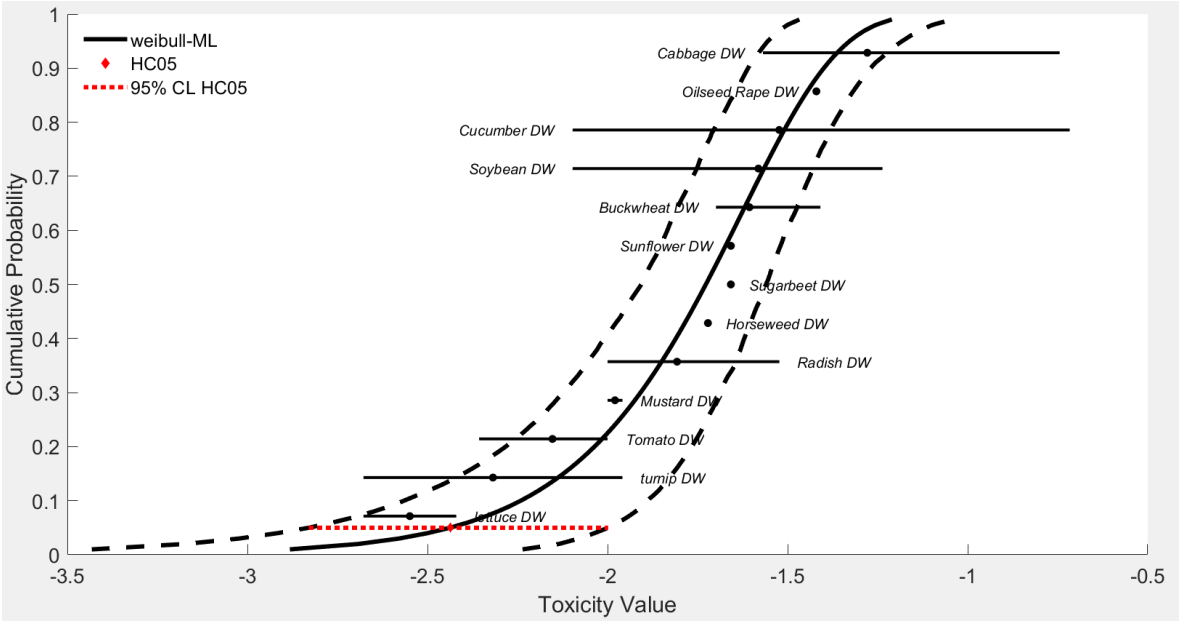
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0043 | 0.1968 |
| 2 | logistic | ML | 0.0046 | 0.2897 |
| 3 | triangular | ML | 0.0040 | 0.3666 |
| 4 | gumbel | ML | 0.0040 | 0.0579 |
| 5 | weibull | ML | 0.0037 | 0.7842 |
| 6 | burr | ML | 0.0031 | 0.8402 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.003905 |
| Model-averaged SE of HCp: | 0.0017137 |
| CV of HCp: | 0.43886 |

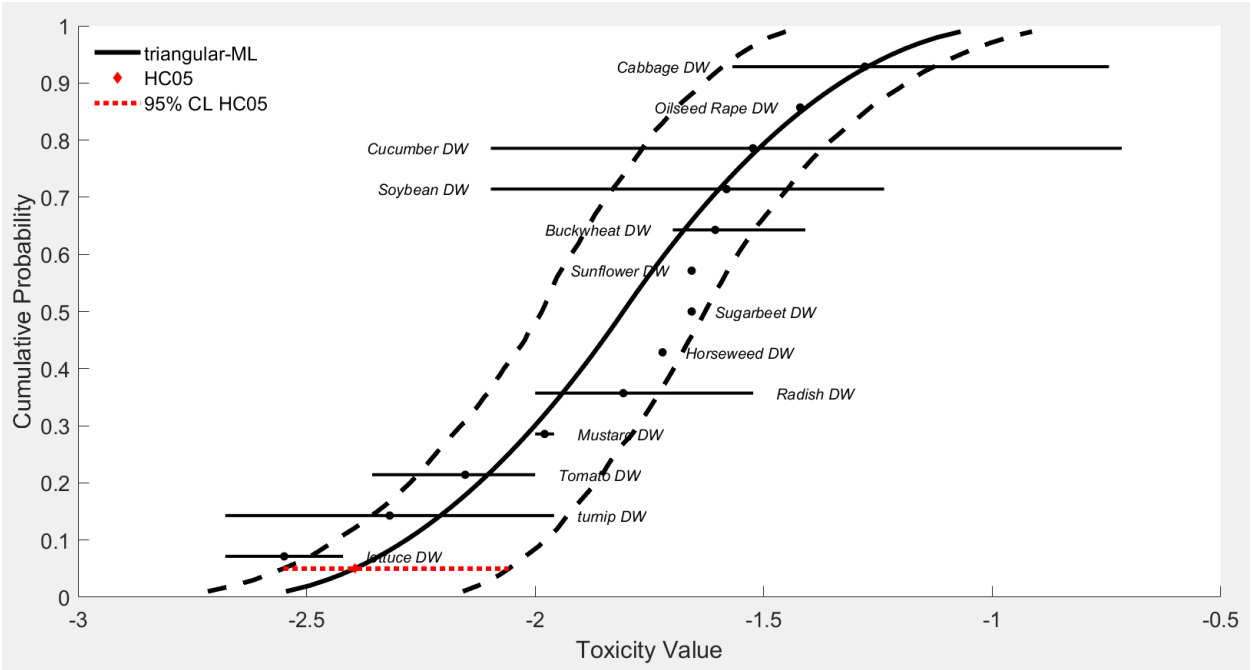
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | weibull | -72.5851 | 0 | 0.4359 | 0.0037 | 0.0018 |
| 2 | triangular | -70.8493 | 1.7357 | 0.1830 | 0.0040 | 7.1035e-04 |
| 3 | normal | -70.4625 | 2.1225 | 0.1508 | 0.0043 | 0.0015 |
| 4 | logistic | -70.1863 | 2.3987 | 0.1314 | 0.0046 | 0.0019 |
| 5 | burr | -69.1465 | 3.4386 | 0.0781 | 0.0031 | 0.0023 |
| 6 | gumbel | -66.4868 | 6.0982 | 0.0207 | 0.0040 | 0.0011 |

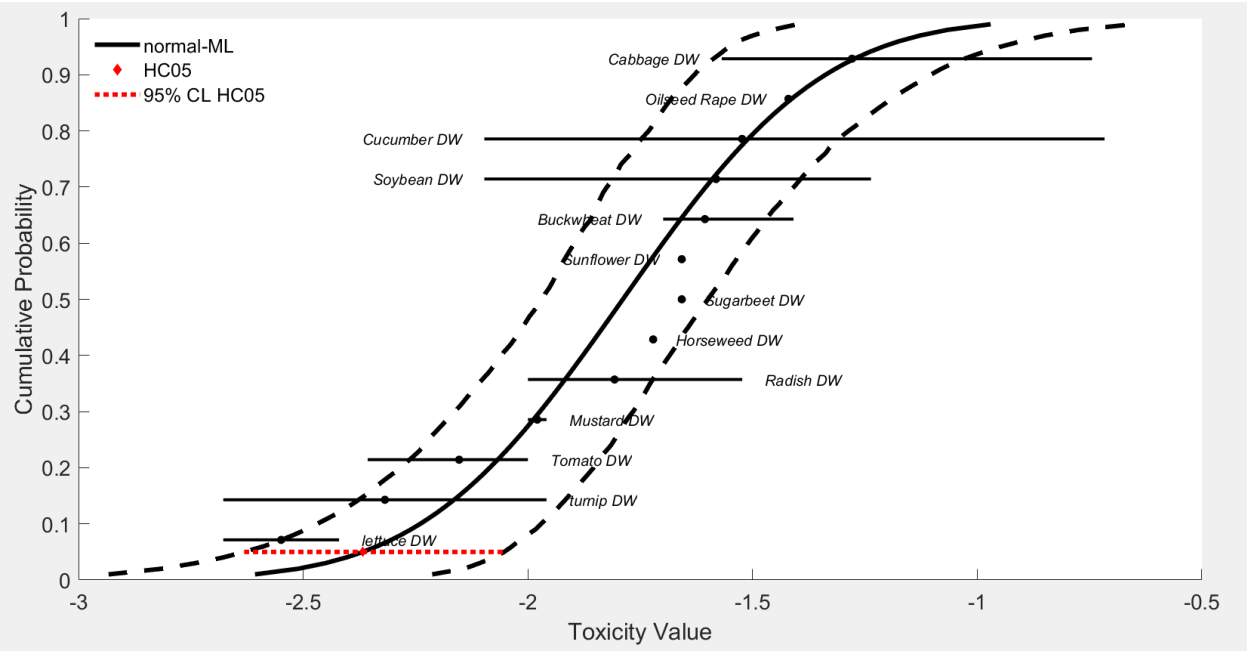
Based on the goodness of fit, EPA moved forward with the Weibull, triangular and normal distributions, and ultimately selected the Weibull distribution for the weight data from the vegetative vigor tests when using only the dicot data.




**Weibull (selected distribution)**




Triangular


normal-ML
HC05
95% CL HC05
Cumulative Probability
Toxicity Value
Cabbage DW
Oilseed Rape DW
Cucumber DW
Soybean DW
Buckwheat DW
Sunflower DW
Sugarbeet DW
Horseweed DW
Radish DW
Mustard DW
Tomato DW
turnip DW
lettuce DW

Normal

## 6.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 6-23. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.0 lb a.e./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | 0* | 0* | 0* | 0* | 0* | 0* | 0* |
| **Application Rate of 1.5 lb a.e./A (maximum rate for use on corn and strawberries and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | 0* | 0* | 0* | 0* | 0* | 0* | 0* |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 299.2 µg a.e./L for duckweed, *Lemna gibba* (MRID 42712204). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For 2,4-D, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 6.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 6-24. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 2.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 27.0 | 27.0 | 27.0 | 57.0 | 55.1 | 54.7 | 54.5 | 25.7 |
| 10 | 18.2 | 16.3 | 15.0 | 14.2 | 5.1 | 2.5 | 1.5 | 12.5 |
| 20 | 13.5 | 10.8 | 9.3 | 7.2 | 2.4 | 1.4 | 0.8 | 7.0 |
| 25 | 11.6 | 8.8 | 7.3 | 5.3 | 1.8 | 1.1 | 0.6 | 5.1 |
| 50 | 9.1 | 5.8 | 3.9 | 2.6 | 0.9 | 0.6 | 0.4 | 1.8 |
| 75 | 6.4 | 3.9 | 2.5 | 1.7 | 0.6 | 0.5 | 0.3 | 0.9 |
| 100 | 5.4 | 3.1 | 2.0 | 1.4 | 0.5 | 0.4 | 0.2 | 0.6 |
| 125 | 4.0 | 2.3 | 1.5 | 1.1 | 0.4 | 0.3 | 0.2 | 0.4 |
| 150 | 3.4 | 1.9 | 1.2 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 175 | 2.8 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 | 0.2 |
| 200 | 2.5 | 1.4 | 0.8 | 0.7 | 0.3 | 0.2 | 0.1 | 0.1 |
| 225 | 2.3 | 1.2 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 2.0 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.8 | 0.9 | 0.5 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 400 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.037 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 2.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 263.1 | 263.1 | 263.1 | 555.4 | 536.5 | 533.1 | 530.5 | 250.7 |
| 10 | 177.1 | 159.1 | 145.9 | 138.2 | 49.2 | 24.4 | 14.6 | 121.3 |
| 20 | 131.6 | 105.5 | 90.4 | 69.6 | 23.3 | 13.2 | 7.9 | 68.3 |
| 25 | 112.5 | 85.6 | 70.9 | 51.3 | 17.3 | 10.4 | 6.3 | 49.4 |
| 50 | 88.3 | 56.9 | 37.6 | 24.9 | 8.8 | 6.1 | 3.7 | 17.9 |
| 75 | 62.0 | 38.4 | 24.8 | 16.6 | 6.2 | 4.4 | 2.8 | 8.6 |
| 100 | 52.4 | 30.6 | 19.4 | 13.3 | 5.1 | 3.7 | 2.4 | 5.6 |
| 125 | 39.1 | 22.6 | 14.5 | 10.4 | 4.1 | 3.1 | 2.0 | 3.4 |
| 150 | 32.8 | 18.0 | 11.3 | 8.6 | 3.5 | 2.7 | 1.7 | 2.3 |
| 175 | 27.4 | 15.0 | 9.2 | 7.2 | 3.0 | 2.3 | 1.5 | 1.6 |
| 200 | 24.3 | 13.2 | 7.9 | 6.4 | 2.7 | 2.1 | 1.4 | 1.3 |
| 225 | 22.1 | 11.2 | 6.7 | 5.6 | 2.4 | 1.9 | 1.3 | 1.0 |
| 250 | 19.3 | 9.7 | 5.8 | 4.9 | 2.2 | 1.7 | 1.2 | 0.7 |
| 275 | 17.6 | 8.6 | 5.1 | 4.4 | 2.0 | 1.6 | 1.1 | 0.6 |
| 300 | 16.0 | 7.6 | 4.6 | 3.9 | 1.8 | 1.5 | 1.0 | 0.5 |
| 325 | 14.6 | 6.9 | 4.2 | 3.6 | 1.7 | 1.3 | 0.9 | 0.4 |
| 350 | 13.7 | 6.5 | 4.0 | 3.3 | 1.6 | 1.3 | 0.9 | 0.3 |
| 375 | 12.8 | 6.0 | 3.7 | 3.0 | 1.5 | 1.2 | 0.8 | 0.3 |
| 400 | 11.9 | 5.6 | 3.5 | 2.8 | 1.4 | 1.1 | 0.8 | 0.2 |
| 500 | 9.9 | 4.6 | 2.8 | 1.5 | 0.6 | 0.5 | 0.3 | 0.2 |
| 600 | 8.5 | 3.9 | 2.4 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 700 | 7.6 | 3.5 | 2.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 800 | 7.0 | 3.2 | 1.9 | 0.7 | 0.3 | 0.3 | 0.2 | <0.1 |
| 900 | 6.6 | 3.0 | 1.8 | 0.6 | 0.3 | 0.2 | 0.2 | <0.1 |
| 1000 | 6.2 | 2.8 | 1.7 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0038 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-26. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 2.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 71.4 | 71.4 | 71.4 | 150.7 | 145.6 | 144.7 | 144.0 | 68.0 |
| 10 | 48.1 | 43.2 | 39.6 | 37.5 | 13.4 | 6.6 | 4.0 | 32.9 |
| 20 | 35.7 | 28.6 | 24.5 | 18.9 | 6.3 | 3.6 | 2.2 | 18.5 |
| 25 | 30.5 | 23.2 | 19.2 | 13.9 | 4.7 | 2.8 | 1.7 | 13.4 |
| 50 | 24.0 | 15.4 | 10.2 | 6.8 | 2.4 | 1.6 | 1.0 | 4.9 |
| 75 | 16.8 | 10.4 | 6.7 | 4.5 | 1.7 | 1.2 | 0.8 | 2.3 |
| 100 | 14.2 | 8.3 | 5.3 | 3.6 | 1.4 | 1.0 | 0.6 | 1.5 |
| 125 | 10.6 | 6.1 | 3.9 | 2.8 | 1.1 | 0.8 | 0.5 | 0.9 |
| 150 | 8.9 | 4.9 | 3.1 | 2.3 | 0.9 | 0.7 | 0.5 | 0.6 |
| 175 | 7.4 | 4.1 | 2.5 | 2.0 | 0.8 | 0.6 | 0.4 | 0.4 |
| 200 | 6.6 | 3.6 | 2.2 | 1.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| 225 | 6.0 | 3.0 | 1.8 | 1.5 | 0.7 | 0.5 | 0.3 | 0.3 |
| 250 | 5.3 | 2.6 | 1.6 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 275 | 4.8 | 2.3 | 1.4 | 1.2 | 0.5 | 0.4 | 0.3 | 0.2 |
| 300 | 4.3 | 2.1 | 1.2 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.0 | 1.9 | 1.1 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 3.7 | 1.8 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 375 | 3.5 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.2 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.7 | 1.2 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.3 | 1.1 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.8 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.7 | 0.8 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 1.5 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M[2] | M-C[2] | C-VC | VF-F[2] High Boom | VF-F[2] Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 20.3 | 20.3 | 20.3 | 42.8 | 41.3 | 41.1 | 40.9 | 19.3 |
| 10 | 13.6 | 12.3 | 11.2 | 10.6 | 3.8 | 1.9 | 1.1 | 9.3 |
| 20 | 10.1 | 8.1 | 7.0 | 5.4 | 1.8 | 1.0 | 0.6 | 5.3 |
| 25 | 8.7 | 6.6 | 5.5 | 3.9 | 1.3 | 0.8 | 0.5 | 3.8 |
| 50 | 6.8 | 4.4 | 2.9 | 1.9 | 0.7 | 0.5 | 0.3 | 1.4 |
| 75 | 4.8 | 3.0 | 1.9 | 1.3 | 0.5 | 0.3 | 0.2 | 0.7 |
| 100 | 4.0 | 2.4 | 1.5 | 1.0 | 0.4 | 0.3 | 0.2 | 0.4 |
| 125 | 3.0 | 1.7 | 1.1 | 0.8 | 0.3 | 0.2 | 0.2 | 0.3 |
| 150 | 2.5 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.1 | 1.2 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.7 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.037 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-28. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 1.5 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M[2] | M-C[2] | C-VC | VF-F[2] High Boom | VF-F[2] Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 197.4 | 197.3 | 197.3 | 416.5 | 402.4 | 399.8 | 397.8 | 188.0 |
| 10 | 132.8 | 119.3 | 109.5 | 103.6 | 36.9 | 18.3 | 11.0 | 91.0 |
| 20 | 98.7 | 79.1 | 67.8 | 52.2 | 17.5 | 9.9 | 6.0 | 51.3 |
| 25 | 84.4 | 64.2 | 53.2 | 38.4 | 13.0 | 7.8 | 4.7 | 37.0 |
| 50 | 66.2 | 42.7 | 28.2 | 18.7 | 6.6 | 4.5 | 2.8 | 13.5 |
| 75 | 46.5 | 28.8 | 18.6 | 12.4 | 4.6 | 3.3 | 2.1 | 6.5 |
| 100 | 39.3 | 23.0 | 14.5 | 9.9 | 3.8 | 2.8 | 1.8 | 4.2 |
| 125 | 29.3 | 16.9 | 10.8 | 7.8 | 3.1 | 2.3 | 1.5 | 2.6 |
| 150 | 24.6 | 13.5 | 8.5 | 6.4 | 2.6 | 2.0 | 1.3 | 1.7 |
| 175 | 20.5 | 11.3 | 6.9 | 5.4 | 2.3 | 1.7 | 1.1 | 1.2 |
| 200 | 18.2 | 9.9 | 5.9 | 4.8 | 2.0 | 1.6 | 1.1 | 1.0 |
| 225 | 16.6 | 8.4 | 5.0 | 4.2 | 1.8 | 1.4 | 1.0 | 0.7 |
| 250 | 14.5 | 7.3 | 4.3 | 3.7 | 1.6 | 1.3 | 0.9 | 0.6 |
| 275 | 13.2 | 6.4 | 3.8 | 3.3 | 1.5 | 1.2 | 0.8 | 0.4 |
| 300 | 12.0 | 5.7 | 3.4 | 2.9 | 1.4 | 1.1 | 0.7 | 0.4 |
| 325 | 11.0 | 5.2 | 3.2 | 2.7 | 1.3 | 1.0 | 0.7 | 0.3 |
| 350 | 10.3 | 4.9 | 3.0 | 2.5 | 1.2 | 1.0 | 0.7 | 0.3 |
| 375 | 9.6 | 4.5 | 2.8 | 2.3 | 1.1 | 0.9 | 0.6 | 0.2 |
| 400 | 9.0 | 4.2 | 2.6 | 2.1 | 1.0 | 0.8 | 0.6 | 0.2 |
| 500 | 7.4 | 3.4 | 2.1 | 1.1 | 0.4 | 0.4 | 0.2 | 0.1 |
| 600 | 6.4 | 3.0 | 1.8 | 0.8 | 0.3 | 0.3 | 0.2 | 0.1 |
| 700 | 5.7 | 2.6 | 1.6 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 800 | 5.3 | 2.4 | 1.4 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 |
| 900 | 4.9 | 2.3 | 1.3 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 1000 | 4.7 | 2.1 | 1.2 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0038 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 1.5 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 53.6 | 53.6 | 53.6 | 113.1 | 109.2 | 108.5 | 108.0 | 51.0 |
| 10 | 36.1 | 32.4 | 29.7 | 28.1 | 10.0 | 5.0 | 3.0 | 24.7 |
| 20 | 26.8 | 21.5 | 18.4 | 14.2 | 4.7 | 2.7 | 1.6 | 13.9 |
| 25 | 22.9 | 17.4 | 14.4 | 10.4 | 3.5 | 2.1 | 1.3 | 10.1 |
| 50 | 18.0 | 11.6 | 7.6 | 5.1 | 1.8 | 1.2 | 0.8 | 3.7 |
| 75 | 12.6 | 7.8 | 5.0 | 3.4 | 1.3 | 0.9 | 0.6 | 1.8 |
| 100 | 10.7 | 6.2 | 3.9 | 2.7 | 1.0 | 0.8 | 0.5 | 1.1 |
| 125 | 8.0 | 4.6 | 2.9 | 2.1 | 0.8 | 0.6 | 0.4 | 0.7 |
| 150 | 6.7 | 3.7 | 2.3 | 1.7 | 0.7 | 0.5 | 0.4 | 0.5 |
| 175 | 5.6 | 3.1 | 1.9 | 1.5 | 0.6 | 0.5 | 0.3 | 0.3 |
| 200 | 5.0 | 2.7 | 1.6 | 1.3 | 0.6 | 0.4 | 0.3 | 0.3 |
| 225 | 4.5 | 2.3 | 1.4 | 1.1 | 0.5 | 0.4 | 0.3 | 0.2 |
| 250 | 3.9 | 2.0 | 1.2 | 1.0 | 0.4 | 0.4 | 0.2 | 0.2 |
| 275 | 3.6 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 300 | 3.3 | 1.6 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 325 | 3.0 | 1.4 | 0.9 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 350 | 2.8 | 1.3 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 375 | 2.6 | 1.2 | 0.8 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 400 | 2.4 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 500 | 2.0 | 0.9 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.7 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 1.6 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.4 | 0.7 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 900 | 1.3 | 0.6 | 0.4 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.3 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-30. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 0.50 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 6.8 | 6.8 | 6.8 | 14.3 | 13.8 | 13.7 | 13.6 | 6.4 |
| 10 | 4.5 | 4.1 | 3.7 | 3.5 | 1.3 | 0.6 | 0.4 | 3.1 |
| 20 | 3.4 | 2.7 | 2.3 | 1.8 | 0.6 | 0.3 | 0.2 | 1.8 |
| 25 | 2.9 | 2.2 | 1.8 | 1.3 | 0.4 | 0.3 | 0.2 | 1.3 |
| 50 | 2.3 | 1.5 | 1.0 | 0.6 | 0.2 | 0.2 | 0.1 | 0.5 |
| 75 | 1.6 | 1.0 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 0.2 |
| 100 | 1.3 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 125 | 1.0 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 150 | 0.8 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 175 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 200 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 225 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.037 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 0.50 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 65.8 | 65.8 | 65.8 | 138.8 | 134.1 | 133.3 | 132.6 | 62.7 |
| 10 | 44.3 | 39.8 | 36.5 | 34.5 | 12.3 | 6.1 | 3.7 | 30.3 |
| 20 | 32.9 | 26.4 | 22.6 | 17.4 | 5.8 | 3.3 | 2.0 | 17.1 |
| 25 | 28.1 | 21.4 | 17.7 | 12.8 | 4.3 | 2.6 | 1.6 | 12.3 |
| 50 | 22.1 | 14.2 | 9.4 | 6.2 | 2.2 | 1.5 | 0.9 | 4.5 |
| 75 | 15.5 | 9.6 | 6.2 | 4.1 | 1.5 | 1.1 | 0.7 | 2.2 |
| 100 | 13.1 | 7.7 | 4.8 | 3.3 | 1.3 | 0.9 | 0.6 | 1.4 |
| 125 | 9.8 | 5.6 | 3.6 | 2.6 | 1.0 | 0.8 | 0.5 | 0.9 |
| 150 | 8.2 | 4.5 | 2.8 | 2.1 | 0.9 | 0.7 | 0.4 | 0.6 |
| 175 | 6.8 | 3.8 | 2.3 | 1.8 | 0.8 | 0.6 | 0.4 | 0.4 |
| 200 | 6.1 | 3.3 | 2.0 | 1.6 | 0.7 | 0.5 | 0.4 | 0.3 |
| 225 | 5.5 | 2.8 | 1.7 | 1.4 | 0.6 | 0.5 | 0.3 | 0.2 |
| 250 | 4.8 | 2.4 | 1.4 | 1.2 | 0.5 | 0.4 | 0.3 | 0.2 |
| 275 | 4.4 | 2.1 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 300 | 4.0 | 1.9 | 1.1 | 1.0 | 0.5 | 0.4 | 0.2 | 0.1 |
| 325 | 3.7 | 1.7 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 350 | 3.4 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 375 | 3.2 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.0 | 1.4 | 0.9 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 500 | 2.5 | 1.1 | 0.7 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 2.1 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 1.8 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 900 | 1.6 | 0.8 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.6 | 0.7 | 0.4 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0038 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-32. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 0.50 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 17.9 | 17.9 | 17.9 | 37.7 | 36.4 | 36.2 | 36.0 | 17.0 |
| 10 | 12.0 | 10.8 | 9.9 | 9.4 | 3.3 | 1.7 | 1.0 | 8.2 |
| 20 | 8.9 | 7.2 | 6.1 | 4.7 | 1.6 | 0.9 | 0.5 | 4.6 |
| 25 | 7.6 | 5.8 | 4.8 | 3.5 | 1.2 | 0.7 | 0.4 | 3.4 |
| 50 | 6.0 | 3.9 | 2.5 | 1.7 | 0.6 | 0.4 | 0.3 | 1.2 |
| 75 | 4.2 | 2.6 | 1.7 | 1.1 | 0.4 | 0.3 | 0.2 | 0.6 |
| 100 | 3.6 | 2.1 | 1.3 | 0.9 | 0.3 | 0.3 | 0.2 | 0.4 |
| 125 | 2.7 | 1.5 | 1.0 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 150 | 2.2 | 1.2 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 175 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.7 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 275 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-33. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 0.07 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 0.9 | 0.9 | 0.9 | 2.0 | 1.9 | 1.9 | 1.9 | 0.9 |
| 10 | 0.6 | 0.6 | 0.5 | 0.5 | 0.2 | 0.1 | 0.1 | 0.4 |
| 20 | 0.5 | 0.4 | 0.3 | 0.3 | 0.1 | <0.1 | <0.1 | 0.2 |
| 25 | 0.4 | 0.3 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | 0.2 |
| 50 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | 0.1 |
| 75 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 100 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 125 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.037 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-34. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 0.12 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 9.2 | 9.2 | 9.2 | 19.4 | 18.8 | 18.7 | 18.6 | 8.8 |
| 10 | 6.2 | 5.6 | 5.1 | 4.8 | 1.7 | 0.9 | 0.5 | 4.2 |
| 20 | 4.6 | 3.7 | 3.2 | 2.4 | 0.8 | 0.5 | 0.3 | 2.4 |
| 25 | 3.9 | 3.0 | 2.5 | 1.8 | 0.6 | 0.4 | 0.2 | 1.7 |
| 50 | 3.1 | 2.0 | 1.3 | 0.9 | 0.3 | 0.2 | 0.1 | 0.6 |
| 75 | 2.2 | 1.3 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 100 | 1.8 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.4 | 0.8 | 0.5 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 |
| 150 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 225 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0038 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 6-35. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 0.12 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 4.3 | 4.3 | 4.3 | 9.0 | 8.7 | 8.7 | 8.6 | 4.1 |
| 10 | 2.9 | 2.6 | 2.4 | 2.3 | 0.8 | 0.4 | 0.2 | 2.0 |
| 20 | 2.1 | 1.7 | 1.5 | 1.1 | 0.4 | 0.2 | 0.1 | 1.1 |
| 25 | 1.8 | 1.4 | 1.2 | 0.8 | 0.3 | 0.2 | 0.1 | 0.8 |
| 50 | 1.4 | 0.9 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | 0.3 |
| 75 | 1.0 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.1 |
| 100 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 125 | 0.6 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 150 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 7 Dicamba Case Study Example (PC Codes 029801, 029802, 029803, 029806, 100094, 128931, 128944, 129043)

## 7.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft draft Strategy (HSStrategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 7.2 Use Information

Dicamba is a systemic (*i.e.,* absorbed through plant leaves and roots) benzoic acid used primarily to control annual, biennial, and perennial broadleaf weeds[45] by mimicking auxins (a type of plant hormone) and causing abnormal cell growth. Dicamba is available in acid form as well as several salts (seven salts have currently registered products[46]) which disassociate to the

[45] Broadleaf weeds are typically dicotyledonous flowering plants (or dicots). Because the target weed is a dicot, dicamba is more toxic to dicots than to monocots. See **Section 7.3.1** for information about dicamba's toxicity.
[46] Dicamba dimethylamine salt (DMA; PC 029802), dicamba diethanolamine salt (DEA; PC 029803), dicamba sodium salt (PC 029806), dicamba N,N-Bis-(3-aminopropyl) methylamine salt (BAPMA; PC 100094), dicamba diglycoamine salt (DGA; PC 128931), dicamba isopropylamine salt (IPA; PC 128944), and dicamba potassium salt (PC 129043)

acid.[47] The residues of concern[48] for ecological risk include dicamba and two of its degradates (3,6-dichlorosalicylic acid [DCSA] and 2-chloro-6-hydroxybenzoic acid [6-CSA]) depending on the taxonomic group and exposure pathway.

Dicamba is soluble (6,100 mg/L) and mobile ($K_{OC}$ = 13.4 L/kg o.c.) in the laboratory. It breaks down quickly in aerobic environments by microbes with half-lives on the order of days to weeks. It is generally stable to abiotic processes such as interactions with water and sunlight and generally more persistent under anaerobic (low oxygen) conditions, which generally occur deeper in the soil profile and sediments. Dicamba may reach surface water via runoff, by spray drift during application, and by vapor drift due to volatilization based on the findings of multiple academic and registrant submitted studies, incident data, and the potential for increased volatility associated with applications during warmer temperatures and in later season applications. Note that although volatilization is an exposure pathway for dicamba, volatilization is not considered at this time in the draft Strategy. However, important exposure pathways that are limited to a small number of pesticides such as volatilization or bioaccumulation will still be considered and addressed if appropriate on a case-by-case basis during chemical specific regulatory evaluations or individual consultations for that pesticide.

The DCSA degradate is soluble (2,112 mg/L) and slightly to moderately mobile ($K_{OC}$ = 1,209 L/kg o.c.). DCSA may be transported to surface water via runoff or to groundwater via leaching. DCSA tends to be more stable to aerobic metabolism than dicamba with most half-lives ranging from 2 to 6 weeks. Data are not available to assess DCSA's stability to abiotic processes or in anaerobic conditions. Based on structural modeling, DCSA is classified as being intermediately volatile from dry non-adsorbing surfaces. Fate data are not available for the 6-CSA degradate which adds an uncertainty to the dicamba risk assessment; however, in the 2022 Draft Risk Assessment (DP460423) for Registration Review, EPA used conservative assumptions when modeling (*i.e.,* DCSA + 6-CSA) to estimate exposure to 6-CSA.

Dicamba was first registered in the United States in 1967 and is currently registered for use on a wide variety of agricultural crops (*e.g.,* soybean, cotton, corn, grains, and sorghum) as well as non-agricultural uses (*e.g.,* residential premises, rangeland, fallow fields, and turf). The uses are primarily pre-emergent or fallow-field applications, but some (*i.e.,* corn, small grains, soybeans, and cotton) may also be made as post-emergent applications. EPA did not include dicamba-tolerant uses (*i.e.,* post-emergent applications to dicamba tolerant soybean and cotton) in this case study as it has completed biological evaluations and incorporated mitigations to address non-target exposure for these uses. Dicamba end-use products are formulated as emulsifiable concentrate, soluble concentrate, granule, wetted powder, and ready-to-use solution. Dicamba

[47] Throughout this document, EPA uses 'dicamba' to collectively refer to the acid and all salts, unless otherwise specified.
[48] Residues of concern include pesticide active ingredients and chemicals that form in the environment as a result of chemical reactions with the active ingredient or its degradates that are expected to be toxic.

can be applied by broadcast spray (aerial and ground), spot treatment, banded, wipe on/wipe off treatment, cut-stem treatments, forestry injection, and basal bark treatment.

**Table 7-1** includes the use information from the 2022 Draft Risk Assessment (DRA; DP460423) for Registration Review. EPA only included the non-GMO agricultural uses[49] which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for dicamba, changes to the registered labels and uses (including mitigation) since this DRA are not considered at this time but would be considered when EPA conducts assessments for dicamba for regulatory decisions when using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2022 assessment. **Table 7-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 7.5**. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5**.

For this case study, EPA estimated exposures using the selected[50] uses and application information provided in **Table 7-1**. **Table 7-1** presents all application rates in acid equivalents (a.e.) to allow for comparison, in common units, across application rates for the various dicamba salts. The selected uses do not necessarily represent all registered uses of dicamba and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where dicamba usage is most common. EPA selected these example uses to illustrate the draft Herbicide Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Herbicide Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of dicamba as this application method represents the greatest source of potential offsite movement. Although granular formulations of dicamba are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

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[49] Dicamba is registered for use on genetically modified organism (GMO) dicamba tolerant (DT) soybean and DT-cotton plants. These uses are not included in this case study example.

[50] The uses evaluated as part of the proposed draft Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2022 Draft Risk Assessment (DP460423) for Registration Review for dicamba. Any uses not evaluated in the 2022 assessment and any new uses since this assessment are not included in this example case study for the proposed draft Herbicide Strategy.

**Table 7-1. Summary of the Selected Agricultural Use Patterns Labeled for Dicamba (2022 Draft Risk Assessment for Registration Review, DP460423)[1]**

| Use | Max Single App Rate (lb ae/A) | Number of Applications[2] | Max Annual App Rate (lb ae/A/yr)[2] | MRI (days) | Application Method | Application Timing | Comments |
|---|---|---|---|---|---|---|---|
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | | |
| Asparagus | 0.74 | NS (1) | 0.74 | NA | A, G | Pre- and post-emergence | NA |
| **Other Grains Use Data Layer** | | | | | | | |
| Barley, oat, small grains, sorghum | 1.0 | NS (2) | 2.0 | NS | A, G | Pre-plant, post-plant, post-emergence, fallow | Rates reflect the maximum amount (1 lb ae/A) that can be applied to a field that can grow these crops, rather than the maximum amount that can be applied to the crop itself. The application rates for applications to the crop itself are lower, as reflected below in the rows for the individual crops. |
| Barley | 0.26 | NS (2) | 0.38 | NS | A, G | Post-emergence | NA |
| Oat | 0.13 | NS (2) | 0.26 | 30 | A, G | Post-harvest | NA |
| Proso millet | 0.18 | NS (1) | 0.18 | NA | A, G | Post-emergence | NA |
| Sorghum | 0.25 | NS (2) | 0.5 | NS | A, G | Pre-plant, pre-emergence, post-emergence, pre-harvest | NA |
| Sugarcane | 1.0 | NS (2) | 2.0 | NS | A, G | Pre- and post-emergence | NA |
| Triticale | 0.18 | NS (1) | 0.18 | NA | A, G | Post-emergence | NA |
| Triticale | 0.12 | 2 | NS (0.24) | NS | A, G | Post-emergence | NA |
| **Wheat Use Data Layer** | | | | | | | |
| Wheat | 1.0 | NS (2) | 2.0 | NS | A, G | Pre-plant, post-plant, post-emergence, fallow | Rates reflect the maximum amount (1 lb ae/A) that can be applied to a field that can grow wheat, rather than the maximum amount that can |

| Use | Max Single App Rate (lb ae/A) | Number of Applications[2] | Max Annual App Rate (lb ae/A/yr)[2] | MRI (days) | Application Method | Application Timing | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | | | be applied to wheat itself. The application rates for applications to wheat itself are lower, as reflected in the row below. |
| Wheat | 0.44 | NS (2) | 0.61 | NS | A, G | Post-emergence | NA |
| **Corn Use Data Layer** | | | | | | | |
| Corn | 1.0 | NS (2) | 2.0 | NS | G | Pre- and post-emergence | NA |
| **Cotton Use Data Layer** | | | | | | | |
| Cotton | 1.0 | NS (2) | 2.0 | NS | A, G | Fallow field | Does not include dicamba tolerant use. |
| **Soybeans Use Data Layer** | | | | | | | |
| Soybean | 1.0 | NS (2) | 2.0 | NS | A, G | Pre-plant, pre-harvest | Pre-harvest application used to reduce weeds so as to improve harvesting and reduce staining of soybean seeds.<br><br>Does not include dicamba tolerant use. |
| **Other Crops Use Data Layer** | | | | | | | |
| Fallow/Idle/Conservation Reserve[3] | 1.0 | NS (2) | 2.0 | NS | A, G | Pre-plant, post-harvest | NA |

App=application; a.e.=acid equivalent; MRI = Minimum retreatment interval; A=aerial; G=ground; incorp.=incorporated; NS=not specified on the label; NA=not applicable.

[1] The use information presented in this table is identical to the agricultural uses included in the 2022 Draft Risk Assessment for Registration Review (DP460423).

[2] Values in parenthesis were calculated based on other information provided on the label. These values are not on the label.

[3] For the purposes of the draft Strategy, use on fallow/idle/conservation reserve lands is considered an agricultural use. However, runoff/erosion EECs were not generated for this use pattern in this case study document. In the future, if this Strategy is applied to dicamba for regulatory (*i.e.,* not example) purposes, this use pattern will be included.

## 7.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of dicamba (**Section 7.3.1**), reported incidents (**Section 7.3.2**), and the EECs to calculate magnitude of difference values (**Section 7.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 7.3.1 Toxicity Information

**Table 7-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for dicamba.

**Table 7-2. Summary of the Most Sensitive Toxicity Endpoints for Dicamba (As Summarized in the 2022 Draft Risk Assessment for Registration Review, DP460423)**

| Study Type[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Dicot: Oilseed Rape (Brassica napus) | NOAEC = 0.0234 lb a.e./A<br>$IC_{25}$ = 0.0357 lb a.e./A | 48718014 Acceptable | Test with TEP containing 47.9% BAPMA salt (BAS 183 22 H formulation); Based on effects on dry weight |
| | Monocot: Wheat (Triticum aestivum) | NOAEC = 0.0642 lb a.e./A<br>$IC_{25}$ = 0.344 lb a.e./A | | Test with TEP containing 47.9% BAPMA salt (BAS 183 22 H formulation); Based on effects on dry weight |
| Vegetative Vigor[2] | Dicot: Soybean (Glycine max) | NOAEC = 0.000261 lb a.e./A<br>$IC_{25}$ = 0.000513 lb a.e./A | 47815102 Supplemental | Test with TEP containing 40.3% DGA salt (Clarity 4.0 SL formulation); Based on effects on height |
| | Monocot: Onion (Allium cepa) | NOAEC = 0.0721 lb a.e./A<br>$IC_{25}$ = 0.0924 lb a.e./A | 48718015 Acceptable | Test with TEP containing 47.9% BAPMA salt (BAS 183 22 H formulation); Based on effects on dry weight |
| Aquatic Vascular Plant | Parrot feather watermilfoil (*Myriophyllum aquaticum*) | 7-day $IC_{50}$ = 1290 µg a.e./L | 51610901 Quantitative | Tunic et al. (2015)[3]<br><br>Test with TGAI (98% dicamba acid); Based on effects on shoot length yield |
| Aquatic Nonvascular Plant | Blue-green algae (Anabaena flos-aquae) | NOAEC = 5 µg a.e./L<br>120-h $EC_{50}$ = 61 µg a.e./L | 42774109 Acceptable | Test with TGAI (89.5% dicamba acid); Based on effects on cell density |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}/_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.e.=acid equivalent; TEP=typical end-use product; TGAI=technical grade active ingredient; BAPMA salt= dicamba N,N-Bis-(3-aminopropyl) methylamine salt (PC Code 100094) ; DGA salt=dicamba diglycoamine salt (PC Code 128931)

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots and listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all dicot species, EPA generated Species Sensitivity Distributions (SSDs) using results for all dicot terrestrial plant test species (*i.e.,* not only the most sensitive) from the dicamba vegetative vigor tests. See **Table 7-3** and **Figure 7-2** for these SSD results. EPA used the most sensitive $IC_{25}$ value for vegetative vigor across all tested monocots to calculate the magnitude of difference for monocots (see **Table 7-3**).
[2] The toxicity endpoints presented in this table reflect those summarized and used in the 2022 Draft Risk Assessment (DP460423). For monocots, it is notable that a more sensitive toxicity endpoint ($IC_{25}$ = 0.0221 lb a.e./A) based on effects on wheat dry weight is available based on a vegetative vigor study with DGA salt and glyphosate (MRID 50103801). As this document is only for example purposes to demonstrate the Herbicide Strategy framework, the 2022 assessment endpoints are used in this Herbicide Strategy case study; however, in the future the more sensitive wheat toxicity endpoint may be used.
[3] Tunic, T., V. Knezevic, D. Kerkez, A. Tubic, D. Sunjka, S. Lazic, D. Brkic, and I. Teodorovic. 2015. Some Arguments in Favor of a *Myriophyllum aquaticum* Growth Inhibition Test in a Water–Sediment System as an Additional Test in Risk Assessment of Herbicides. *Environmental Toxicology and Chemistry*, Vol. 34, No. 9, pp. 2104-2115.

As explained below, EPA calculated Species Sensitivity Distributions (SSDs) for the vegetative vigor dicot height and weight endpoints. EPA did not calculate SSDs for the seedling emergence data, because vegetative vigor toxicity is the driver of risk for dicamba (see previous risk assessments such as DP460423). Based on the full set of definitive toxicity endpoints from the vegetative vigor tests, monocots and dicots are substantially different in terms of sensitivity with dicots being more sensitive (**Figure 7-1**). Specifically, the 75$^{th}$ percentiles of the dicot toxicity endpoints (weight: 0.057 lb a.e./A; height: 0.061 lb a.e./A) are approximately equivalent to or less than the 25$^{th}$ percentile of monocot toxicity endpoints for both dry weight and height (weight: 0.092 lb a.e./A; height: 0.056 lb a.e./A; **Figure 7-1**). Furthermore, the mean values of the growth endpoints (*i.e.,* the concentrations resulting in 25% inhibition in growth ($IC_{25}$ values)) for dicot weight and height are up to 7 times lower than for monocots, and the median $IC_{25}$ values are up to 82 times lower for dicots than for monocots. Therefore, for generating the dicamba SSDs, EPA determined that the monocot and dicot data should not be combined. Because there are a sufficient number of dicot species tested in the vegetative vigor studies to generate SSDs for plant height and weight data, EPA generated two SSDs in total for dicamba (dicots only; **Figure 7-2** and **Table 7-3**). See **Section 7.7** for the data used to generate the SSDs and **Section 7.8** for the process for calculating the SSDs, respectively.

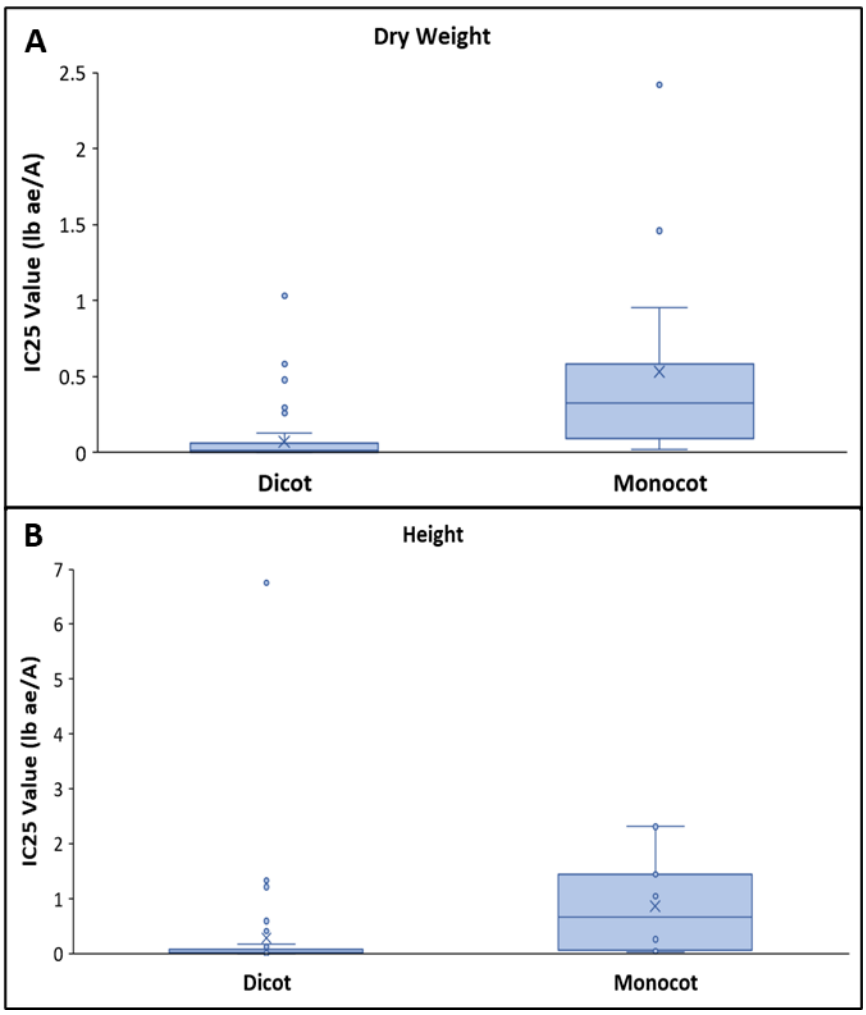


**Figure 7-1. Distribution of All Dicot and Monocot Vegetative Vigor Toxicity Endpoints for Dicamba. A) Dry Weight Data, and B) Height Data.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 7.3.3**). Overall, the magnitude of difference between the endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship[51]).

The SSD based on the vegetative vigor weight data resulted in the most sensitive 25$^{th}$ percentile $IC_{25}$ value (represented by the black square in **Figure 7-2**); therefore, EPA used this SSD (instead of the dicot height SSD[52]) within this case study example. For terrestrial and wetland dicots and

[51] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend. Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.
[52] Although the 5$^{th}$ percentile from the dicot height SSD is more sensitive than the 5$^{th}$ percentile for dicot weight, EPA selects the SSD based on the most sensitive 25$^{th}$ percentile value.

animals that obligately depend on dicots, EPA calculated the magnitude of as a ratio of the EEC to the 5th percentile of the dicot weight SSD (**Table 7-3** and **Table 7-4**; see **Section 7.3.3**).

Because the data are too few for monocots, EPA could not generate an SSD for monocots. Therefore, EPA used the most sensitive $IC_{25}$ value for monocots to calculate the magnitude of difference between the EECs and toxicity endpoint. These magnitude of difference ratios are applicable for monocots and animals that obligately depend on monocots. The most sensitive monocot $IC_{25}$ value from **Table 7-2** (0.0924 lb a.e./A) is 66 times greater than the 5th percentile value (0.0014 lb a.e./A) from the selected SSD for dicot weight, which further supports EPA's approach of analyzing dicots and monocots separately for dicamba.

For animals that generally rely upon terrestrial or wetland plants for diet or habitat and for designated critical habitats (CH), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25th percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated CHs is the ratio of the EEC to the 25th percentile of the dicot SSD (**Table 7-3** and **Table 7-4**; see **Section 7.3.3**).

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[53] are available to evaluate potential impacts of dicamba on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 7-2** and **Table 7-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[54].

[53] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[54] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

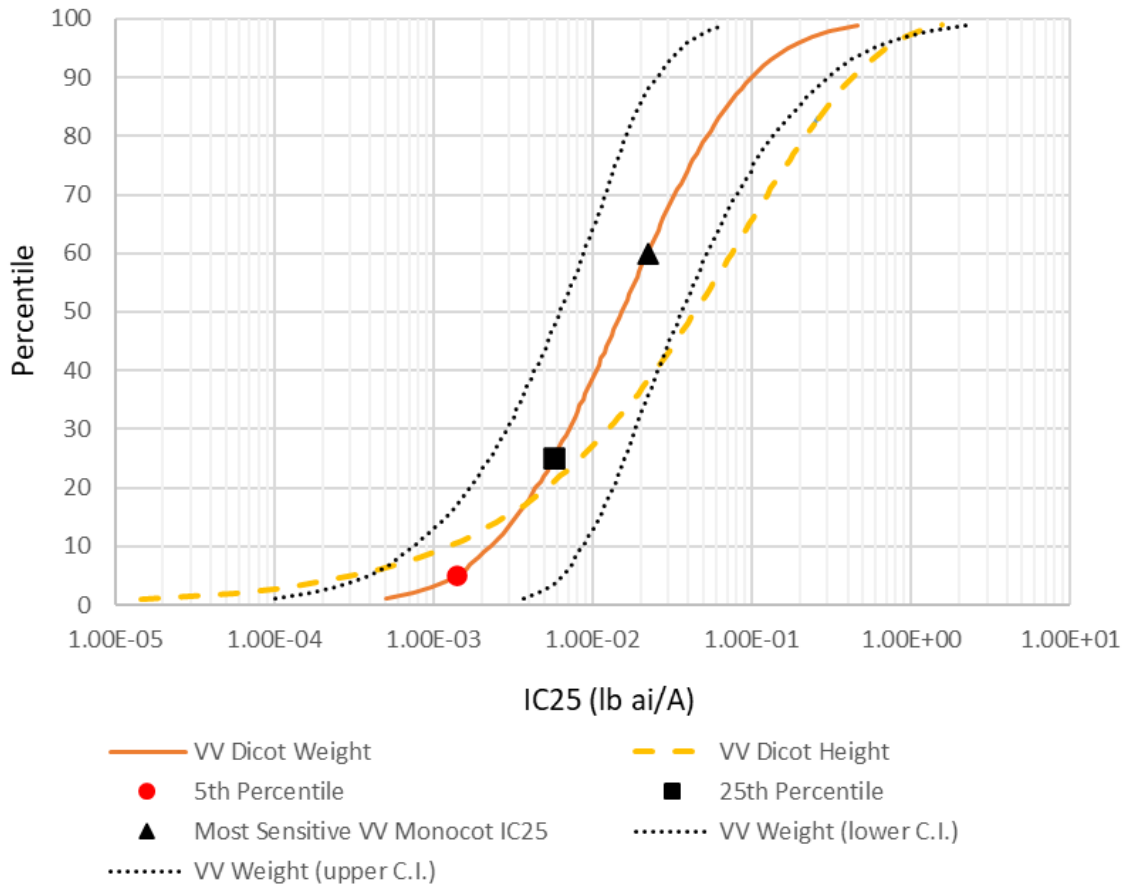


**Figure 7-2. Vegetative Vigor (VV) Study Species Sensitivity Distributions (SSDs) representing the Distributions of the Dicot Height and Weight IC25s for Dicamba. The Upper and Lower Confidence Intervals (C.I.) are plotted for the VV weight SSD. Also shown is where the most sensitive monocot VV weight $IC_{25}$ is located on the SSD.**

**Table 7-3. Summary of Species Sensitivity Distribution (SSD) Results for Dicots for Dicamba**

| Percentile (x) | Vegetative Vigor Test: Dicots | |
|---|---|---|
| | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** |
| 5 | 0.0014 (0.00039 – 0.0065) | 0.00032 (0.00021 – 0.0074) |
| 25 | 0.0057 (0.0023 – 0.016) | 0.0084 (0.0016 – 0.046) |
| 50 | 0.015 (0.0062 – 0.036) | 0.044 (0.012 – 0.14) |

**Bolded** endpoints indicate the most sensitive endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed dicots, animals that depend obligately on dicots, and animals that generally depend on monocots/dicots. For listed monocots and animals that obligately depend on monocots, the most sensitive $IC_{25}$ value was used (shown in **Table 7-2** and **Table 7-4**).

**Table 7-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Dicamba[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | Monocots: 0.0924 lb a.e./A<br>Dicots: 0.0014 lb a.e./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | Monocots: 0.0924 lb a.e./A<br>Dicots: 0.0014 lb a.e./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | Monocots: 0.0924 lb a.e./A<br>Dicots: 0.0014 lb a.e./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | Monocots: 0.0924 lb a.e./A<br>Dicots: 0.0014 lb a.e./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | Monocots: 0.0924 lb a.e./A<br>Dicots: 0.0014 lb a.e./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | Based on terrestrial plant dicot SSD: 0.0057 lb a.e./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant dicot SSD: 0.0057 lb a.e./A |
| | | Based on aquatic plant endpoints: 1290 µg a.e./L (Vascular), 61 µg a.e./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 1290 µg a.e./L<br>Nonvascular: 61 µg a.e./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Herbicide Strategy. In this case study for dicamba, EPA calculated eight sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.e./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.e./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.e./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 7.3.2 Incidents

The summary of the incident information from the 2022 Draft Risk Assessment (DP460423) is included below, focusing on the plant incidents only. The 2022 assessment provides an in-depth characterization of these incidents. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[55] (as discussed in **Section 7.3.3.3**), which informs the potential population-level impacts (**Section 7.6**), and to identify the proposed level of mitigation (see **Section 7.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 7.3.3.3**).[56] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

Dicamba use has been associated with incident reports of damage to a wide variety of plants, predominantly from residential uses and off-site damage to non-dicamba tolerant soybeans from agricultural applications. Until the approval of over-the-top (OTT) use on dicamba tolerant (DT) plants, localized small-scale residential uses (*e.g.,* lawn care products) previously accounted for most alleged incidents. Prior to the registration of OTT use on DT-plants (cotton and soybean) for the 2017 growing season, there were almost 11,800 alleged incidents associated with dicamba that occurred between 1981 and 2016 and were reported in the Incident Data System (IDS)[57] at the time of the last database search in June 2021. Over 90% of those incidents were associated with residential uses.

The high number of incidents of direct impacts to plants off of the treated field is one line of evidence supporting the setting of the medium category of magnitude of effect at magnitude of difference values between 1 and 10 for dicamba (**Section 7.3.3.3**).

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[55] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[56] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

[57] Some ecological incidents were formerly located in the Ecological Incident Information System (EIIS) and the incidents reported within were integrated into IDS.

### 7.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *7.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 7-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoints to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of dicamba ($5^{th}$ percentile of the dicot SSD = 0.0014 lb a.e./A for dicots; most sensitive toxicity endpoint = 0.0924 lb a.e./A for monocots). To estimate potential diet/habitat impacts to generalist animals, EPA selected the most sensitive endpoint applicable for generalists (*i.e.,* $25^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore, in **Table 7-5**, EPA based the spray drift distances for generalist animals on the $25^{th}$ percentile of dicot SSD (0.0057 lb a.e./A).

Within **Table 7-5**, the modeled application rates are representative of the maximum single application rate currently registered for dicamba on non-GMO agricultural uses (*i.e.,* corn, cotton, soybean, sugarcane, fallow land, and fields where various grains are grown; 1.0 lb a.e./A) and reduced rates (0.50, 0.25, 0.12 lb a.e./A) representative of maximum single application rates for other uses (**Table 7-1**). **Table 7-5** gives the distance at which the spray drift deposition equals the $5^{th}$ percentile of the dicot SSD, monocot $IC_{25}$, or $25^{th}$ percentile of the dicot SSD, and also the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size, as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 7.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 7.9**). This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland

plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 7-5. Spray Drift Distances to the Population-Level Impacts Endpoint for for Dicamba for Listed Terrestrial and Wetland Plants and Listed Animals that Depend on Plants, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| Application Rate (lb a.e./A) | | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|---|
| | | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Listed Monocots and Listed Animals that Obligately Depend on Monocots** | | | | | | | | |
| 1.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | 125 | 75 | 50 | 50 | 10 | 10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.3 [300] | 0.2 [300] | 0.2 [200] | 0.1 [200] | 0.1 [100] | 0.1 [100] | <0.1 [100] |
| 0.25 (maximum rate for use on sorghum) | Distance to Medium MoE[2,3] (ft) | 10 | 10 | 10 | 10 | <10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.1 [300] | <0.1 [300] | <0.1 [200] | <0.1 [200] | <0.1 [100] | <0.1 [100] | <0.1 [100] |
| 0.12 (maximum rate for use on triticale) | Distance to Medium MoE[2,3] (ft) | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | <0.1 [300] | <0.1 [300] | <0.1 [200] | <0.1 [200] | <0.1 [100] | <0.1 [100] | <0.1 [100] |
| **Listed Dicots and Listed Animals that Obligately Depend on Dicots** | | | | | | | | |
| 1.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | >1000 | 800 | 500 | 450 | 425 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **22** [300] | **10** [300] | **11** [200] | **8.7** [200] | **6.9** [100] | **5.1** [100] | **3.2** [100] |
| 0.25 (maximum rate for use on sorghum) | Distance to Medium MoE[2,3] (ft) | >1000 | 900 | 500 | 375 | 175 | 125 | 75 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **5.4** [300] | **2.6** [300] | **2.7** [200] | **2.2** [200] | **1.7** [100] | **1.3** [100] | 0.8 [100] |
| 0.12 (maximum rate for use on triticale) | Distance to Medium MoE[2,3] (ft) | 1000 | 375 | 250 | 200 | 75 | 50 | 25 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.6** [300] | **1.2** [300] | **1.3** [200] | **1.0** [200] | 0.8 [100] | 0.6 [100] | 0.4 [100] |

| Application Rate (lb a.e./A) | | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|---|
| | | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Listed Generalist Animals** | | | | | | | | |
| 1.0 (maximum rate) | Distance to Medium MoE[2,3] (ft) | >1000 | 900 | 475 | 375 | 175 | 125 | 75 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **5.3** [300] | **2.5** [300] | **2.6** [200] | **2.1** [200] | **1.7** [100] | **1.2** [100] | 0.8 [100] |
| 0.25 (maximum rate for use on sorghum) | Distance to Medium MoE[2,3] (ft) | 400 | 225 | 150 | 125 | 50 | 25 | 20 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.3** [300] | 0.6 [300] | 0.7 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| 0.12 (maximum rate for use on triticale) | Distance to Medium MoE[2,3] (ft) | 200 | 125 | 75 | 50 | 20 | 10 | 10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.3 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the vegetative vigor endpoint for monocots (0.0924 lb a.e./A), the 5$^{th}$ percentile of the SSD for dicots (0.0014 lb a.e./A), and the 25$^{th}$ percentile of the dicot SSD for generalist animals (0.0057 lb a.e./A) are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For dicamba, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 7.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE >25 ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 7.9** contains the full output of results.

#### *7.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1.**

**Table 7-6** through **Table 7-10** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, monocot $IC_{25}$, 5th or 25th percentile of the dicot plant SSD).

**Table 7-6. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Asparagus | 2.6 – 23 | 0.002 – 0.02 | 0.04 – 0.38 |
| Barley | 1.4 – 5.31 | 0.001 – 0.004 | 0.02 – 0.09 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 3.0 – 47 | 0.002 – 0.04 | 0.05 – 0.77 |
| Corn | 6.1 – 40 | 0.005 –0.03 | 0.10 – 0.65 |
| Cotton | 6.1 – 33 | 0.005 –0.03 | 0.11 – 0.54 |
| Oats | 0.19 – 3.9 | <0.001 – 0.003 | 0.003 – 0.06 |
| Proso Millet | 0.62 – 3.3 | <0.001 – 0.003 | 0.01 – 0.05 |
| Sorghum | 0.63 – 42 | <0.001 – 0.03 | 0.01 – 0.68 |
| Soybean | 5.9 – 58 | 0.005 – 0.05 | 0.10 – 0.95 |
| Sugarcane | 6.1 – 19 | 0.005 – 0.02 | 0.10 – 0.32 |
| Triticale | 0.65 – 6.6 | 0.001 – 0.01 | 0.01 – 0.11 |
| Wheat | 0.89 – 8.3 | 0.001 – 0.01 | 0.01 – 0.14 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for dicamba, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 7-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Monocots | Wetland Dicots | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Asparagus | 0.05 – 0.23 | 0.49 – 2.5 | 33 – 170 | 41 – 1300 | 0.03 – 1.0 | 0.67 – 21 |
| Barley | 0.02 – 0.13 | 0.26 – 1.4 | 17 – 89 | 23 – 780 | 0.02 – 0.61 | 0.37 – 13 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.04 – 0.68 | 0.41 – 7.4 | 27 – 490 | 50 – 4200 | 0.04 – 3.2 | 0.82 – 68 |
| Corn | 0.11 - 0.33 | 1.2 – 3.5 | 76 – 230 | 130 – 1900 | 0.10 – 1.4 | 2.1 – 30 |
| Cotton | 0.15 – 0.44 | 1.6 – 4.7 | 110 - 310 | 200 – 210 | 0.15 – 1.6 | 3.2 – 35 |
| Oats | 0.004 – 0.09 | 0.05 – 0.96 | 3.2 – 64 | 17 - 400 | 0.01 – 0.31 | 0.28 – 6.6 |
| Proso Millet | 0.01 – 0.05 | 0.12 – 0.50 | 7.9 – 33 | 14 – 320 | 0.01 – 0.25 | 0.23 – 5.3 |
| Sorghum | 0.01 – 0.54 | 0.15 – 5.8 | 9.6 – 390 | 57 - 3700 | 0.04 – 2.9 | 0.94 – 61 |
| Soybean | 0.15 – 0.51 | 1.6 – 5.5 | 110 – 360 | 170 – 3600 | 0.13 – 2.8 | 2.7 – 59 |
| Sugarcane | 0.11 – 0.26 | 1.1 – 2.8 | 76 – 180 | 110 – 1800 | 0.09 – 1.4 | 1.9 – 29 |
| Triticale | 0.01 – 0.13 | 0.12 – 1.4 | 7.9 – 91 | 12 – 880 | 0.01 – 0.68 | 0.19 – 15 |
| Wheat | 0.02 – 0.13 | 0.18 – 1.4 | 12 – 89 | 33 – 870 | 0.03 – 0.67 | 0.55 – 14 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 7-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Monocots and Dicots and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Monocots and/or Dicots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Asparagus | 0.05 – 0.23 | 8.0 – 41 |
| Barley | 0.02 – 0.13 | 4.3 – 22 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.04 – 0.68 | 6.6 – 120 |
| Corn | 0.11 - 0.33 | 19 – 57 |
| Cotton | 0.15 – 0.44 | 26 – 77 |
| Oats | 0.004 – 0.09 | 0.79 – 16 |
| Proso Millet | 0.01 – 0.05 | 1.9 – 8.2 |
| Sorghum | 0.01 – 0.54 | 2.4 – 95 |
| Soybean | 0.15 – 0.51 | 26 – 89 |
| Sugarcane | 0.11 – 0.26 | 19 – 45 |
| Triticale | 0.01 – 0.13 | 1.9 – 23 |
| Wheat | 0.02 – 0.13 | 2.9 – 22 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 7-7**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] A Species Sensitivity Distribution is not available for monocots for dicamba. For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the 25$^{th}$ percentile of the dicot SSD.

**Table 7-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Monocots | Terrestrial Dicots |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Range of Magnitude of Difference[2] |
| Asparagus | 0.05 – 0.17 | 0.57 – 1.8 | 38 – 120 |
| Barley | 0.03 – 0.07 | 0.29 – 0.74 | 19 – 49 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.03 – 0.35 | 0.35 – 3.8 | 23 – 250 |
| Corn | 0.13 – 0.17 | 1.4 – 1.8 | 90 – 120 |
| Cotton | 0.15 – 0.36 | 1.6 – 3.9 | 110 – 260 |
| Oats | 0.003 – 0.05 | 0.03 – 0.50 | 2.3 – 33 |
| Proso Millet | 0.01 – 0.03 | 0.14 – 0.35 | 9.0 – 23 |
| Sorghum | 0.01 – 0.35 | 0.14 – 3.8 | 9.5 - 250 |
| Soybean | 0.14 – 0.37 | 1.6 – 4.0 | 100 – 260 |
| Sugarcane | 0.13 – 0.34 | 1.4 – 3.7 | 92 – 250 |
| Triticale | 0.01 – 0.13 | 0.14 – 1.4 | 9.1 – 93 |
| Wheat | 0.02 – 0.13 | 0.20 – 1.4 | 13 – 94 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 7-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Monocots and Dicots and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Monocots and/or Dicots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Asparagus | 0.05 – 0.17 | 9.2 – 30 |
| Barley | 0.03 – 0.07 | 4.6 – 12 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.03 – 0.35 | 5.6 – 61 |
| Corn | 0.13 – 0.17 | 22 – 30 |
| Cotton | 0.15 – 0.36 | 26 – 63 |
| Oats | 0.003 – 0.05 | 0.57 – 8.2 |
| Proso Millet | 0.01 – 0.03 | 2.2 – 5.8 |
| Sorghum | 0.01 – 0.35 | 2.3 – 61 |
| Soybean | 0.14 – 0.37 | 25 – 64 |
| Sugarcane | 0.13 – 0.34 | 23 – 60 |
| Triticale | 0.01 – 0.13 | 2.2 – 23 |
| Wheat | 0.02 – 0.13 | 3.3 – 23 |

[1] The ranges of magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[2] A Species Sensitivity Distribution is not available for monocots for dicamba. For animals that generally rely upon terrestrial plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in terrestrial habitats is the ratio of the EEC to the 25$^{th}$ percentile of the dicot SSD.

#### *7.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 7-11**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 7.3.3.1** and **7.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories is discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories is influential for identifying mitigation measures (**Section 7.4**) and conducting a population-level impact analysis (**Section 7.6**).

For dicamba, given the toxicity profile (including only about a 4X difference between the 5th and 25th percentiles of the most sensitive dicot SSD with a relatively steep slope)[58] and given the high number of untreated area plant incidents (see **Section 7.3.2**), EPA assigned a low magnitude of effect in **Table 7-11** on a use basis to groups of listed species and critical habitats (CHs)[59] when the magnitude of difference is less than 1. For low magnitude of effect (when the magnitude of difference is <1), population-level impacts are not expected. EPA assigned a medium, high, or very high magnitude of effect in **Table 7-11** when the magnitude of difference is from 1 to 10, 10 up to 100, or greater than 100, respectively.

**Table 7-11. Use-Based Magnitude of Effect for Dicamba.[1]**

| Use | Terrestrial | | | Wetland and Small Waterbodies[2] | | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | | Generalist Animals and CHs[4] | Plants and Obligate Animals | | Generalist Animals and CHs[4] | Plants[5], Obligate & Generalist Animals[6], CHs |
| | Monocots | Dicots | | Monocots | Dicots | | |
| Asparagus | Medium | Very High | High | Medium | Very High | High | Low |
| Barley | Low | High | High | Low | High | High | Low |
| Fields where grains are grown (not the crops themselves) | Medium | Very High | High | Medium | Very High | High | Low |
| Corn | Medium | Very High | High | Medium | Very High | High | Low |
| Cotton | Medium | Very High | High | Medium | Very High | High | Low |
| Oats | Low | High | Medium | Low | High | Medium | Low |
| Proso Millet | Low | High | Medium | Low | High | Medium | Low |
| Sorghum | Medium | Very High | High | Medium | Very High | High | Low |
| Soybean | Medium | Very High | High | Medium | Very High | High | Low |
| Sugarcane | Medium | Very High | High | Medium | Very High | High | Low |
| Triticale | Low | High | Medium | Low | High | Medium | Low |
| Wheat | Medium | High | High | Low | High | High | Low |

CH=designated critical habitat

[58] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[59] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 7.3.3.3**) and to conduct the population-level impacts analysis (**Section 7.6**). If the magnitude of effect is medium or higher for dicamba, EPA determined that there is a potential for population-level impacts.
[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).
[4] For animals that generally rely upon terrestrial/wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots, and $IC_{50}$ for aquatic plants (applicable for wetlands and small waterbodies only)). The magnitude of effect in this table reflects the highest magnitude of difference calculated for generalists for each use, which is based on the 25$^{th}$ percentile of the dicot SSD (see **Table 7-7, Table 7-8**, and **Table 7-10**).
[5] All listed aquatic plants are also found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.
[6] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. Therefore, the results for obligate and generalist animals in larger waterbodies are equivalent.

## 7.4 Framework Step 2: Identify Mitigation Measures

**Section 7.4** outlines the mitigation measures identified for dicamba for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 7.4.1**) and runoff/erosion (**Section 7.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 7.4.1 Spray Drift Mitigation Measures Identified

**Table 7-12** presents the spray drift buffers EPA identified to address potential population-level impacts to listed terrestrial and wetland dicots and listed animals that obligately depend on these plants. Although EPA calculated spray drift buffer distances for listed monocots and animals obligately depending on monocots in **Table 7-5**, the spray drift buffer distances for listed monocots and animals obligately depending on monocots are shorter than the distances for generalist animals. This is because EPA used the 25$^{th}$ percentile of the dicot SSD to calculate the buffer distances for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the dicot SSD, EPA identified larger spray drift buffer distances for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the extent of the spray drift buffers, EPA grouped listed monocots and animals that obligately rely on monocots with generalist animals, and EPA relied upon the results based on

the 25th percentile of the dicot SSD to determine the spray drift buffer distances. **Table 7-13** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed monocots, animals that obligately rely on monocots, and animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 7-12. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Dicots and Animals that Obligately Depend on Dicots as Related to Single Maximum Application Rate, Application Method, and Droplet Size.[1]**

| Single Maximum Application Rate (lb ae/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.0 | 300 + windbreak[3] | 300 + windbreak[3] | 200 + windbreak[3] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 0.25 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 75[e,f,g] |
| 0.12 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 75[f,g] | 50[f,g] | 25[h] |
| Mitigation measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70% | | | [d] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[e] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 7-1.**
[3] Additional mitigation measures (*e.g.,* windbreak, hedgerow) would apply for aerial applications at a 1.0 lb a.e./A rate because the magnitude of difference exceeds 10 at the maximum buffer distance. Use of additional mitigation measures do not result in reduced buffer distances.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 7-13. Spray Drift Mitigations Measures Identified for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Animal Generalists as Related to Single Maximum Application Rate, Application Method, and Droplet Size.[1,2]**

| Single Maximum Application Rate (lb ae/A)[3] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 75[f,g,h] |
| 0.25 | 300[a,b,c] | 225[a,b] | 150[b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| 0.12 | 200[a,b] | 125[b,d] | 75[b,d] | 50[g,h] | 20[i] | 10[i] | 10[i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] EPA proposes to use the spray drift buffer distances in this table (based on the 25th percentile of the dicot SSD) for listed monocots, animals obligately relying on monocots, and generalist animals. This is due to the differential sensitivity of monocots and dicots to dicamba and the shorter spray drift distances modeled for monocots than for generalist animals (due to the toxicity to dicots driving the spray drift distances for generalists; see **Table 7-5**).
[3] Single maximum label rates reflect the range of uses represented in **Table 7-1.**
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 7.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of the runoff mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts differs across uses and, as shown in **Figure 7-3**, the level of mitigation is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed plants (5th percentile endpoint), generalists (25th percentile endpoint)). **Figure 7-3** visually represents the targeted reduction in EECs through the implementation of runoff mitigation for dicamba.

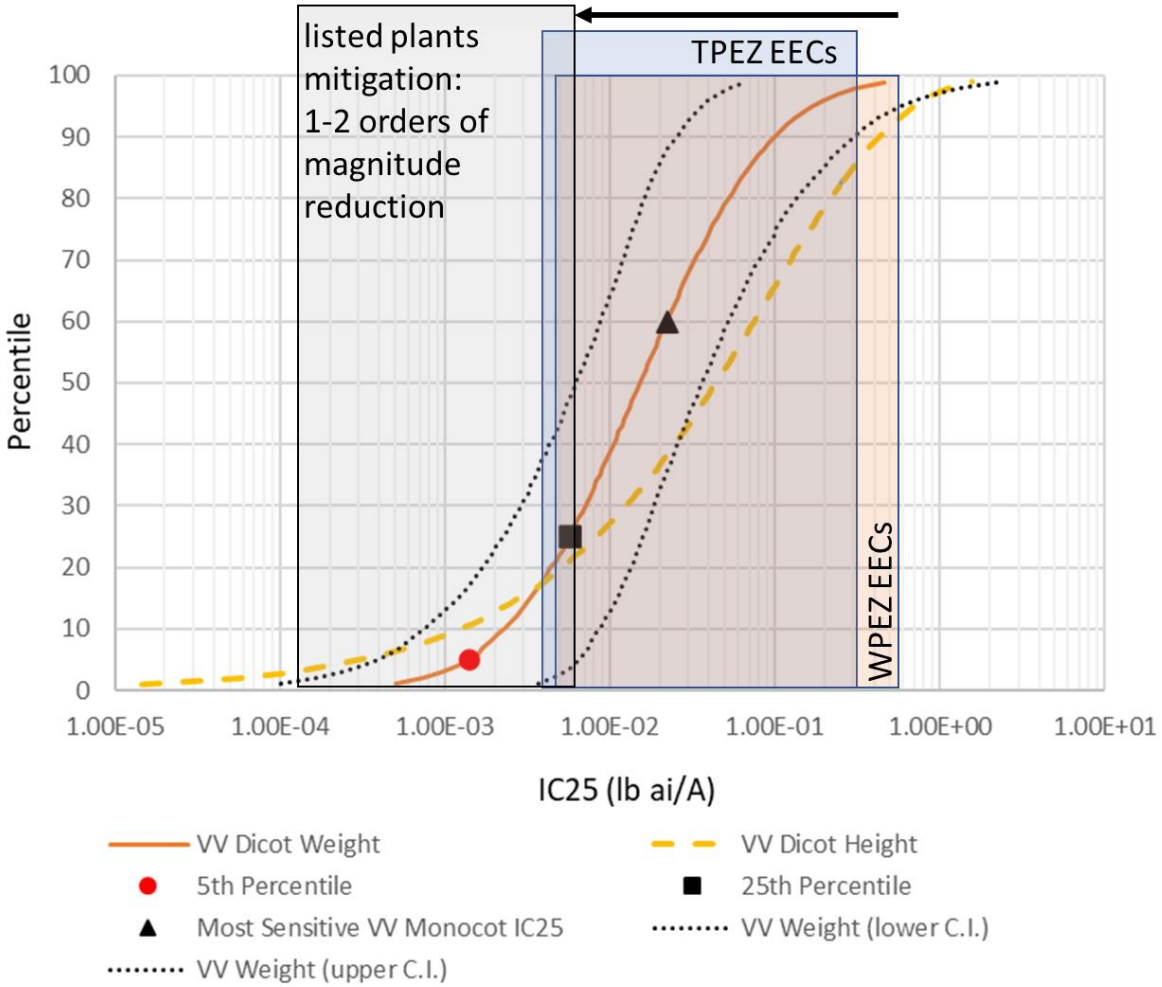


**Figure 7-3. Dicamba Vegetative Vigor (VV) Dicot Weight and Height Species Sensitivity Distributions (SSD) and the Most Sensitive Monocot Endpoint Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5$^{th}$ percentile (represents listed dicots and animals with obligate relationships to dicots) and the 25$^{th}$ percentile (represents listed generalists and designated Critical Habitat) from the VV dicot weight SSD for dicot related evaluations, and the most sensitive monocot endpoint for direct impacts to monocots and animals with obligate relationships to monocots. Upper and lower confidence intervals (C.I.) are provided for the VV dicot weight SSD.**

For dicamba, see **Section 6.3.3.27.3.3.2** for more details on the magnitude of difference between EECs and toxicity endpoints and the mitigation identification for each use separated by plant and animal groups. EPA assigns the mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in Section 5.2 in the Strategy Framework document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of

dicamba is <1,000 L/kg-o.c. (mean $K_{OC}$ = 13.4 L/kg-o.c.), higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework** EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation is identified. If the magnitude of difference is between 10 and 100, medium mitigation is identified, and if it is between 100 and 1,000, high mitigation is identified. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For dicamba, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for dicamba, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this case study.

- For listed aquatic plants and animals that depend on aquatic plants[60] and designated Critical Habitats in waterbodies similar in size to the EPA farm pond or larger[61], no mitigations are identified to reduce the likelihood of potential population-level impacts (**Table 7-14**).
- For semi-aquatic/wetland monocots and the animals that obligately depend on these plants[62], no mitigation is identified for five of the uses (barley, oats, proso millet, triticale, wheat), whereas EPA identified low mitigation for the rest of the uses[63] (**Table 7-15**).
- For semi-aquatic/wetland dicots and the animals that obligately depend on these plants[62], EPA identified medium mitigation for five of the uses (barley, oats, proso millet, triticale, wheat) but high mitigation for the rest of the uses (**Table 7-15**).
- For aquatic plants in wetlands or small waterbodies[64] and for animals that depend on these plants (both obligately and generally[65]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. The resulting mitigation category is low for five uses (use on fields that grow grains, cotton, sorghum, soybean, sugarcane) for aquatic vascular plants, whereas no mitigation is identified for the other uses of dicamba (**Table**

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[60] None of the listed aquatic animals have obligate relationships to plants.
[61] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** in the **Case Study Summary and Process** document for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[62] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[63] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios ≥1000), High (ratios ≥100 but <1000), Medium (ratios ≥10 but <100), Low (ratios ≥1 but <10), No Mitigation (ratios <1).
[64] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[65] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

**7-15**). For nonvascular plants in wetlands or small waterbodies, EPA identified low mitigation for four of the uses (oats, proso millet, triticale, wheat) and medium mitigation for all other uses (**Table 7-15**).

- For animals that have a generalist relationship[65] to wetland plants, the mitigation category is low for use on oats, proso millet, and triticale and medium for all other use patterns (**Table 7-16**).
- For terrestrial monocots and the animals that obligately depend on these plants, EPA identified no mitigation for four of the uses (barley, oats, proso millet, triticale) and low mitigation for all other uses (**Table 7-17**).
- For terrestrial dicots and the animals that obligately depend on these plants, EPA identified medium mitigation for five of the uses (barley, oats, proso millet, triticale, wheat) and high mitigation for the other uses (**Table 7-17**).
- For animals that have a generalist relationship[65] to terrestrial plants, the mitigation category is low for use on oats, proso millet, and triticale and medium for all other use patterns (**Table 7-18**).

**Table 7-14. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Asparagus | 2.6 – 23 | 0.002 – 0.02 | No mitigation | 0.04 – 0.38 | No mitigation |
| Barley | 1.4 – 5.31 | 0.001 – 0.004 | No mitigation | 0.02 – 0.09 | No mitigation |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 3.0 – 47 | 0.002 – 0.04 | No mitigation | 0.05 – 0.77 | No mitigation |
| Corn | 6.1 – 40 | 0.005 –0.03 | No mitigation | 0.10 – 0.65 | No mitigation |
| Cotton | 6.1 – 33 | 0.005 –0.03 | No mitigation | 0.11 – 0.54 | No mitigation |
| Oats | 0.19 – 3.9 | <0.001 – 0.003 | No mitigation | 0.003 – 0.06 | No mitigation |
| Proso Millet | 0.62 – 3.3 | <0.001 – 0.003 | No mitigation | 0.01 – 0.05 | No mitigation |
| Sorghum | 0.63 – 42 | <0.001 – 0.03 | No mitigation | 0.01 – 0.68 | No mitigation |
| Soybean | 5.9 – 58 | 0.005 – 0.05 | No mitigation | 0.10 – 0.95 | No mitigation |
| Sugarcane | 6.1 – 19 | 0.005 – 0.02 | No mitigation | 0.10 – 0.32 | No mitigation |
| Triticale | 0.65 – 6.6 | 0.001 – 0.01 | No mitigation | 0.01 – 0.11 | No mitigation |
| Wheat | 0.89 – 8.3 | 0.001 – 0.01 | No mitigation | 0.01 – 0.14 | No mitigation |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for dicamba, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 7-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Monocots | | Wetland Dicots | | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Asparagus | 0.05 – 0.23 | 0.49 – 2.5 | Low | 33 – 170 | High | 41 – 1300 | 0.03 – 1.0 | No mitigation[6] | 0.67 – 21 | Medium |
| Barley | 0.02 – 0.13 | 0.26 – 1.4 | No mitigation[6] | 17 – 89 | Medium | 23 – 780 | 0.02 – 0.61 | No mitigation | 0.37 – 13 | Medium |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.04 – 0.68 | 0.41 – 7.4 | Low | 27 – 490 | High | 50 – 4200 | 0.04 – 3.2 | Low | 0.82 – 68 | Medium |
| Corn | 0.11 - 0.33 | 1.2 – 3.5 | Low | 76 – 230 | High | 130 – 1900 | 0.10 – 1.4 | No mitigation[6] | 2.1 – 30 | Medium |
| Cotton | 0.15 – 0.44 | 1.6 – 4.7 | Low | 110 - 310 | High | 200 – 2100 | 0.15 – 1.6 | Low | 3.2 – 35 | Medium |
| Oats | 0.004 – 0.09 | 0.05 – 0.96 | No mitigation | 3.2 – 64 | Medium | 17 - 400 | 0.01 – 0.31 | No mitigation | 0.28 – 6.6 | Low |
| Proso Millet | 0.01 – 0.05 | 0.12 – 0.50 | No mitigation | 7.9 – 33 | Medium | 14 – 320 | 0.01 – 0.25 | No mitigation | 0.23 – 5.3 | Low |
| Sorghum | 0.01 – 0.54 | 0.15 – 5.8 | Low | 9.6 – 390 | High | 57 - 3700 | 0.04 – 2.9 | Low | 0.94 – 61 | Medium |
| Soybean | 0.15 – 0.51 | 1.6 – 5.5 | Low | 110 – 360 | High | 170 – 3600 | 0.13 – 2.8 | Low | 2.7 – 59 | Medium |
| Sugarcane | 0.11 – 0.26 | 1.1 – 2.8 | Low | 76 – 180 | High | 110 – 1800 | 0.09 – 1.4 | Low | 1.9 – 29 | Medium |
| Triticale | 0.01 – 0.13 | 0.12 – 1.4 | No mitigation[6] | 7.9 – 91 | Medium | 12 – 880 | 0.01 – 0.68 | No mitigation | 0.19 – 15 | Low[6] |
| Wheat | 0.02 – 0.13 | 0.18 – 1.4 | No mitigation[6] | 12 – 89 | Medium | 33 – 870 | 0.03 – 0.67 | No mitigation | 0.55 – 14 | Low[6] |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.
[5] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation needs.
[6] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 7-15** outlines the proposed mitigation categories identified for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[66]. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[67]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 3.3**. For dicamba, EPA determined the proposed mitigation categories presented in **Table 7-15** based on the weight of evidence discussed below, which is specifically relevant for use on asparagus, barley, corn, triticale, and wheat.

In **Table 7-15**, the magnitude of difference for aquatic vascular plants ranges from 0.03 to 1.0 for use on asparagus. When considering aquatic vascular plants, EPA identified no mitigation for this use because the highest ratio is equivalent to, but does not exceed, the threshold for requiring low mitigation (*i.e.,* 1.0).

For use on barley, the magnitude of difference ranges from 0.26 to 1.4 for wetland monocots. Out of 42 wetland magnitude of difference values estimated for use on barley, only two indicated the low mitigation category, whereas the rest indicated no mitigation. Given that 95% of the scenarios resulted in a magnitude of difference that indicates no mitigation, EPA set the category as no mitigation for use on barley to protect listed wetland monocots and animals obligately depending on these plants.

For use on corn, the magnitude of difference ranges from 0.10 to 1.4 for aquatic vascular plants. Out of 21 wetland scenarios modeled for use on corn, only three fell in the low mitigation category, whereas the rest indicated no mitigation. Given that 86% of the scenarios resulted in a magnitude of difference that indicates no mitigation, EPA set the category as no mitigation for use on corn when considering aquatic vascular plants.

For use on triticale, the magnitude of difference ranges from 0.12 to 1.4 for wetland monocots. Out of 84 scenarios modeled for use on triticale, only one reached the low mitigation category, whereas the rest indicated no mitigation. Given that 99% of the scenarios resulted in a magnitude of difference that indicates no mitigation, EPA set the category at no mitigation for this use to protect listed wetland monocots and animals obligately depending on these plants. Similarly, the magnitude of difference ranges from 0.19 to 15 for aquatic nonvascular plants. Only one of the 84 wetland EECs resulted in a magnitude of difference corresponding to the medium mitigation category for nonvascular plants, whereas the rest indicated low mitigation. Given that 99% of the scenarios resulted in a magnitude of difference indicating low mitigation, EPA identified low mitigation for use on triticale when considering aquatic nonvascular plants.

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[66] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.e./A or µg a.e./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[67] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1**.

For use on wheat, the magnitude of difference ranges from 0.18 to 1.4 for wetland monocots. Out of 71 scenarios modeled for use on wheat, nine ratios exceeded 1.0, indicating low mitigation, whereas 62 scenarios indicated no mitigation. Given that 87% of the scenarios resulted in a magnitude of difference that indicates no mitigation, EPA set the mitigation category as no mitigation for this use to protect listed wetland monocots and animals obligately depending on these plants. Similarly, the magnitude of difference ranges from 0.55 to 14 for aquatic nonvascular plants. Eight of the 71 scenarios resulted in ratios that exceed 10 for nonvascular plants, indicating medium mitigation, whereas 63 scenarios indicated low mitigation. Given that 89% of the scenarios resulted in a magnitude of difference that indicates low mitigation, EPA identified low mitigation for use on wheat when considering aquatic nonvascular plants.

**Table 7-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Monocots and/or Dicots[4] | |
|---|---|---|---|
| | | Range of Magnitude of Difference | Mitigation Category |
| Asparagus | 0.05 – 0.23 | 8.0 – 41 | Medium |
| Barley | 0.02 – 0.13 | 4.3 – 22 | Medium |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.04 – 0.68 | 6.6 – 120 | Medium[5] |
| Corn | 0.11 – 0.33 | 19 – 57 | Medium |
| Cotton | 0.15 – 0.44 | 26 – 77 | Medium |
| Oats | 0.004 – 0.09 | 0.79 – 16 | Low[5] |
| Proso Millet | 0.01 – 0.05 | 1.9 – 8.2 | Low |
| Sorghum | 0.01 – 0.54 | 2.4 – 95 | Medium |
| Soybean | 0.15 – 0.51 | 26 – 89 | Medium |
| Sugarcane | 0.11 – 0.26 | 19 – 45 | Medium |
| Triticale | 0.01 – 0.13 | 1.9 – 23 | Low[5] |
| Wheat | 0.02 – 0.13 | 2.9 – 22 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 7-15**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] A Species Sensitivity Distribution is not available for monocots for dicamba. For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore,

the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the 25th percentile of the dicot SSD.
[5] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 7-16** outlines the proposed mitigation category identified for listed animals that generally rely on wetland plants and designated critical habitats for listed plants and animal in wetlands or small waterbodies[68]. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 4**. For dicamba, EPA determined the proposed mitigation categories presented in **Table 7-16** based on the weight of evidence discussed below, which is specifically relevant for use on fields that grow grains, oat, and triticale.

For use on fields where grains (*e.g.,* barley, oats, wheat, etc.) are grown (but not the crops themselves), the magnitude of difference ranges from 6.6 to 120 for animals generally relying on wetland plants. Out of 42 scenarios modeled for these uses, one magnitude of difference indicated low mitigation and one indicated high mitigation, whereas 40 scenarios indicated medium mitigation. Given that 95% of the scenarios resulted in a magnitude of difference indicating medium mitigation, EPA set the mitigation category as medium for the use on fields where grains are grown to protect listed animals that generally depend on wetland plants.

Similarly, for use on oats, the magnitude of difference ranges from 0.79 to 16 for animals generally relying on wetland plants. Out of 42 scenarios modeled for use on oats, one magnitude of difference ratio indicated no mitigation and two ratios indicated medium mitigation, with 39 scenarios indicating low mitigation. Given that 93% of the scenarios resulted in a magnitude of difference identifying low mitigation, EPA set the mitigation category as low for use on oats to protect listed animals that generally depend on wetland plants.

For use on triticale, the magnitude of difference ranges from 1.9 to 23 for animals generally relying on wetland plants. Out of 84 scenarios modeled for use on triticale, only four magnitude of difference ratios indicated that medium mitigation, whereas 80 indicated low mitigation. Given that 95% of the scenarios resulted in a magnitude of difference identifying low mitigation, EPA set the mitigation category as low for use on triticale.

[68] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.e./A or µg a.e./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

**Table 7-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Monocots | | Terrestrial Dicots | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category[3] | Range of Magnitude of Difference[2] | Mitigation Category[3] |
| Asparagus | 0.05 – 0.17 | 0.57 – 1.8 | Low | 38 – 120 | High |
| Barley | 0.03 – 0.07 | 0.29 – 0.74 | No mitigation | 19 – 49 | Medium |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.03 – 0.35 | 0.35 – 3.8 | Low | 23 – 250 | High |
| Corn | 0.13 – 0.17 | 1.4 – 1.8 | Low | 90 – 120 | High |
| Cotton | 0.15 – 0.36 | 1.6 – 3.9 | Low | 110 – 260 | High |
| Oats | 0.003 – 0.05 | 0.03 – 0.50 | No mitigation | 2.3 – 33 | Medium |
| Proso Millet | 0.01 – 0.03 | 0.14 – 0.35 | No mitigation | 9.0 – 23 | Medium |
| Sorghum | 0.01 – 0.35 | 0.14 – 3.8 | Low | 9.5 - 250 | High |
| Soybean | 0.14 – 0.37 | 1.6 – 4.0 | Low | 100 – 260 | High |
| Sugarcane | 0.13 – 0.34 | 1.4 – 3.7 | Low | 92 – 250 | High |
| Triticale | 0.01 – 0.13 | 0.14 – 1.4 | No mitigation[4] | 9.1 – 93 | Medium |
| Wheat | 0.02 – 0.13 | 0.20 – 1.4 | Low | 13 – 94 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Mitigations were identified whenever the magnitude of difference is >1.
[4] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 7-17** outlines the proposed mitigation category identified for listed terrestrial plants and animals that obligately rely on terrestrial plants. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 4**. For dicamba, EPA determined the proposed mitigation categories presented in **Table 7-17** based on the weight of evidence discussed below, which is specifically relevant for use on triticale.

For use on triticale, the magnitude of difference ranges from 0.14 to 1.4 for terrestrial monocots. Out of 84 ratios of EEC to endpoint estimated for this use, one ratio indicated low mitigation. Given that nearly all of the scenarios (99%) resulted in a magnitude of difference less than 1.0 for terrestrial monocots, EPA set the mitigation category at no mitigation.

**Table 7-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Monocots and/or Dicots[2] | |
|---|---|---|---|
| | | Range of Magnitude of Difference | Mitigation Category |
| Asparagus | 0.05 – 0.17 | 9.2 – 30 | Medium |
| Barley | 0.03 – 0.07 | 4.6 – 12 | Medium |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 0.03 – 0.35 | 5.6 – 61 | Medium |
| Corn | 0.13 – 0.17 | 22 – 30 | Medium |
| Cotton | 0.15 – 0.36 | 26 – 63 | Medium |
| Oats | 0.003 – 0.05 | 0.57 – 8.2 | Low |
| Proso Millet | 0.01 – 0.03 | 2.2 – 5.8 | Low |
| Sorghum | 0.01 – 0.35 | 2.3 – 61 | Medium |
| Soybean | 0.14 – 0.37 | 25 – 64 | Medium |
| Sugarcane | 0.13 – 0.34 | 23 – 60 | Medium |
| Triticale | 0.01 – 0.13 | 2.2 – 23 | Low[3] |
| Wheat | 0.02 – 0.13 | 3.3 – 23 | Medium |

[1] The ranges of magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[2] A Species Sensitivity Distribution is not available for monocots for dicamba. For animals that generally rely upon terrestrial plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* 25$^{th}$ percentile of the dicot SSD or $IC_{25}$ for monocots) while considering the differential toxicity of dicamba to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in terrestrial habitats is the ratio of the EEC to the 25$^{th}$ percentile of the dicot SSD.

[3] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 7-18** outlines the proposed mitigation categories identified for listed animals that generally rely on terrestrial plants and designated critical habitats for species in terrestrial environments. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 4**. For dicamba, EPA determined the proposed mitigation categories presented in **Table 7-18** based on the weight of evidence discussed below, which is specifically relevant for use on triticale.

For use on triticale, the magnitude of difference ranges from 2.2 to 23 for animals generally relying on terrestrial plants. Out of 84 scenarios modeled, only one magnitude of difference

ratio indicated medium mitigation. Given that nearly all of the scenarios (99%) resulted in a magnitude of difference that indicates low mitigation, EPA set the mitigation category as low for use on triticale to protect listed animals that generally depend on terrestrial plants.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, EPA assigns mitigation points based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 7-14** and **Table 7-15**) and wetland plants (**Table 7-15** and **Table 7-16**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the area is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, EPA assigned mitigation points based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 7-17**) and for generalist animals (**Table 7-18**).

**Table 7-19** and **Table 7-20** provide the runoff mitigation points identified for each evaluated use of dicamba. Although EPA calculated the magnitude of difference values and determined the runoff mitigation categories for listed monocots and listed animals that obligately rely on monocots, these values are not presented in **Table 7-19** and **Table 7-20**. The mitigation categories and mitigation points identified for listed monocots and animals obligately depending on monocots are lower than the values for generalist animals. This is because EPA used the 25$^{th}$ percentile of the dicot SSD to calculate the magnitude of difference for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the dicot SSD, EPA identified higher mitigation levels for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the runoff mitigation levels for dicamba, EPA grouped listed monocots and animals that obligately rely on monocots with generalist animals.

**Table 7-19. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Dicots and Animals Obligately Relying on Dicots (Mitigation Points) | Listed Monocots, Animals Obligately Relying on Monocots, Generalist Animals, and CHs (Mitigation Points) |
| Asparagus | High (9 pts) | Medium (6 pts) |
| Barley | Medium (6 pts) | Medium (6 pts) |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow | High (9 pts) | Medium (6 pts) |

| | | |
|---|---|---|
| these crops, not the crops themselves) | | |
| Corn | High (9 pts) | Medium (6 pts) |
| Cotton | High (9 pts) | Medium (6 pts) |
| Oats | Medium (6 pts) | Low (3 pts) |
| Proso Millet | Medium (6 pts) | Low (3 pts) |
| Sorghum | High (9 pts) | Medium (6 pts) |
| Soybean | High (9 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | Medium (6 pts) |
| Triticale | Medium (6 pts) | Low (3 pts) |
| Wheat | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 7-14** and **Table 7-15**), listed animals that obligately depend on aquatic and wetland plants (**Table 7-14** and **Table 7-15**), and listed animals that generally depend on aquatic and wetland plants (**Table 7-14**, **Table 7-15**, and **Table 7-16**).

### Table 7-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]

| Use | Terrestrial Habitats | |
|---|---|---|
| | **Dicots and Animals Obligately Relying on Dicots (Mitigation Points)** | **Listed Monocots, Animals Obligately Relying on Monocots, Generalist Animals, and CHs (Mitigation Points)** |
| Asparagus | High (9 pts) | Medium (6 pts) |
| Barley | Medium (6 pts) | Medium (6 pts) |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | High (9 pts) | Medium (6 pts) |
| Corn | High (9 pts) | Medium (6 pts) |
| Cotton | High (9 pts) | Medium (6 pts) |
| Oats | Medium (6 pts) | Low (3 pts) |
| Proso Millet | Medium (6 pts) | Low (3 pts) |
| Sorghum | High (9 pts) | Medium (6 pts) |
| Soybean | High (9 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | Medium (6 pts) |
| Triticale | Medium (6 pts) | Low (3 pts) |
| Wheat | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 7-17**), listed animals that obligately depend on terrestrial plants (**Table 7-17**), and listed animals that generally depend on terrestrial plants (**Table 7-18**).

## 7.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for dicamba are discussed in this section.

Dicamba targets broadleaf weeds (which are typically dicots); therefore, dicamba is more toxic to dicots than monocots. Given the higher toxicity to dicots, EPA identified more restrictive mitigations for listed dicots and listed animals that obligately rely on dicots than for other listed species such as listed monocots, listed animals that obligately rely on listed monocots, and generalist animals. Although monocots are less sensitive than dicots, EPA used the 25$^{th}$ percentile of the dicot SSD to calculate the magnitude of difference for generalist animals because generalist animals are assumed to rely on both monocots and dicots, depending on what is available in their habitat. By using the 25$^{th}$ percentile of the dicot SSD, EPA identified higher mitigation levels for generalist animals than for listed monocots (as explained in **Sections 7.4.1** and **7.4.2**). However, listed monocots and animals obligately relying on monocots occur in areas where listed generalist animals occur. Therefore, for identifying the extent of mitigation measures, EPA sorted the listed species into two groups for differential mitigations: listed dicots and animals that obligately rely on dicots vs. listed monocots, animals that obligately rely on monocots, and generalist animals.

As indicated above, EPA would generate two different sets of spray drift mitigation measures for this example: one for listed dicots (**Table 7-12**); and one for listed monocots, animals that obligately depend on monocots, and generalist animals that depend on plants (**Table 7-13**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate spray drift mitigations that would be applied on the general label and using Bulletins because the spray drift buffer distances are different for these two groups of species. For dicamba, the less restrictive mitigations relevant for listed monocots, listed animals obligately relying on monocots, and listed generalists animals that are depicted in **Table 7-13** would be applied to the general label because generalist animals are distributed widely across the United States and more restrictive mitigation is not needed for listed monocots nor animals that obligately depend on monocots. Listed monocots and animals that obligately rely on monocots occur in areas where generalist animals also occur; therefore, the higher mitigations based on the spray drift distances for generalists would be needed in these areas. The more restrictive mitigations identified in **Table 7-12** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed dicots and listed obligate animals occur. Specifically, in this example, EPA identified that the dicot PULAs (PULAs 1 and 3) would be applicable for dicamba.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats (**Section 5.3** of **Strategy Framework** document). However, for dicamba, the mitigations are identical for both of these habitat types. Like with the spray drift mitigations, there are different levels of runoff mitigations identified for listed dicots and animals obligately relying on dicots vs. listed monocots, animals obligately relying on monocots, and generalist animals (see **Table 7-19** and **Table 7-20**). **Table 7-21** summarizes the points identified for the different dicamba uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by two of the PULAs. PULAs 1 and 3 are grouped because the same mitigations would be applied to dicots in terrestrial habitats and in wetland and aquatic habitats. The monocot PULAs (PULAs 2 and 4) are not needed for dicamba because the mitigations for listed monocots are grouped with generalist animals.

**Table 7-21. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | Geographically Specific Mitigation Points |
|---|---|---|
| | Terrestrial, Aquatic, and Wetland Habitats | PULAs 1 and 3 (Terrestrial, Aquatic, and Wetland Habitats) |
| Asparagus | 6 | 9 |
| Barley | 6 | 6 |
| Barley, oat, small grains, sorghum, wheat (applied to fields that grow these crops, not the crops themselves) | 6 | 9 |
| Corn | 6 | 9 |
| Cotton | 6 | 9 |
| Oats | 3 | 6 |
| Proso Millet | 3 | 6 |
| Sorghum | 6 | 9 |
| Soybean | 6 | 9 |
| Sugarcane | 6 | 9 |
| Triticale | 3 | 6 |
| Wheat | 6 | 6 |

## 7.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in the **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 7.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of dicamba. For major crops (corn, cotton, wheat, and soybean), EPA selected the crop-specific UDLs. For other uses such as on asparagus and barley, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). As indicated in **Section 7.2**, EPA did not include the uses on fallow/idle cropland, which would be represented by the other crops UDL. EPA based its overlap analysis on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential dicamba use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 7-11**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 7-22** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected dicamba UDLs[69] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. However, for this illustrative example, EPA would only use two of the PULAs (PULAs 1 and 3). For the four PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For PULAs 1 and 3, EPA identified 338 listed dicots and animals obligately depending on dicots and 73 CHs as having >5% overlap with the cultivated landcover. For dicamba's UDLs, fewer species (278) and CHs (61) have >5% overlap. An important consideration for the purposes of this example is that EPA did not evaluate all registered uses of dicamba (see **Section 7.2**), so

[69] The selected use data layers (UDLs) do not represent every registered use of dicamba. See **Section 7.2** for more information on the selected uses evaluated in this example.

additional species could be identified in the future for dicamba. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of dicamba; however, the PULAs include some species and CHs that have <5% overlap with dicamba's potential exposure area for the considered uses.

**Table 7-22. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Dicamba Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Vegetables and Ground Fruit | 469 / 142 | 147 | 28 |
| Other Grains | | 236 | 51 |
| Corn | | 150 | 30 |
| Cotton | | 71 | 13 |
| Soybeans | | 88 | 9 |
| Wheat | | 160 | 33 |
| Total across all UDLs above[2] | | 278 | 61 |
| Cultivated | | 383 | 85 |
| Dicot PULAs (PULAs 1 and 3) | | 338 | 73 |
| **Listed Animal Generalists** | | | |
| Vegetables and Ground Fruit | 534 / 316 | 152 | 74 |
| Other Grains | | 255 | 118 |
| Corn | | 277 | 126 |
| Cotton | | 158 | 64 |
| Soybeans | | 190 | 75 |
| Wheat | | 267 | 116 |
| Total across all UDLs above[2] | | 350 | 164 |
| Cultivated | | 412 | 199 |

CH=designated critical habitat; PULA=pesticide use limitation area

[1] These values are based on EPA's analyses for example purposes for dicamba. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for dicamba (excluding the Cultivated UDL, which is summarized below this row).

## 7.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

As previously mentioned, the vegetative vigor endpoints are substantially more sensitive than the seedling emergence endpoints; therefore, EPA only considered the vegetative vigor data in the SSD analysis. Additionally, since the ranges of monocot and dicot toxicity endpoints have limited overlap (**Figure 7-1**), and the mean and median $IC_{25}$ values for monocots are up to 7.5 and 82 times greater than the dicot mean and median $IC_{25}$ values, respectively, EPA did not combine the data for monocots and dicots to generate a single SSD. The dicot dataset contained a sufficient number of distinct species and definitive endpoints to generate SSDs (n = 42 $IC_{25}$ values and 10 tested dicot species for the height data; n = 70 $IC_{25}$ values and 10 tested dicot species for the weight data). On the contrary, the monocot dataset did not contain sufficient data to generate robust SSDs (n = 12 $IC_{25}$ values but only 4 tested monocot species for the height data; n = 24 $IC_{25}$ values but only 4 tested monocot species for the weight data).

The 'Dicot v Monocot Comparisons' tab, the ranges of $IC_{25}$ values for plant height from the vegetative vigor studies are 0.00008 to 6.76 lb a.e./A (excluding non-definitive endpoints[70]) for dicots and 0.032 to 2.31 lb a.e./A (excluding non-definitive endpoints) for monocots, with mean $IC_{25}$ values of 0.28 and 0.86 lb a.e./A, respectively. For the dry weight data, the ranges of $IC_{25}$ values from the vegetative vigor studies are 0.0003 to 1.03 lb a.e./A (excluding non-definitive endpoints) for dicots and 0.022 to 2.42 lb a.e./A (excluding non-definitive endpoints) for monocots, with mean $IC_{25}$ values of 0.071 and 0.53 lb a.e./A, respectively.

[70] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 2 lb a.e./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 7.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

As explained previously in **Section 7.3.1** and **7.7**, the monocot and dicot toxicity data show substantial differences in sensitivity, so EPA could not generate combined (monocot plus dicot) SSDs. Because the number of monocot test species was limited and because vegetative vigor (VV) toxicity data (not seedling emergence toxicity data) are the driver for risk, EPA could reliably generate only two SSDs in total for dicamba. EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for vegetative vigor dry weight and height toxicity endpoints for dicot plants exposed to dicamba.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. **Section 7.7** and appendix subsections 5.1 and 5.2 below provide summary statistics from the fitted SSD for dry weight and height (if sufficient data are available). Following EPA's standard process, the Agency used the 5$^{th}$ and 25$^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the dicamba data and ran bootstrap goodness-of-fit tests with 10,000

replicates. Since distributions with p-values <0.05 are a poor fit to the endpoint data, EPA did not consider them further.

### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

### Distributions

The cumulative distribution functions for vegetative vigor SSDs, which EPA chose based on the process described above, are provided below. EPA made comparison of the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### Species Sensitivity Distribution (SSD) for Dicamba

As stated previously, SSDs were generated only for the dicot height and weight data from the vegetative vigor studies.

### Vegetative Vigor Height Data

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 6.5700e-04 | 0.5035 |
| 2 | logistic | ML | 5.3747e-04 | 0.3876 |
| 3 | triangular | ML | 7.0741e-04 | 0.5904 |
| 4 | gumbel | ML | 7.1933e-04 | 0.5944 |
| 5 | weibull | ML | 3.2038e-04 | 0.3546 |
| 6 | burr | ML | 0 | 0.4568 |

Figure A1. Vegetative Vigor Goodness of Fit

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0004596 |
| Model-averaged SE of HCp: | 0.0005750 |
| CV of HCp: | 1.2509 |

**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -26.2078 | 0 | 0.2504 | 7.0741e-04 | 5.0284e-04 |
| 2 | weibull | -26.1740 | 0.0338 | 0.2462 | 3.2038e-04 | 5.1001e-04 |
| 3 | burr | -25.5467 | 0.6611 | 0.1799 | 0 | 0 |
| 4 | normal | -25.3905 | 0.8172 | 0.1664 | 6.5700e-04 | 6.7305e-04 |
| 5 | logistic | -24.4175 | 1.7903 | 0.1023 | 5.3747e-04 | 6.5537e-04 |
| 6 | gumbel | -23.1629 | 3.0449 | 0.0546 | 7.1933e-04 | 5.2428e-04 |

Figure A2. Vegetative vigor height SSD Akaike's Information Criterion results.

Based on the goodness of fit, EPA moved forward with triangular and Weibull distributions, and ultimately selected the Weibull distribution for the height data from the vegetative vigor toxicity tests.

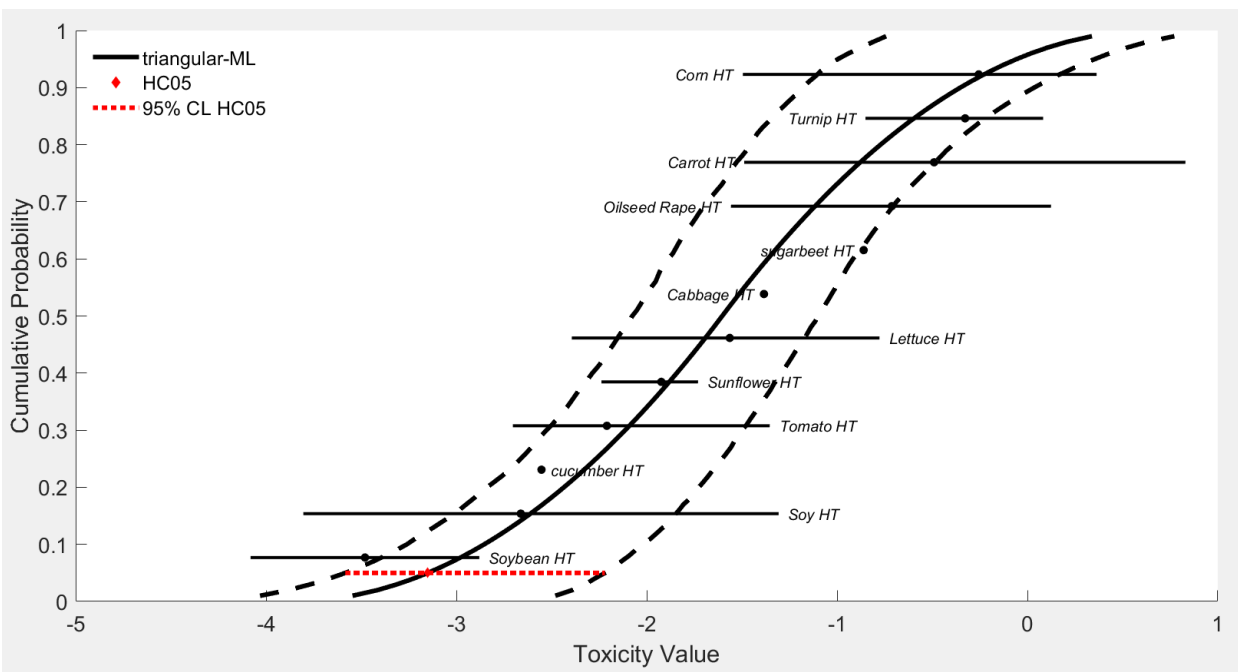


Figure A3. Vegetative vigor height SSD based on triangular distribution.

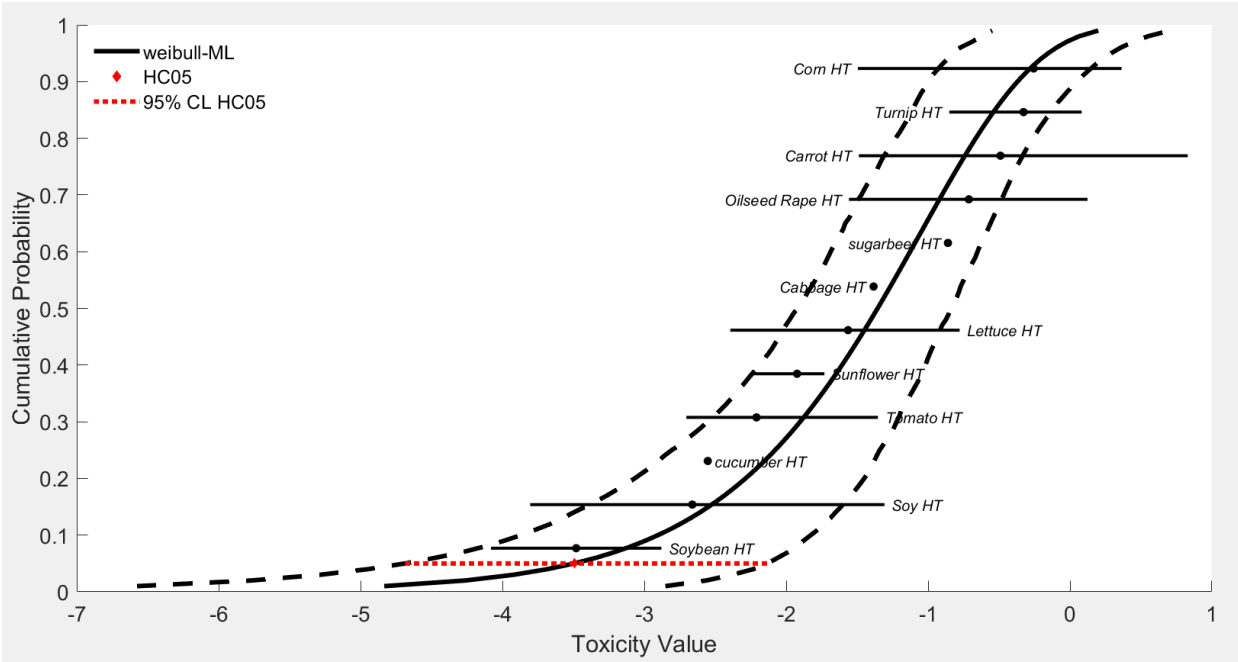


Figure A4. Selected vegetative vigor height SSD based on Weibull distribution.

## Vegetative Vigor Weight Data

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0014 | 0.2917 |
| 2 | logistic | ML | 0.0010 | 0.2218 |
| 3 | triangular | ML | 0.0016 | 0.3696 |
| 4 | gumbel | ML | 0.0018 | 0.4865 |
| 5 | weibull | ML | 6.2498e-04 | 0.2008 |
| 6 | burr | ML | 0.0018 | 0.3856 |

Figure A5. Vegetative Vigor Goodness of Fit

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0013777 |
| Model-averaged SE of HCp: | 0.0011727 |
| CV of HCp: | 0.85119 |

**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -42.9873 | 0 | 0.3385 | 0.0016 | 0.0011 |
| 2 | normal | -41.9464 | 1.0408 | 0.2012 | 0.0014 | 9.7111e-04 |
| 3 | gumbel | -41.6596 | 1.3277 | 0.1743 | 0.0018 | 8.2383e-04 |
| 4 | weibull | -41.3022 | 1.6851 | 0.1458 | 6.2498e-04 | 7.4569e-04 |
| 5 | logistic | -40.9126 | 2.0747 | 0.1200 | 0.0010 | 8.7308e-04 |
| 6 | burr | -37.3507 | 5.6366 | 0.0202 | 0.0018 | 0.0040 |

Figure A6. Vegetative vigor height SSD Akaike's Information Criterion results.

Based on the goodness of fit, EPA moved forward with triangular and normal distributions, and ultimately selected the normal distribution for the weight data from the vegetative vigor toxicity tests.

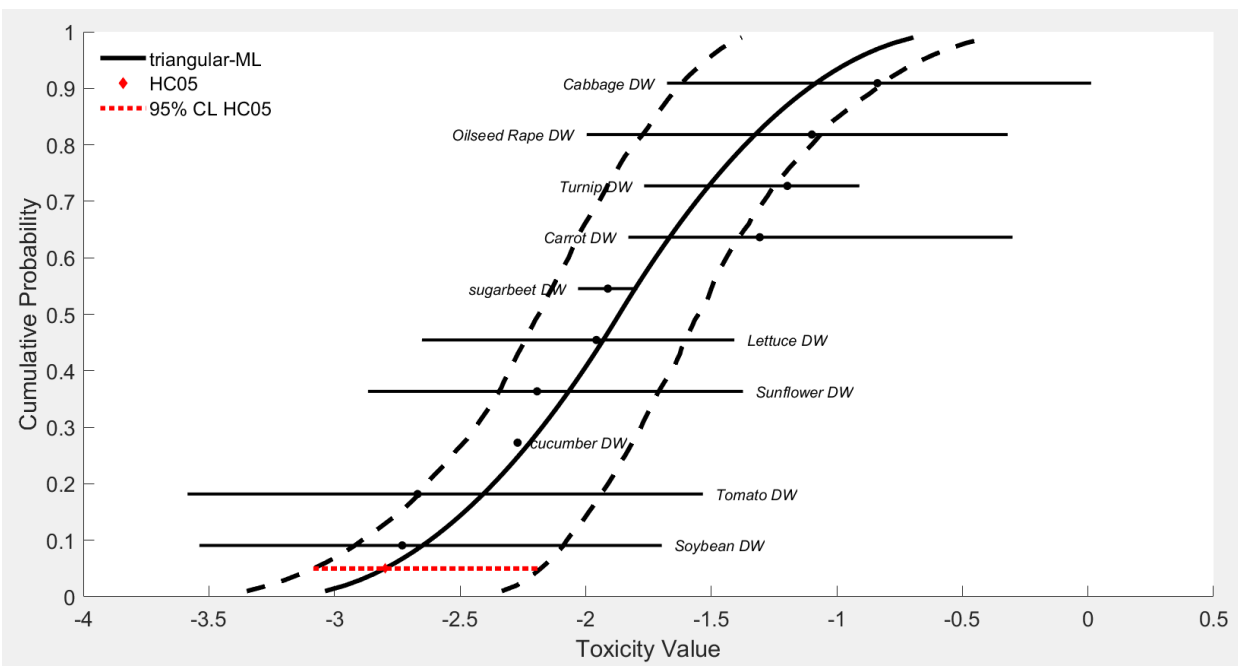


Figure A7. Vegetative vigor height SSD based on triangular distribution.

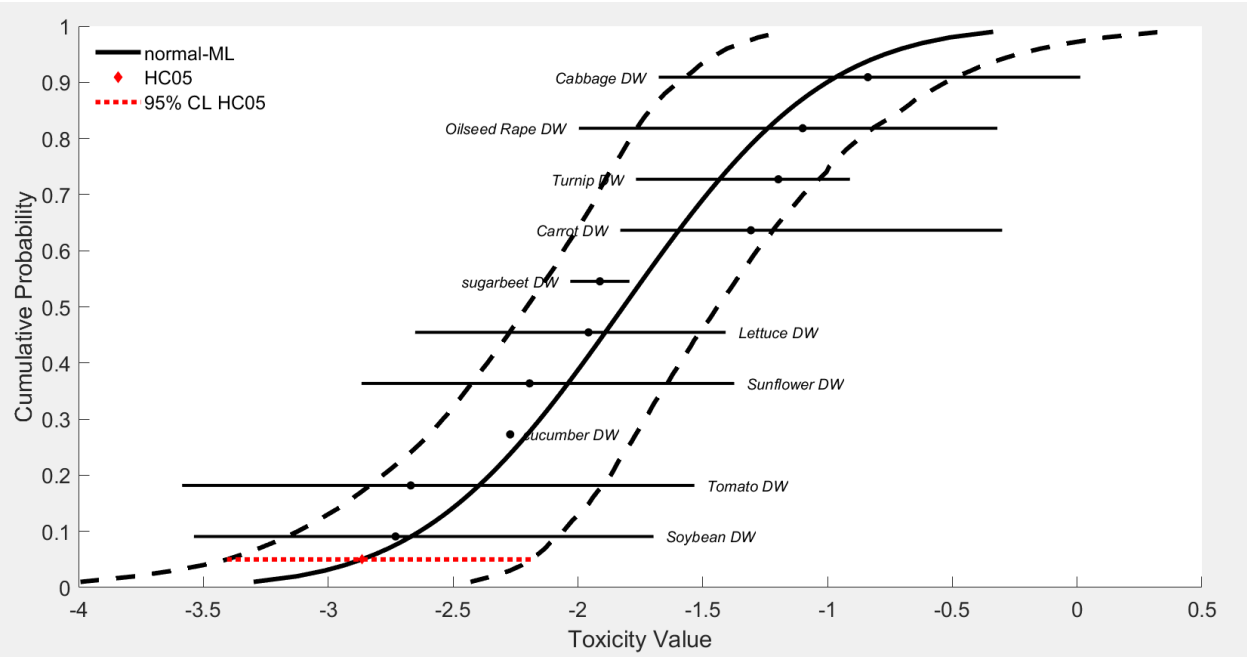

Figure A8. Selected vegetative vigor height SSD based on normal distribution.

## 7.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 7-23. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.0 lb a.e./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 75 | 50 | 20 | 20 | 5 | 5 | 0 * |
| **Application Rate of 0.25 lb a.e./A (maximum rate for use on sorghum and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 61 µg a.e./L for blue-green algae, *Anabaena flos-aquae* (MRID 42774109). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For dicamba, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 7.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 7-24. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 1.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 5.4 | 5.4 | 5.4 | 11.4 | 11.0 | 11.0 | 10.9 | 5.2 |
| 10 | 3.6 | 3.3 | 3.0 | 2.8 | 1.0 | 0.5 | 0.3 | 2.5 |
| 20 | 2.7 | 2.2 | 1.9 | 1.4 | 0.5 | 0.3 | 0.2 | 1.4 |
| 25 | 2.3 | 1.8 | 1.5 | 1.1 | 0.4 | 0.2 | 0.1 | 1.0 |
| 50 | 1.8 | 1.2 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.4 |
| 75 | 1.3 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | 0.2 |
| 100 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.1 |
| 125 | 0.8 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 150 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 175 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.0924 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 1.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 357.1 | 357.1 | 357.1 | 753.7 | 728.1 | 723.4 | 719.9 | 340.2 |
| 10 | 240.4 | 215.9 | 198.1 | 187.5 | 66.8 | 33.1 | 19.9 | 164.6 |
| 20 | 178.6 | 143.2 | 122.7 | 94.5 | 31.6 | 17.9 | 10.8 | 92.7 |
| 25 | 152.7 | 116.2 | 96.2 | 69.6 | 23.5 | 14.1 | 8.6 | 67.0 |
| 50 | 119.9 | 77.2 | 51.0 | 33.9 | 12.0 | 8.2 | 5.1 | 24.4 |
| 75 | 84.2 | 52.1 | 33.6 | 22.5 | 8.4 | 6.0 | 3.8 | 11.7 |
| 100 | 71.1 | 41.5 | 26.3 | 18.0 | 6.9 | 5.1 | 3.2 | 7.6 |
| 125 | 53.0 | 30.7 | 19.6 | 14.1 | 5.6 | 4.2 | 2.7 | 4.6 |
| 150 | 44.5 | 24.5 | 15.3 | 11.6 | 4.7 | 3.6 | 2.3 | 3.1 |
| 175 | 37.1 | 20.4 | 12.5 | 9.8 | 4.1 | 3.2 | 2.1 | 2.2 |
| 200 | 33.0 | 17.9 | 10.8 | 8.7 | 3.7 | 2.9 | 1.9 | 1.7 |
| 225 | 30.0 | 15.2 | 9.0 | 7.6 | 3.3 | 2.6 | 1.7 | 1.3 |
| 250 | 26.3 | 13.2 | 7.8 | 6.7 | 3.0 | 2.4 | 1.6 | 1.0 |
| 275 | 23.9 | 11.6 | 6.9 | 6.0 | 2.7 | 2.1 | 1.5 | 0.8 |
| 300 | 21.7 | 10.4 | 6.2 | 5.3 | 2.5 | 2.0 | 1.4 | 0.7 |
| 325 | 19.8 | 9.4 | 5.7 | 4.8 | 2.3 | 1.8 | 1.3 | 0.5 |
| 350 | 18.7 | 8.8 | 5.4 | 4.5 | 2.2 | 1.7 | 1.2 | 0.5 |
| 375 | 17.3 | 8.1 | 5.0 | 4.1 | 2.0 | 1.6 | 1.1 | 0.4 |
| 400 | 16.2 | 7.5 | 4.7 | 3.8 | 1.9 | 1.5 | 1.1 | 0.3 |
| 500 | 13.4 | 6.2 | 3.8 | 2.0 | 0.8 | 0.6 | 0.4 | 0.2 |
| 600 | 11.6 | 5.4 | 3.2 | 1.5 | 0.6 | 0.5 | 0.3 | 0.1 |
| 700 | 10.4 | 4.8 | 2.8 | 1.2 | 0.5 | 0.4 | 0.3 | 0.1 |
| 800 | 9.5 | 4.4 | 2.6 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 900 | 8.9 | 4.1 | 2.4 | 0.8 | 0.4 | 0.3 | 0.2 | <0.1 |
| 1000 | 8.4 | 3.8 | 2.2 | 0.6 | 0.4 | 0.3 | 0.2 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-26. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 1.0 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 87.7 | 87.7 | 87.7 | 185.1 | 178.8 | 177.7 | 176.8 | 83.6 |
| 10 | 59.0 | 53.0 | 48.6 | 46.1 | 16.4 | 8.1 | 4.9 | 40.4 |
| 20 | 43.9 | 35.2 | 30.1 | 23.2 | 7.8 | 4.4 | 2.6 | 22.8 |
| 25 | 37.5 | 28.5 | 23.6 | 17.1 | 5.8 | 3.5 | 2.1 | 16.5 |
| 50 | 29.4 | 19.0 | 12.5 | 8.3 | 2.9 | 2.0 | 1.2 | 6.0 |
| 75 | 20.7 | 12.8 | 8.3 | 5.5 | 2.1 | 1.5 | 0.9 | 2.9 |
| 100 | 17.5 | 10.2 | 6.5 | 4.4 | 1.7 | 1.2 | 0.8 | 1.9 |
| 125 | 13.0 | 7.5 | 4.8 | 3.5 | 1.4 | 1.0 | 0.7 | 1.1 |
| 150 | 10.9 | 6.0 | 3.8 | 2.9 | 1.2 | 0.9 | 0.6 | 0.8 |
| 175 | 9.1 | 5.0 | 3.1 | 2.4 | 1.0 | 0.8 | 0.5 | 0.5 |
| 200 | 8.1 | 4.4 | 2.6 | 2.1 | 0.9 | 0.7 | 0.5 | 0.4 |
| 225 | 7.4 | 3.7 | 2.2 | 1.9 | 0.8 | 0.6 | 0.4 | 0.3 |
| 250 | 6.4 | 3.2 | 1.9 | 1.6 | 0.7 | 0.6 | 0.4 | 0.2 |
| 275 | 5.9 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.4 | 0.2 |
| 300 | 5.3 | 2.5 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 325 | 4.9 | 2.3 | 1.4 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 |
| 350 | 4.6 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 400 | 4.0 | 1.9 | 1.2 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 500 | 3.3 | 1.5 | 0.9 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 600 | 2.8 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 700 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.3 | 1.1 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.2 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 2.1 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.0057 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the "**Technical Support for Mitigation** document.

**Table 7-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 0.25 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 1.4 | 1.4 | 1.4 | 2.9 | 2.8 | 2.7 | 2.7 | 1.3 |
| 10 | 0.9 | 0.8 | 0.8 | 0.7 | 0.3 | 0.1 | 0.1 | 0.6 |
| 20 | 0.7 | 0.5 | 0.5 | 0.4 | 0.1 | 0.1 | <0.1 | 0.4 |
| 25 | 0.6 | 0.4 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.3 |
| 50 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | 0.1 |
| 75 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 100 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 125 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.0924 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-28. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 0.25 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 89.3 | 89.3 | 89.3 | 188.4 | 182.0 | 180.9 | 180.0 | 85.0 |
| 10 | 60.1 | 54.0 | 49.5 | 46.9 | 16.7 | 8.3 | 5.0 | 41.2 |
| 20 | 44.7 | 35.8 | 30.7 | 23.6 | 7.9 | 4.5 | 2.7 | 23.2 |
| 25 | 38.2 | 29.0 | 24.1 | 17.4 | 5.9 | 3.5 | 2.1 | 16.8 |
| 50 | 30.0 | 19.3 | 12.7 | 8.5 | 3.0 | 2.1 | 1.3 | 6.1 |
| 75 | 21.0 | 13.0 | 8.4 | 5.6 | 2.1 | 1.5 | 0.9 | 2.9 |
| 100 | 17.8 | 10.4 | 6.6 | 4.5 | 1.7 | 1.3 | 0.8 | 1.9 |
| 125 | 13.3 | 7.7 | 4.9 | 3.5 | 1.4 | 1.0 | 0.7 | 1.2 |
| 150 | 11.1 | 6.1 | 3.8 | 2.9 | 1.2 | 0.9 | 0.6 | 0.8 |
| 175 | 9.3 | 5.1 | 3.1 | 2.4 | 1.0 | 0.8 | 0.5 | 0.5 |
| 200 | 8.3 | 4.5 | 2.7 | 2.2 | 0.9 | 0.7 | 0.5 | 0.4 |
| 225 | 7.5 | 3.8 | 2.3 | 1.9 | 0.8 | 0.6 | 0.4 | 0.3 |
| 250 | 6.6 | 3.3 | 2.0 | 1.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| 275 | 6.0 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.4 | 0.2 |
| 300 | 5.4 | 2.6 | 1.6 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 325 | 5.0 | 2.4 | 1.4 | 1.2 | 0.6 | 0.5 | 0.3 | 0.1 |
| 350 | 4.7 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 4.3 | 2.0 | 1.3 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 400 | 4.1 | 1.9 | 1.2 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 500 | 3.3 | 1.5 | 1.0 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 600 | 2.9 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 700 | 2.6 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.4 | 1.1 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.2 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 0.25 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 21.9 | 21.9 | 21.9 | 46.3 | 44.7 | 44.4 | 44.2 | 20.9 |
| 10 | 14.8 | 13.3 | 12.2 | 11.5 | 4.1 | 2.0 | 1.2 | 10.1 |
| 20 | 11.0 | 8.8 | 7.5 | 5.8 | 1.9 | 1.1 | 0.7 | 5.7 |
| 25 | 9.4 | 7.1 | 5.9 | 4.3 | 1.4 | 0.9 | 0.5 | 4.1 |
| 50 | 7.4 | 4.7 | 3.1 | 2.1 | 0.7 | 0.5 | 0.3 | 1.5 |
| 75 | 5.2 | 3.2 | 2.1 | 1.4 | 0.5 | 0.4 | 0.2 | 0.7 |
| 100 | 4.4 | 2.6 | 1.6 | 1.1 | 0.4 | 0.3 | 0.2 | 0.5 |
| 125 | 3.3 | 1.9 | 1.2 | 0.9 | 0.3 | 0.3 | 0.2 | 0.3 |
| 150 | 2.7 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.3 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 200 | 2.0 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.8 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.0057 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-30. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Monocots at an Application Rate of 0.12 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 0.6 | 0.6 | 0.6 | 1.4 | 1.3 | 1.3 | 1.3 | 0.6 |
| 10 | 0.4 | 0.4 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.3 |
| 20 | 0.3 | 0.3 | 0.2 | 0.2 | 0.1 | <0.1 | <0.1 | 0.2 |
| 25 | 0.3 | 0.2 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | 0.1 |
| 50 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 75 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 100 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 125 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive $IC_{25}$ = 0.0924 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Dicots at an Application Rate of 0.12 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 42.9 | 42.8 | 42.8 | 90.4 | 87.4 | 86.8 | 86.4 | 40.8 |
| 10 | 28.8 | 25.9 | 23.8 | 22.5 | 8.0 | 4.0 | 2.4 | 19.8 |
| 20 | 21.4 | 17.2 | 14.7 | 11.3 | 3.8 | 2.1 | 1.3 | 11.1 |
| 25 | 18.3 | 13.9 | 11.5 | 8.3 | 2.8 | 1.7 | 1.0 | 8.0 |
| 50 | 14.4 | 9.3 | 6.1 | 4.1 | 1.4 | 1.0 | 0.6 | 2.9 |
| 75 | 10.1 | 6.3 | 4.0 | 2.7 | 1.0 | 0.7 | 0.5 | 1.4 |
| 100 | 8.5 | 5.0 | 3.2 | 2.2 | 0.8 | 0.6 | 0.4 | 0.9 |
| 125 | 6.4 | 3.7 | 2.4 | 1.7 | 0.7 | 0.5 | 0.3 | 0.6 |
| 150 | 5.3 | 2.9 | 1.8 | 1.4 | 0.6 | 0.4 | 0.3 | 0.4 |
| 175 | 4.5 | 2.4 | 1.5 | 1.2 | 0.5 | 0.4 | 0.2 | 0.3 |
| 200 | 4.0 | 2.1 | 1.3 | 1.0 | 0.4 | 0.3 | 0.2 | 0.2 |
| 225 | 3.6 | 1.8 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 250 | 3.2 | 1.6 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 2.9 | 1.4 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 300 | 2.6 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 325 | 2.4 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 350 | 2.2 | 1.1 | 0.6 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 |
| 375 | 2.1 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 400 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.6 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.4 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.2 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.1 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 1.1 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.0 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0014 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 7-32. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint Relevant for Generalist Animals at an Application Rate of 0.12 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 10.5 | 10.5 | 10.5 | 22.2 | 21.5 | 21.3 | 21.2 | 10.0 |
| 10 | 7.1 | 6.4 | 5.8 | 5.5 | 2.0 | 1.0 | 0.6 | 4.9 |
| 20 | 5.3 | 4.2 | 3.6 | 2.8 | 0.9 | 0.5 | 0.3 | 2.7 |
| 25 | 4.5 | 3.4 | 2.8 | 2.1 | 0.7 | 0.4 | 0.3 | 2.0 |
| 50 | 3.5 | 2.3 | 1.5 | 1.0 | 0.4 | 0.2 | 0.1 | 0.7 |
| 75 | 2.5 | 1.5 | 1.0 | 0.7 | 0.2 | 0.2 | 0.1 | 0.3 |
| 100 | 2.1 | 1.2 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.6 | 0.9 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 150 | 1.3 | 0.7 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 225 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 250 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.0057 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 8 Diuron Case Study Example (PC Code 035505)

## 8.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 8.2 Use Information

Diuron is a substituted phenylurea herbicide that inhibits photosynthesis. Diuron initially causes chlorosis and then death of the exposed plant. It is moderately to slightly mobile, moderately persistent, and is systemic in plants. Diuron can be applied pre-plant, pre-emergence, or post-emergence to control broadleaf weeds and grassy weeds in a wide range of agricultural crops and non-crop use sites, including alfalfa, citrus, corn, cotton, wheat, rights-of-way, and recreational areas. Applications may be made as ground or aerial sprays. Granular products are registered.

includes the use information from the 2020 Draft Risk Assessment (DRA; DP457224) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for diuron, changes to the registered labels and uses since this DRA (e.g., changes outlined in the Proposed Interim Decision in April 2022) are not considered at this time but would be considered when EPA conducts assessments for diuron for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2020 assessment. **Table 8-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in Section 8.6 of this document. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL.

EPA estimated exposures using the selected[71] uses and application information provided in **Table 8-1**. The selected uses do not necessarily represent all registered uses of diuron and instead include large acreage uses sites (e.g., corn) and the agricultural use sites where diuron usage is most common. Note that pineapple is a labeled use of diuron; however, pineapple is not grown in the conterminous United States (CONUS), and therefore EPA did not evaluate this use further as part of the draft Herbicide Strategy. The selected uses are examples to illustrate the draft Herbicide Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Herbicide Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of diuron as this application method represents the greatest source of potential offsite movement. Although granular formulations of diuron are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

[71] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2020 Draft Risk Assessment for Registration Review (DP457224) for diuron. Any uses not evaluated in the 2020 assessment and any new uses since this assessment are not included in this example case study for the Herbicide Strategy.

**Table 8-1.Summary of the Selected Agricultural Use Patterns Labeled for Diuron (2020 Draft Risk Assessment for Registration Review, DP457224)[1]**

| Use Site/Location | App Target | App Type | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d) |
|---|---|---|---|---|---|---|---|---|
| **Alfalfa Use Data Layer** | | | | | | | | |
| Alfalfa | Foliage, Soil | Broadcast | G | Post-emergence | 2.4 | 1 | 2.4 | N/A |
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | | | |
| Artichoke | Foliage, Soil | Broadcast | G | Post-emergence | 3.2 | 1 | 3.2 | N/A |
| Asparagus | Foliage, Soil | Broadcast | G | Pre-/Post-emergence | 3.2 | 1 | 3.2 | N/A |
| Berry | Foliage, Soil | Broadcast | G | Post-emergence | 3.2 | 1 | 3.2 | N/A |
| Peas | Foliage, Soil | Broadcast | A, G | Pre-emergence | 1.6 | 1 | 1.6 | N/A |
| Pineapple[2] | Foliage, Soil | Broadcast | G | Pre-/Post-emergence | 6.4 | 2 | 12.8 | NS |
| **Citrus Use Data Layer** | | | | | | | | |
| Citrus | Foliage, Soil | Broadcast | G | Post-emergence | 6.4 | 1 | 6.4 | N/A |
| **Corn Use Data Layer** | | | | | | | | |
| Corn | Foliage, Soil | Broadcast | G | Pre-emergence | 1.6 | 1 | 1.6 | N/A |
| **Cotton Use Data Layer** | | | | | | | | |
| Cotton | Foliage, Soil | Broadcast | A (pre), G | Pre-/Post-emergence | 2 | 1 | 2 | N/A |
| **Grapes Use Data Layer** | | | | | | | | |
| Grape | Foliage, Soil | Broadcast | G | Post-emergence | 8 | 1 | 8 | N/A |
| **Other Grains Use Data Layer** | | | | | | | | |
| Barley | Foliage, Soil | Broadcast | G | Pre-emergence | 1.6 | 1 | 1.6 | N/A |
| Sorghum | Foliage, Soil | Broadcast | G | Post-emergence | 0.4 | 1 | 0.4 | N/A |
| Sugarcane | Foliage, Soil | Broadcast | G | Post-emergence | 6.4 | 1 | 6.4 | N/A |
| Other Orchards Use Data Layer | | | | | | | | |
| Pome Fruit | Foliage, Soil | Broadcast | G | Pre-/Post-emergence | 3.2 | 1 | 3.2 | N/A |
| Peach | Foliage, Soil | Broadcast | G | Post-emergence | 3 | 1 | 3 | N/A |
| Tree Nuts | Foliage, Soil | Broadcast | G | Post-emergence | 4.8 | 1 | 4.8 | N/A |
| **Wheat Use Data Layer** | | | | | | | | |
| Wheat | Foliage, Soil | Broadcast | G | Post-emergence | 1.6 | 1 | 1.6 | N/A |

App=application; equip=equipment; MRI = Minimum retreatment interval; ai=active ingredient; d=day; A=aerial; G=ground

[1] The use information presented in this table is identical to the agricultural uses included in the 2020 Draft Risk Assessment for Registration Review (DP457224).
[2] Pineapple is not grown within CONUS (the conterminous United States), so although it is presented as a use in this table, mitigations for use on pineapple will not be identified as part of the draft Strategy.

## 8.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of diuron (**Section 8.3.1**), reported incidents (**Section 8.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 8.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 8.3.1 Toxicity Information

**Table 8-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for diuron.

**Table 8-2. Summary of the Most Sensitive Toxicity Endpoints for Diuron (As Summarized in the 2020 Draft Risk Assessment for Registration Review (DP457224) and Response to Comments (DP462459))**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Onion (*Allium cepa*) | NOAEC = 0.042 lb a.i./A<br>$IC_{25}$ = 0.086 lb a.i./A | 44113401 Acceptable | Test with TGAI; Based on effects on dry weight |
| | Dicot: Tomato (Solanum lycopersicum) | NOAEC = 0.047 lb a.i./A<br>$IC_{25}$ = 0.075 lb a.i./A | | Test with TGAI; Based on effects on dry weight |
| Vegetative Vigor | Monocot: Wheat (*Triticum aestivum*) | NOAEC = 0.0017 lb a.i./A<br>$IC_{25}$ = 0.0208 lb a.i./A | 44113401 Acceptable | Test with TGAI; Based on effects on dry weight |
| | Dicot: Tomato (Solanum lycopersicum) | NOAEC = 0.0010 lb a.i./A<br>$IC_{25}$ = 0.0017 lb a.i./A | | Test with TGAI; Based on effects on dry weight |
| Aquatic Vascular Plant | Duckweed (Lemna gibba) | NOAEC = 2.49 µg a.i./L<br>$IC_{50}$ = 13 µg a.i./L | 46996701 Acceptable | Based on reduction in biomass (dry weight) |
| Aquatic Nonvascular Plant | Green Algae (Raphidocelis subcapitata) | NOAEC = 1.14 µg a.i./L<br>$IC_{50}$ = 3.08 µg a.i./L | 42218401 Acceptable | Based on cell count, reduced by 44% at the LOAEC (2.25 µg a.i./L) |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}/_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration
**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the diuron seedling emergence and vegetative vigor tests. See **Figure 8-1** for these SSD results.

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). See **Section 8.7** for the data used to generate the SSDs and **Section 8.8** for the process for calculating the SSDs. In total, EPA calculated four SSDs for diuron by combining the results for tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to diuron. Specifically, as summarized in **Section 8.7**, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the seedling emergence and vegetative vigor studies overlap when considering all definitive values available. Additionally, the mean $IC_{25}$ values for monocot and dicot height data only differ by a factor of 4 when data are compared within the same test design (seedling emergence or vegetative vigor). The median $IC_{25}$ values differ more substantially where the median $IC_{25}$ for dicot height is less than that for monocot height. Similarly, the mean $IC_{25}$ values for monocot and dicot dry weight only differ by a factor of 2 when data are compared within the same test design (seedling emergence or vegetative vigor), but the median $IC_{25}$ values for dry weight differ more substantially than the mean values, with lower dicot weights. Nonetheless, the median values are within approximately an order of magnitude for monocots and dicots. Given these considerations, EPA did not create separate SSDs for monocots and dicots.

**Figure 8-1** shows the four SSDs that EPA generated. The SSD based on the vegetative vigor weight data resulted in the most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values (represented as red and black dots in **Figure 8-1**, respectively). EPA used the resulting most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values from the SSD to calculate the ratio of EEC to toxicity endpoint (**Table 8-3** and **Table 8-4**; see **Section 8.3.3**). By combining the monocot and dicot data, these $5^{th}$ and $25^{th}$ percentile values represent the sensitivities of both types of flowering plants to diuron.

For this case study, the most sensitive aquatic plant toxicity studies[72] for diuron, required in the Code of Federal Regulations at 40 CFR Part 158[73], were relied upon to evaluate potential impacts of diuron on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 8-2** and **Table 8-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[74].

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[72] In USEPA 2011, an SSD was estimated for diuron aquatic plant toxicity studies. In this case study example, this SSD was not relied upon to estimate the magnitude of difference or to estimate mitigation. While not utilized in this example, the SSD may be incorporated into future assessments.
[73] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158
[74] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

**Table 8-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Diuron**

| Percentile (x) | Seedling Emergence Test | | Vegetative Vigor Test | |
|---|---|---|---|---|
| | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Height: X Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A |
| 5 | 0.014 (0.0011 – 0.21) | 0.12 (0.051 – 0.53) | 0.0091 (0.0056 – 0.021) | 0.023 (0.012 – 0.066) |
| 25 | 0.20 (0.04 – 0.88) | 0.33 (0.16 – 1.1) | 0.018 (0.012 – 0.036) | 0.053 (0.030 – 0.13) |
| 50 | 0.80 (0.24 – 2.1) | 0.83 (0.31 – 2.9) | 0.034 (0.019 – 0.068) | 0.11 (0.054 – 0.32) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

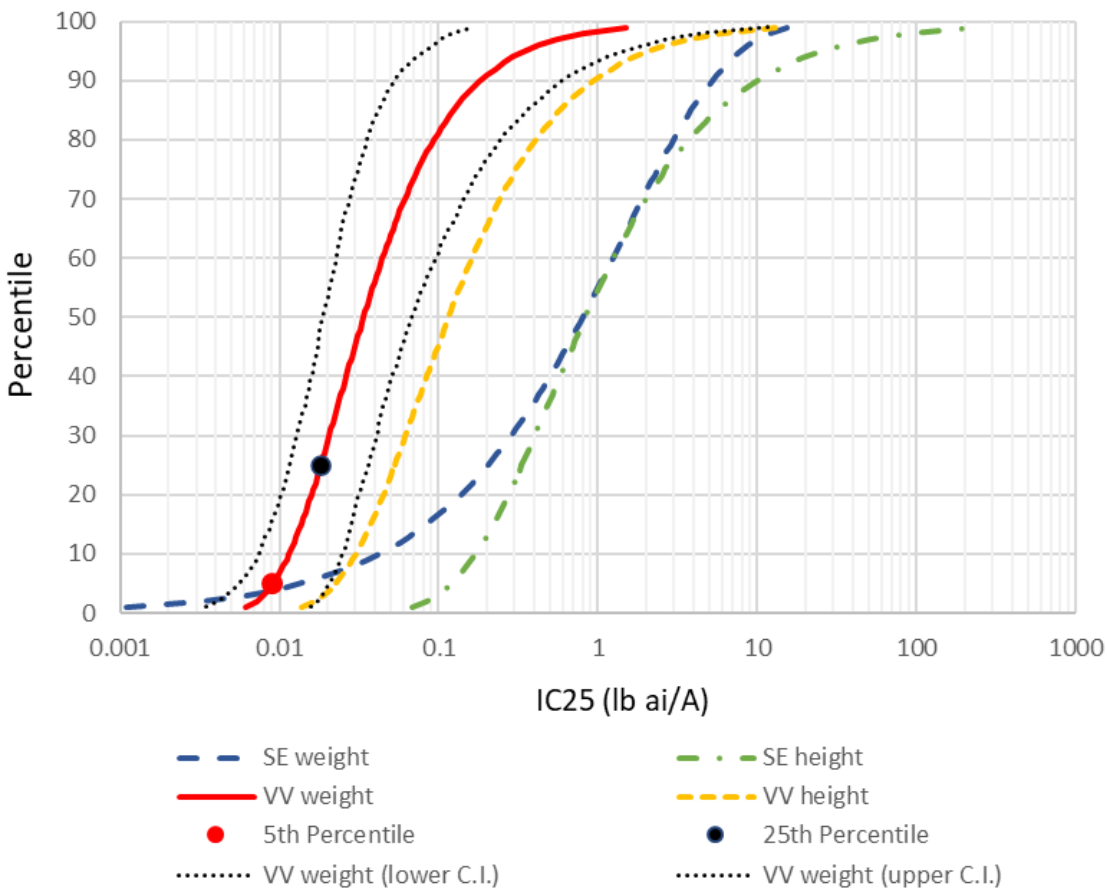



**Figure 8-1. Seedling Emergence (SE) and Vegetative Vigor (VV) Study Species Sensitivity Distributions representing the Distributions of the Plant Weight and Height IC25s for Diuron. The Upper and Lower Confidence Intervals (C.I.) are plotted for the VV plant weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 8.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on these plants[75], EPA calculated the magnitude of difference as a ratio of the EEC to the 5$^{th}$ percentile of the vegetative vigor plant weight SSD (**Table 8-4**). For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[76] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25$^{th}$ percentile of the SSD (**Table 8-4**). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value (**Table 8-4**).

**Table 8-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Diuron[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.0091 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.0091 lb a.i./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.0091 lb a.i./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.0091 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.0091 lb a.i./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.018 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 0.018 lb a.i./A |
| | | Based on aquatic plant endpoints: 13 µg a.i./L (Vascular), 3.08 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 13 µg a.i./L<br>Nonvascular: 3.08 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Herbicide Strategy. In this case study for diuron, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[75] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[76] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 8.3.2 Incidents

The incident information from the 2020 Draft Risk Assessment for Registration Review (DP457224) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[77] (as discussed in **Section 8.3.3.3**), which informs the potential population-level impacts (**Section 8.6**), and to identify the proposed level of mitigation (see **Section 8.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 8.3.3.3**).[78] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the reported ecological incidents associated with pesticides, including those that have been aggregately reported to the EPA. The IDS was searched in September 2020. This search excluded incidents classified as 'unlikely' or

[77] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.
[78] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

‘unrelated’ and only includes incidents with the certainty categories of ‘highly probable’, ‘probable’, and ‘possible’. Also excluded were incidents associated with misuses. Between 1972-2020, 35 incidents involving diuron were reported to EPA. The incident reports involved effects to a variety of plants, including crops and trees. There were four incidents to plants classified as ‘highly probably’, nine classified as ‘probable’, and 22 classified as ‘possible’.

In addition to the incidents recorded in IDS, additional incidents are reported to the Agency in aggregated form. Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. Ecological incidents reported in aggregate reports include those categorized as ‘minor plant’ (P-B) incidents. Eight aggregate incidents involving plants are reported.

Because the plant incidents are few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for diuron. In other words, the diuron incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 8.3.3.3**) are unaltered by the available diuron incident data.

### 8.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *8.3.3.1* Spray *Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 8-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of diuron ($5^{th}$ percentile of SSD = 0.0091 lb a.i./A). **Table 8-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of diuron ($25^{th}$ percentile of SSD = 0.018 lb a.i./A). Within **Table 8-5** and **Table 8-6**, the modeled application rates are representative of the maximum single application rate currently registered for diuron

(8.0 lb a.i./A) and reduced rates (6.4, 3.2, and 1.6 lb a.i./A)[79] representative of maximum single application rates for other uses (**Table 8-1**). **Table 8-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated (5$^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 8-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated (25$^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 8.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants **Table 8-24**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

[79] Aerial applications of diuron are permitted only for application rates of 2 lb a.i./A (for use on cotton) and 1.6 lb a.i./A (for use on peas).

**Table 8-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 8.0 lb a.i./A (maximum application rate for use on grape)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 850 | 500 | 450 | 425 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **10.7** [200] | **8.4** [100] | **6.2** [100] | **3.9** [100] |
| **Application Rate of 6.4 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 800 | 475 | 450 | 400 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **8.6** [200] | **6.8** [100] | **5.0** [100] | **3.2** [100] |
| **Application Rate of 3.2 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 500 | 375 | 300 | 175 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **4.3** [200] | **3.4** [100] | **2.5** [100] | **1.6** [100] |
| **Application Rate of 1.6 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 900 | 475 | 375 | 175 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **5.3** [300] | **2.6** [300] | **2.6** [200] | **2.1** [200] | **1.7** [100] | **1.2** [100] | 0.8 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation is should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For diuron, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 8.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 8.9** contains the full output of results.

**Table 8-6. Spray Drift Distances to the Population-Level Impacts Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 8.0 lb a.i./A (maximum application rate for use on grape)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 600 | 500 | 400 | 225 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **5.4** [200] | **4.3** [100] | **3.1** [100] | **2.0** [100] |
| **Application Rate of 6.4 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 600 | 400 | 325 | 200 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **4.3** [200] | **3.4** [100] | **2.5** [100] | **1.6** [100] |
| **Application Rate of 3.2 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 400 | 200 | 150 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **2.2** [200] | **1.7** [100] | **1.3** [100] | 0.8 [100] |
| **Application Rate of 1.6 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 400 | 275 | 225 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.7** [300] | **1.3** [300] | **1.3** [200] | **1.1** [200] | 0.9 [100] | 0.6 [100] | 0.4 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation is should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For diuron, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 8.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 8.9** contains the full output of results.

#### *8.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 8-7** through **Table 8-10** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 8-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 33 | 2.5 | 11 |
| Berry | 16 – 43 | 1.2 – 3.3 | 5.3 – 14 |
| Citrus | 26 – 110 | 2.0 – 8.8 | 8.4 – 37 |
| Corn | 18 – 38 | 1.4 – 2.9 | 5.9 – 12 |
| Grape | 37 – 85 | 2.8 – 6.6 | 12 – 28 |
| Pome Fruit | 18 – 34 | 1.4 – 2.6 | 5.9 – 11 |
| Cotton | 8.2 – 40 | 0.63 – 3.1 | 2.7 – 13 |
| Alfalfa | 18 – 48 | 1.4 – 3.7 | 5.9 – 16 |
| Asparagus | 13 – 15 | 1.0 – 1.1 | 4.2 – 4.8 |
| Barley | 14 – 41 | 1.0 – 3.1 | 4.4 – 13 |
| Peach | 17 – 22 | 1.3 – 1.7 | 5.5 – 7.1 |
| Pea | 20 – 23 | 1.5 – 1.8 | 6.4 – 7.5 |
| Sorghum | 6.5 – 7.2 | 0.50 – 0.55 | 2.1 – 2.3 |
| Sugarcane | 170 – 200 | 13 – 16 | 54 – 66 |
| Tree Nut | 33 – 64 | 2.5 – 4.9 | 11 – 21 |
| Wheat | 13 – 26 | 0.97 – 2.0 | 4.1 – 8.4 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for diuron, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 8-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 0.59 | 65 | 230 | 17 | 73 |
| Berry | 0.60 – 0.48 | 52 – 66 | 180 – 300 | 14 – 23 | 59 – 96 |
| Citrus | 1.4 – 1.4 | 150 – 160 | 1400 – 2000 | 100 – 150 | 450 – 630 |
| Corn | 0.36 – 3.0 | 39 – 320 | 97 – 250 | 7.5 – 19 | 32 – 80 |
| Grape | 1.3 – 3.8 | 140 – 410 | 620 – 1600 | 48 – 120 | 200 – 510 |
| Pome Fruit | 0.45 – 0.85 | 49 – 94 | 160 – 870 | 12 – 67 | 52 – 280 |
| Cotton | 0.39 – 1.9 | 43 – 210 | 150 – 850 | 12 – 65 | 49 – 280 |
| Alfalfa | 0.42 – 0.57 | 46 – 62 | 230 – 760 | 18 – 59 | 74 – 250 |
| Asparagus | 0.70 – 0.71 | 77 – 78 | 800 – 1000 | 61 – 78 | 260 – 330 |
| Barley | 0.28 – 1.7 | 31 – 180 | 210 – 460 | 17 – 35 | 70 – 150 |
| Peach | 0.58 – 0.61 | 64 – 67 | 220 – 480 | 17 – 37 | 71 – 160 |
| Pea | 0.28 – 0.55 | 30 – 61 | 190 – 630 | 15 – 49 | 62 – 210 |
| Sorghum | 0.22 – 0.39 | 24 – 43 | 44 – 72 | 3.4 – 5.5 | 14 – 23 |
| Sugarcane | 1.8 – 5.06 | 200 – 560 | 310 – 710 | 24 – 54 | 100 – 230 |
| Tree Nut | 0.74 – 1.5 | 82 – 160 | 240 – 910 | 19 – 70 | 78 – 290 |
| Wheat | 0.28 – 0.60 | 31 – 66 | 90 – 510 | 6.9 – 40 | 29 – 170 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 8-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[2] | Animals Generally Relying on Wetland Dicots or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Artichoke | 0.59 | 32.8 |
| Berry | 0.60 – 0.48 | 26.4 – 33.2 |
| Citrus | 1.37 – 1.43 | 76.1 – 79.4 |
| Corn | 0.36 – 2.95 | 19.8 – 164 |
| Grape | 1.27 – 3.76 | 70.6 – 209 |
| Pome Fruit | 0.45 – 0.85 | 24.7 – 47.4 |
| Cotton | 0.39 – 1.93 | 21.6 – 107 |
| Alfalfa | 0.42 – 0.57 | 23.4 – 31.4 |
| Asparagus | 0.70 – 0.71 | 39.1 – 39.3 |
| Barley | 0.28 – 1.67 | 15.4 – 92.8 |
| Peach | 0.58 – 0.61 | 32.4 – 34.1 |
| Pea | 0.28 – 0.55 | 15.4 – 30.7 |
| Sorghum | 0.22 – 0.39 | 12.2 – 21.6 |
| Sugarcane | 1.83 – 5.06 | 102 – 281 |
| Tree Nut | 0.74 – 1.50 | 41.3 – 83.8 |
| Wheat | 0.28 – 0.60 | 15.5 – 33.2 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 8-8**

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 8-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 2.4 | 260 |
| Berry | 1.2 – 1.3 | 130 – 140 |
| Citrus | 2.5 – 12 | 280 – 1400 |
| Corn | 0.74 – 1.4 | 82 – 150 |
| Grape | 4.7 – 11 | 520 – 1200 |
| Pome Fruit | 1.3 – 4.5 | 140 – 500 |
| Cotton | 1.0 – 1.9 | 110 - 210 |
| Alfalfa | 1.1 – 2.4 | 120 – 260 |
| Asparagus | 2.2 | 240 |
| Barley | 0.75 – 1.5 | 82 – 170 |
| Peach | 1.2 – 4.0 | 130 – 440 |
| Pea | 0.79 – 1.1 | 87 – 120 |
| Sorghum | 0.28 – 0.29 | 30 – 32 |
| Sugarcane | 3.6 – 4.0 | 390 – 440 |
| Tree Nut | 1.6 – 2.0 | 180 – 220 |
| Wheat | 0.77 – 1.5 | 84 – 170 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 8-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 2.4 | 130 |
| Berry | 1.2 – 1.3 | 66 – 73 |
| Citrus | 2.5 – 12 | 140 – 660 |
| Corn | 0.74 – 1.4 | 41 – 76 |
| Grape | 4.7 – 11 | 260 – 590 |
| Pome Fruit | 1.3 – 4.5 | 72 – 250 |
| Cotton | 1.0 – 1.9 | 57 – 110 |
| Alfalfa | 1.1 – 2.4 | 62 – 130 |
| Asparagus | 2.2 | 120 |
| Barley | 0.75 – 1.5 | 42 – 83 |
| Peach | 1.2 – 4.0 | 64 – 220 |
| Pea | 0.79 – 1.1 | 44 – 62 |
| Sorghum | 0.28 – 0.29 | 15 – 16 |
| Sugarcane | 3.6 – 4.0 | 200 – 220 |
| Tree Nut | 1.6 – 2.0 | 88 – 110 |

| | | |
|---|---|---|
| Wheat | 0.77 – 1.5 | 43 – 84 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *8.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 8-12** These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 8.3.1** and **8.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 8.4**) and conducting a population-level impact analysis (**Section 8.6**).

For diuron, given the toxicity profile (including only about a 2X difference between the 5$^{th}$ and 25$^{th}$ percentiles of the most sensitive SSD with a steep slope for the most sensitive SSD (**Figure 8-1)**[80], EPA assigned a low magnitude of effect in **Table 8-12** on a use basis to groups of listed species and critical habitats (CHs)[81] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned medium magnitude of effect in **Table 8-12** when the magnitude of difference is from 1 up to 10. EPA assigned a magnitude of effect of high or very high based on a magnitude of difference of 10 up to 100 or greater than 100, respectively.

**Table 8-12. Use-Based Magnitude of Effect for Diuron.[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Artichoke | Very High | Very High | High | High | High | High |
| Berry | Very High | High | High | High | High | High |
| Citrus | Very High | Very High | Very High | Very High | High | High |
| Corn | Very High | High | Very High | High | High | High |
| Grape | Very High | Very High | Very High | Very High | High | High |
| Pome Fruit | Very High | Very High | Very High | Very High | High | High |

[80] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[81] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Cotton | Very High | High | Very High | Very High | High | High |
| Alfalfa | Very High | Very High | Very High | Very High | High | High |
| Asparagus | Very High | Very High | Very High | Very High | Medium | Medium |
| Barley | Very High | High | Very High | Very High | High | High |
| Peach | Very High | Very High | Very High | Very High | Medium | Medium |
| Pea | Very High | High | Very High | Very High | Medium | Medium |
| Sorghum | High | High | High | High | Medium | Medium |
| Sugarcane | Very High | Very High | Very High | Very High | High | High |
| Tree Nut | Very High | Very High | Very High | Very High | High | High |
| Wheat | Very High | High | Very High | Very High | Medium | Medium |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 8.4**) and to conduct the population-level impacts analysis (**Section 8.6**). If the magnitude of effect is medium or higher for diuron, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 8.4 Framework Step 2: Identify Mitigation Measures

**Section 8.4** outlines the mitigation measures identified for diuron for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 8.4.1**) and runoff/erosion (**Section 8.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 8.4.1 Spray Drift Mitigation Measures Identified

**Table 8-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 8-14** presents the spray drift buffers identified for this example of the

proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 8-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 8 | Not permitted on labels | | | 200 + windbreak[3] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 6.4 | | | | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 3.2 | | | | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g,] |
| 1.6 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 75[e,f,g] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70% | | | [d] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[e] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 8-1.**
[3] Additional mitigation measures (*e.g.,* windbreak, hooded sprayers) would apply for ground applications at this rate using this droplet size because the magnitude of difference exceeds 10 at the maximum buffer distance. Use of these additional mitigation measures do not result in reduced buffer distances.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 8-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 8 | Not permitted on labels | | | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 6.4 | | | | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 3.2 | | | | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 75[e,f,g] |
| 1.6 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 75[f,g] | 50[f,g] |

| | | |
|---|---|---|
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[3] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70% | [d] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[e] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 8-1.**
[3] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 8.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts and minimize the potential for future take differs across uses and, as shown in **Figure 8-2,** the level of mitigation is dependent upon the toxicity endpoint and representative species (*e.g.,* listed plants (5$^{th}$ percentile endpoint), generalists (25$^{th}$ percentile endpoint)). **Figure 8-2** visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for diuron.

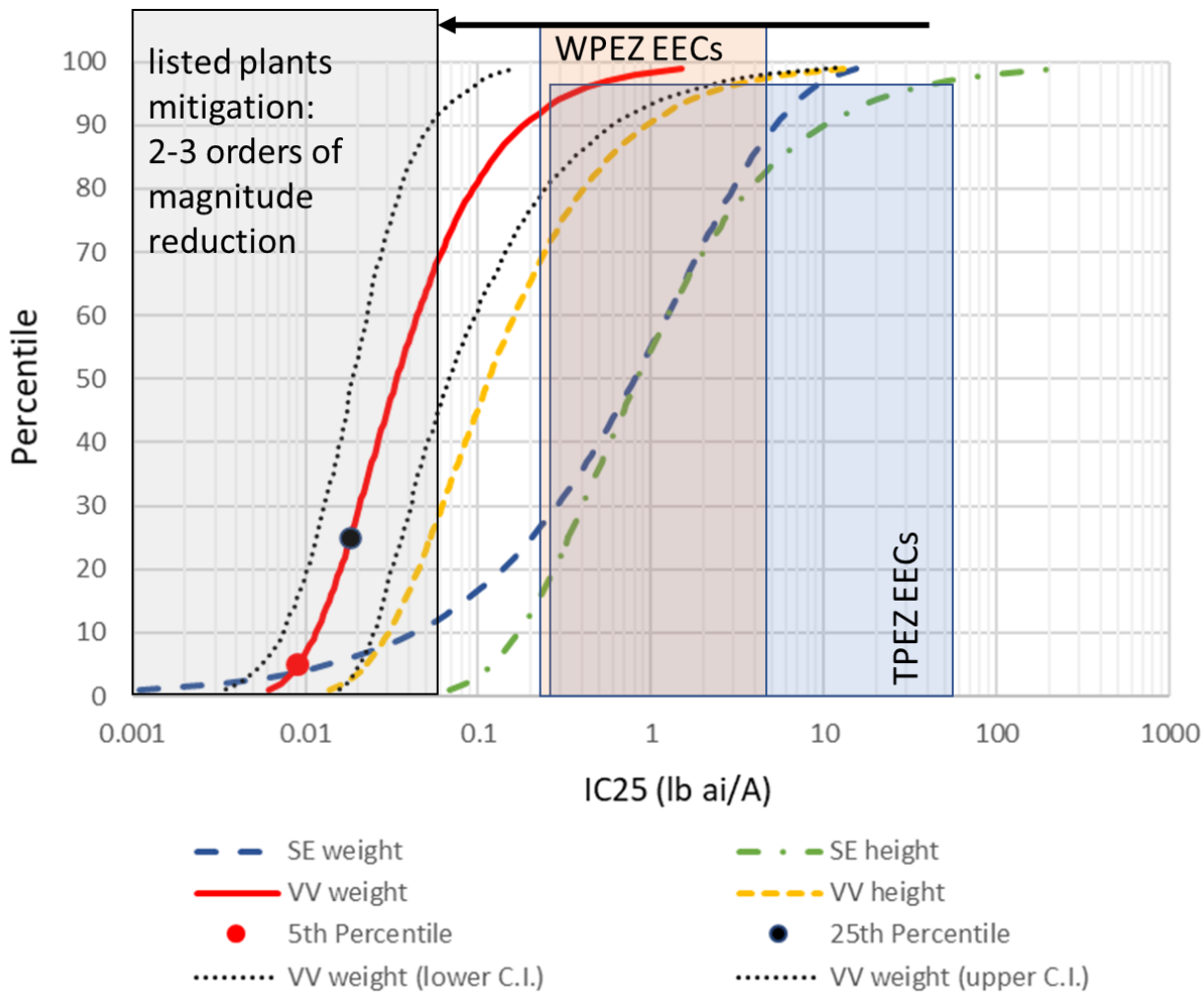



**Figure 8-2. Diuron Vegetative Vigor (VV) and Seedling Emergence (SE) Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5$^{th}$ percentile (represents listed plants and animals with obligate relationships to plants) and the 25$^{th}$ percentile (represents generalists and designated critical habitats) from the VV weight SSD. Upper and lower confidence intervals (C.I.) are provided for the VV weight SSD.**

For diuron, see **Section 8.3.3.2** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of diuron is <1,000 L/kg-o.c. (mean $K_{foC}$ = 920 L/kg-o.c.), higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework**, EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would be applicable and if it is between 100 and 1,000, high mitigation would be applicable. If the magnitude of difference exceeds 1,000, then very high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high/very high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For diuron, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for diuron, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed species in waterbodies similar in size to the EPA farm pond or larger[82], the mitigation category[83] is medium for most uses (based on the more sensitive results for nonvascular plants; **Table 8-15**) for listed aquatic plants and animals that depend on these plants[84]. For use on asparagus, peach, pea, sorghum, and wheat, the mitigation category is low for listed aquatic plants and animals that depend on aquatic plants (**Table 8-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies (**Table 8-15**).
- Except for use on citrus and grape, the mitigation category is medium or high (depending on the use) for terrestrial and wetland plants and animals that obligately depend on these plants[85] (**Table 8-16** and **Table 8-18**). For use on citrus and grape, EPA identified very high mitigation for listed terrestrial plants and obligate animals[85] (**Table 8-18).**
- For aquatic plants in wetlands or small waterbodies[86] and for animals that depend on these plants (both obligately[85] and generally[87]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. The resulting mitigation category is medium or high depending on the use (**Table 8-16**). Specifically, for use on artichoke, berry, corn, and

[82] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[83] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).
[84] None of the listed aquatic animals have obligate relationships to plants.
[85] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[86] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[87] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

sorghum, the mitigation category is medium; for all other uses, the mitigation category is high.

- For animals that have a generalist relationship[87] to wetland or terrestrial plants (*i.e.,* do not obligately depend on plants), the mitigation category is medium or high depending on the specific use (**Table 8-17** and **Table 8-19**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland and terrestrial plants and for animals that depend on wetland and/or terrestrial plants.

**Table 8-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Artichoke | 33 | 2.5 | Low | 11 | Medium |
| Berry | 16 – 43 | 1.2 – 3.3 | Low | 5.3 – 14 | Medium |
| Citrus | 26 – 110 | 2.0 – 8.8 | Low | 8.4 – 37 | Medium |
| Corn | 18 – 38 | 1.4 – 2.9 | Low | 5.9 – 12 | Medium |
| Grape | 37 – 85 | 2.8 – 6.6 | Low | 12 – 28 | Medium |
| Pome Fruit | 18 – 34 | 1.4 – 2.6 | Low | 5.9 – 11 | Medium |
| Cotton | 8.2 – 40 | 0.63 – 3.1 | Low | 2.7 – 13 | Medium |
| Alfalfa | 18 – 48 | 1.4 – 3.7 | Low | 5.9 – 16 | Medium |
| Asparagus | 13 – 15 | 1.0 – 1.1 | Low | 4.2 – 4.8 | Low |
| Barley | 14 – 41 | 1.0 – 3.1 | Low | 4.4 – 13 | Medium |
| Peach | 17 – 22 | 1.3 – 1.7 | Low | 5.5 – 7.1 | Low |
| Pea | 20 – 23 | 1.5 – 1.8 | Low | 6.4 – 7.5 | Low |
| Sorghum | 6.5 – 7.2 | 0.50 – 0.55 | No mitigation | 2.1 – 2.3 | Low |
| Sugarcane | 170 – 200 | 13 – 16 | Medium | 54 – 66 | Medium |
| Tree Nut | 33 – 64 | 2.5 – 4.9 | Low | 11 – 21 | Medium |
| Wheat | 13 – 26 | 0.97 – 2.0 | Low | 4.1 – 8.4 | Low |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for diuron, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 8-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category | | Range of Magnitude of Difference[3] | Mitigation Category | Range of Magnitude of Difference[3] | Mitigation Category |
| Artichoke | 0.59 | 65 | Medium | 230 | 17 | Medium | 73 | Medium |
| Berry | 0.60 – 0.48 | 52 – 66 | Medium | 180 – 300 | 14 – 23 | Medium | 59 – 96 | Medium |
| Citrus | 1.4 – 1.4 | 150 – 160 | High | 1400 – 2000 | 110 – 150 | High | 450 – 630 | High |
| Corn | 0.36 – 3.0 | 39 – 320 | High | 97 – 250 | 7.5 – 19 | Medium | 32 – 80 | Medium |
| Grape | 1.3 – 3.8 | 140 – 410 | High | 620 – 1600 | 48 – 120 | High | 200 – 510 | High |
| Pome Fruit | 0.45 – 0.85 | 49 – 94 | Medium | 160 – 870 | 12 – 67 | Medium | 52 – 280 | High |
| Cotton | 0.39 – 1.9 | 43 – 210 | High | 150 – 850 | 12 – 65 | Medium | 49 – 280 | High |
| Alfalfa | 0.42 – 0.57 | 46 – 62 | Medium | 230 – 760 | 18 – 59 | Medium | 74 – 250 | High |
| Asparagus | 0.70 – 0.71 | 77 – 78 | Medium | 800 – 1000 | 61 – 78 | Medium | 260 – 330 | High |
| Barley | 0.28 – 1.7 | 31 – 180 | High | 210 – 460 | 17 – 35 | Medium | 70 – 150 | High |
| Peach | 0.58 – 0.61 | 64 – 67 | Medium | 220 – 480 | 17 – 37 | Medium | 71 – 160 | High |
| Pea | 0.28 – 0.55 | 30 – 61 | Medium | 190 – 630 | 15 – 49 | Medium | 62 – 210 | High |
| Sorghum | 0.22 – 0.39 | 24 – 43 | Medium | 44 – 72 | 3.4 – 5.5 | Low | 14 – 23 | Medium |
| Sugarcane | 1.8 – 5.1 | 200 – 560 | High | 310 – 710 | 24 – 54 | Medium | 100 – 230 | High |
| Tree Nut | 0.74 – 1.5 | 82 – 160 | High | 240 – 910 | 19 – 70 | Medium | 78 – 290 | High |
| Wheat | 0.28 – 0.60 | 31 – 66 | Medium | 90 – 510 | 6.9 – 40 | Medium | 29 – 170 | High |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

**Table 8-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |
| Artichoke | 0.59 | 33 | Medium |
| Berry | 0.60 – 0.48 | 26 – 33 | Medium |
| Citrus | 1.4 – 1.4 | 76 – 79 | Medium |
| Corn | 0.36 – 2.95 | 20 – 160 | Medium[5] |
| Grape | 1.3 – 3.8 | 71 – 210 | High |
| Pome Fruit | 0.45 – 0.85 | 25 – 47 | Medium |
| Cotton | 0.39 – 1.9 | 22 – 110 | High |
| Alfalfa | 0.42 – 0.57 | 23 – 31 | Medium |
| Asparagus | 0.70 – 0.71 | 39 – 39 | Medium |
| Barley | 0.28 – 1.7 | 15 – 93 | Medium |
| Peach | 0.58 – 0.61 | 32 – 34 | Medium |
| Pea | 0.28 – 0.55 | 15 – 31 | Medium |
| Sorghum | 0.22 – 0.39 | 12 – 22 | Medium |
| Sugarcane | 1.8 – 5.1 | 100 – 280 | High |
| Tree Nut | 0.74 – 1.5 | 41 – 84 | Medium |
| Wheat | 0.28 – 0.60 | 16 – 33 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 8-16**.
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[5] Based on the weight of evidence regarding ratios exceeding 100, EPA set the mitigation category as medium. See the subsequent text for further explanation.

**Table 8-17** outlines the proposed mitigation categories for listed animals that generally rely on monocots or dicots in wetlands or small waterbodies[88]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios

[88] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

available[89]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For diuron, EPA determined the proposed mitigation categories presented in **Table 8-17** based on the weight of evidence discussed below, which is specifically relevant for use on corn.

Although the highest ratio of EEC to terrestrial monocot and dicot 5th percentile of the SSD exceeds 100 (indicating high mitigation) for corn, this only occurred in 1 out of 10 modeled application scenarios with a maximum ratio of 160 (MScornSTD PWC scenario) and the next highest ratio of 76. The MScornSTD PWC scenario is a conservative scenario for screening-level assessments that is known to result in substantially higher runoff EECs than all other corn scenarios. Therefore, given that this scenario (MScornSTD) provides upper bound EECs, EPA set the mitigation category as medium for use on corn.

**Table 8-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants.**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 2.4 | 260 | High |
| Berry | 1.2 – 1.3 | 130 – 140 | High |
| Citrus | 2.5 – 12 | 280 – 1300 | Very High |
| Corn | 0.74 – 1.4 | 82 – 150 | High |
| Grape | 4.7 – 11 | 520 – 1200 | Very High |
| Pome Fruit | 1.3 – 4.5 | 140 – 500 | High |
| Cotton | 1.0 – 1.9 | 110 - 210 | High |
| Alfalfa | 1.1 – 2.4 | 120 – 260 | High |
| Asparagus | 2.2 | 240 | High |
| Barley | 0.75 – 1.5 | 82 – 170 | High |
| Peach | 1.2 – 4.0 | 130 – 440 | High |
| Pea | 0.79 – 1.1 | 87 – 120 | High |
| Sorghum | 0.28 – 0.29 | 30 – 32 | Medium |
| Sugarcane | 3.6 – 4.0 | 390 – 440 | High |
| Tree Nut | 1.6 – 2.0 | 180 – 220 | High |
| Wheat | 0.77 – 1.5 | 84 – 170 | High |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[89] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2** in the **Case Study Summary and Process** document.

**Table 8-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 2.4 | 130 | High |
| Berry | 1.2 – 1.3 | 66 – 73 | Medium |
| Citrus | 2.5 – 12 | 140 – 660 | High |
| Corn | 0.74 – 1.4 | 41 – 76 | Medium |
| Grape | 4.7 – 11 | 260 – 590 | High |
| Pome Fruit | 1.3 – 4.5 | 72 – 250 | High |
| Cotton | 1.0 – 1.9 | 57 – 110 | Medium[3] |
| Alfalfa | 1.1 – 2.4 | 62 – 130 | High |
| Asparagus | 2.2 | 120 | High |
| Barley | 0.75 – 1.5 | 42 – 83 | Medium |
| Peach | 1.2 – 4.0 | 64 – 220 | High |
| Pea | 0.79 – 1.1 | 44 – 62 | Medium |
| Sorghum | 0.28 – 0.29 | 15 – 16 | Medium |
| Sugarcane | 3.6 – 4.0 | 200 – 220 | High |
| Tree Nut | 1.6 – 2.0 | 88 – 110 | High |
| Wheat | 0.77 – 1.5 | 43 – 84 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Based on the weight of evidence regarding ratios exceeding 100, EPA set the mitigation category as medium. See the subsequent text for further explanation.

**Table 8-19** identifies the proposed mitigation category for listed animals that generally rely on terrestrial plants. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For diuron, EPA determined the proposed mitigation categories presented in **Table 8-19** based on the weight of evidence discussed below, which is specifically relevant for use o on cotton.

For use on cotton, the maximum ratio of the terrestrial EECs compared to the 25$^{th}$ percentile of the SSD for terrestrial plants is 110. Although the highest ratio exceeds 100 (indicating high mitigation), this only occurred in 1 out of 9 (11%) modeled application scenarios for an aerial application (NCcottonSTD PWC scenario). Therefore, EPA set the mitigation category as medium for use on cotton.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for

listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 8-15** and **Table 8-16**) and wetland plants (**Table 8-16** and **Table 8-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the area is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 8-18**) and for generalist animals (**Table 8-19**). **Table 8-20** and **Table 8-21** provide the runoff/erosion mitigation points identified for each evaluated use of diuron.

**Table 8-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Artichoke | Medium (6 pts) | Medium (6 pts) |
| Berry | Medium (6 pts) | Medium (6 pts) |
| Citrus | High (9 pts) | High (9 pts) |
| Corn | High (9 pts) | Medium (6 pts) |
| Grape | High (9 pts) | High (9 pts) |
| Pome Fruit | High (9 pts) | High (9 pts) |
| Cotton | High (9 pts) | High (9 pts) |
| Alfalfa | High (9 pts) | High (9 pts) |
| Asparagus | High (9 pts) | High (9 pts) |
| Barley | High (9 pts) | High (9 pts) |
| Peach | High (9 pts) | High (9 pts) |
| Pea | High (9 pts) | High (9 pts) |
| Sorghum | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | High (9 pts) |
| Tree Nut | High (9 pts) | High (9 pts) |
| Wheat | High (9 pts) | High (9 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 8-15** and **Table 8-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 8-15** and **Table 8-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 8-15**, **Table 8-16**, and **Table 8-17**).

**Table 8-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | **Plants and Obligate Animals (Mitigation Points)** | **Generalist Animals and CHs (Mitigation Points)** |
| Artichoke | High (9 pts) | High (9 pts) |
| Berry | High (9 pts) | Medium (6 pts) |
| Citrus | Very High (9 pts plus other mitigations) | High (9 pts) |
| Corn | High (9 pts) | Medium (6 pts) |
| Grape | Very High (9 pts plus other mitigations) | High (9 pts) |
| Pome Fruit | High (9 pts) | High (9 pts) |
| Cotton | High (9 pts) | Medium (6 pts) |
| Alfalfa | High (9 pts) | High (9 pts) |
| Asparagus | High (9 pts) | High (9 pts) |
| Barley | High (9 pts) | Medium (6 pts) |
| Peach | High (9 pts) | High (9 pts) |
| Pea | High (9 pts) | Medium (6 pts) |
| Sorghum | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | High (9 pts) |
| Tree Nut | High (9 pts) | High (9 pts) |
| Wheat | High (9 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 8-18**), listed animals that obligately depend on terrestrial plants (**Table 8-18**), and listed animals that generally depend on terrestrial plants (**Table 8-19**).

## 8.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for diuron are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 8-13**) and one for generalist animals that depend on plants (**Table 8-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are slightly different for these two

groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For diuron, the less restrictive mitigations relevant to generalists animals that are depicted in **Table 8-14** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 8-13** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For both sets of habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 8-20** and **Table 8-21**). **Table 8-22** summarizes the points identified for the different diuron uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by the four PULAs. PULAs 1 and 2 are grouped because the same mitigations would be applied to monocots and dicots in terrestrial habitats; this is supported by diuron's similar toxicity to both monocots and dicots (see **Section 8.3.1**). The same grouping and rational applies for PULAs 3 and 4, which represent monocots and dicots in wetland and aquatic habitats.

**Table 8-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | | Geographically Specific Mitigation Points | |
|---|---|---|---|---|
| | Terrestrial Habitats | Aquatic and Wetland Habitats | PULAs 1,2, 3 and 4 (Terrestrial Habitats)[1] | PULAs 3 and 4 (Aquatic and Wetland Habitats)[1] |
| Artichoke | 9 | 6 | 9 | 6 |
| Berry | 6 | 6 | 9 | 6 |
| Citrus | 9 | 9 | 9 pts plus other mitigations | 9 |
| Corn | 6 | 6 | 9 | 9 |
| Grape | 9 | 9 | 9 pts plus other mitigations | 9 |
| Pome Fruit | 9 | 9 | 9 | 9 |
| Cotton | 6 | 9 | 9 | 9 |
| Alfalfa | 9 | 9 | 9 | 9 |
| Asparagus | 9 | 9 | 9 | 9 |
| Barley | 6 | 9 | 9 | 9 |
| Peach | 9 | 9 | 9 | 9 |
| Pea | 6 | 9 | 9 | 9 |
| Sorghum | 6 | 6 | 6 | 6 |
| Sugarcane | 9 | 9 | 9 | 9 |
| Tree Nut | 9 | 9 | 9 | 9 |
| Wheat | 6 | 9 | 9 | 9 |

[1] Many of the listed wetland species that occur in PULAs 3 and 4 also occur in terrestrial habitats. EPA proposes that if mitigations are applicable for terrestrial habitats (PULAs 1 and 2), these mitigations for terrestrial habitats would also apply to areas covered by PULAs 3 and 4. The result would be that PULAs 3 and 4 would have two sets of mitigations—one set for terrestrial habitats and one for the wetland/aquatic habitats. See **Section 7.2.2 in the Strategy Framework document for the full explanation of this proposal**.

## 8.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 8.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of diuron. For major crops (*e.g.,* corn, cotton, wheat), the crop-specific UDLs were selected. For other uses such as on asparagus and barley, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). EPA's overlap analysis was based on the offsite transport

area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential diuron use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high **Table 8-12**. Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 8-22** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected diuron UDLs[90] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For diuron's UDLs, fewer species (327) and CHs (73) have overlap >5%. An important consideration for the purposes of this example is that EPA did not necessarily evaluate all registered uses of diuron (see **Section 8.2**), so additional species could be identified in the future for diuron. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of diuron; however, the PULAs include some species and CHs that have <5% overlap with diuron's potential exposure area for the considered uses.

[90] The selected use data layers (UDLs) do not necessarily represent every registered use of diuron. See **Section 8.2** for more information on the uses evaluated in this example.

**Table 8-23. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Diuron Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Alfalfa | 469 / 142 | 141 | 42 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Other Grains | | 236 | 51 |
| Citrus | | 50 | 10 |
| Corn | | 150 | 30 |
| Cotton | | 71 | 13 |
| Grapes | | 117 | 31 |
| Other Orchards | | 131 | 36 |
| Wheat | | 182 | 41 |
| Total across all UDLs above[2] | | 327 | 73 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Alfalfa | 534 / 316 | 152 | 82 |
| Vegetables and Ground Fruit | | 166 | 83 |
| Other Grains | | 284 | 137 |
| Citrus | | 33 | 5 |
| Corn | | 317 | 148 |
| Cotton | | 186 | 83 |
| Grapes | | 54 | 30 |
| Other Orchards | | 132 | 80 |
| Wheat | | 304 | 136 |
| Total across all UDLs above[2] | | 408 | 206 |
| Cultivated | | 460 | 225 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for diuron. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for diuron (excluding the Cultivated UDL, which is summarized below this row).

## 8.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

T the ranges of $IC_{25}$ values for plant height from the seedling emergence studies are 0.81 to 10.5 lb a.i./A (excluding non-definitive endpoints[91]) for monocots and 0.18 to 12.6 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 4.9 and 3.3 lb a.i./A, respectively. The ranges of $IC_{25}$ values for plant height from the vegetative vigor studies are 0.048 to 3.68 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.0053 to 1.15 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 1.5 and 0.34 lb a.i./A, respectively.

For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.099 to 3.81 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.075 to 6.87 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 1.7 and 2.1 lb a.i./A, respectively. The ranges of $IC_{25}$ values for dry weight data in the vegetative vigor studies are 0.0208 to 0.422 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.0017 to 0.304 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.21 and 0.089 lb a.i./A, respectively.

[91] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 4 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 8.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to diuron. EPA developed separate SSDs for height and weight.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. **Section 8.7** and the subsections below provide summary statistics from the fitted SSD for dry weight and height (if sufficient data are available). Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the diuron data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5$^{th}$ percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5$^{th}$ percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5$^{th}$ percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

### Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA made comparison of the 5$^{th}$ and 25$^{th}$ percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### Species Sensitivity Distribution (SSD) for Diuron

The toxicity endpoints included in the SSDs and the resulting percentiles of the $IC_{25}$ values from the SSD can be found in **Section 8.7.**

*Seedling Emergence Height Data*

Goodness of fit:

Results:

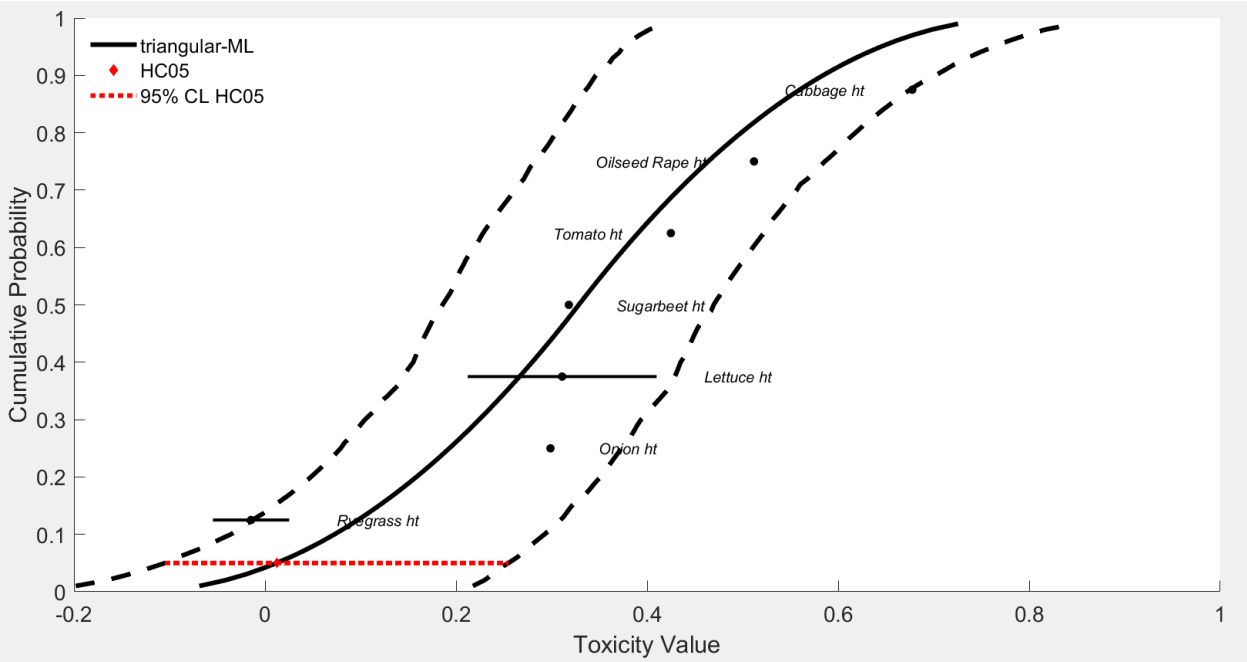
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 1.0821 | 0.7393 |
| 2 | logistic | ML | 1.0999 | 0.6124 |
| 3 | triangular | ML | 1.0283 | 0.5624 |
| 4 | gumbel | ML | 1.0808 | 0.4456 |
| 5 | weibull | ML | 0.8459 | 0.6883 |
| 6 | burr | ML | 1.0381 | 0.6284 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 1.0249 |
| Model-averaged SE of HCp: | 0.30655 |
| CV of HCp: | 0.29909 |

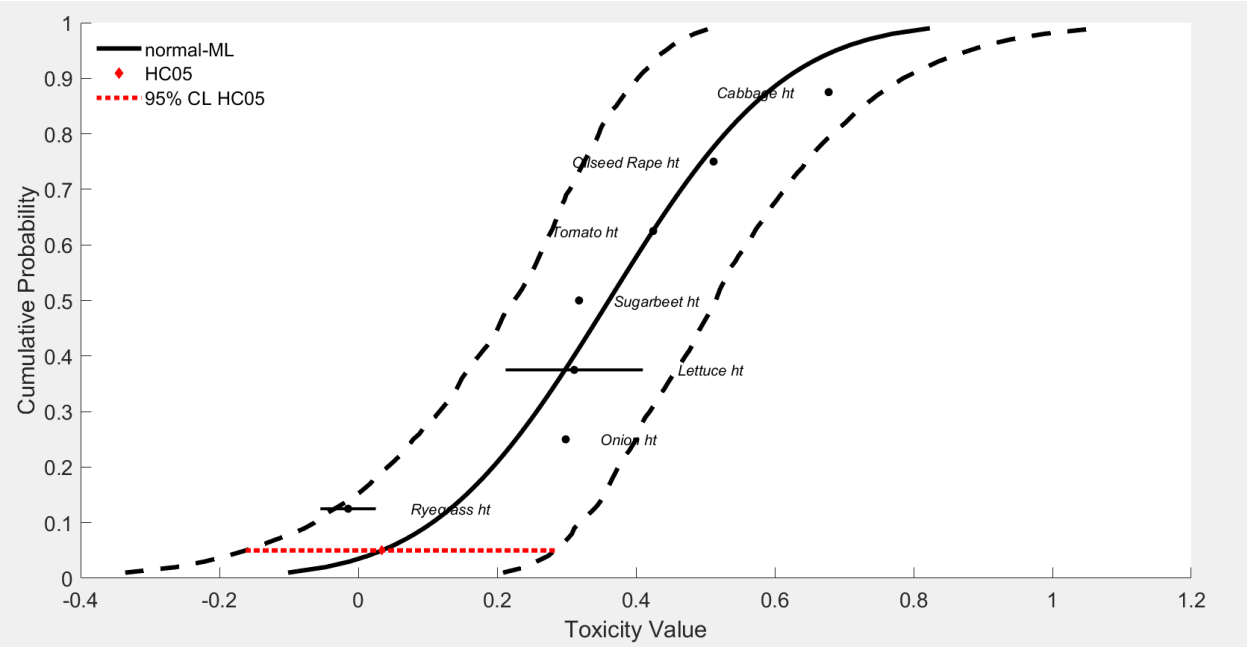
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 26.7741 | 0 | 0.3044 | 1.0283 | 0.2405 |
| 2 | normal | 27.5588 | 0.7847 | 0.2056 | 1.0821 | 0.2870 |
| 3 | logistic | 27.5798 | 0.8057 | 0.2035 | 1.0999 | 0.3229 |
| 4 | weibull | 27.7557 | 0.9816 | 0.1864 | 0.8459 | 0.3647 |
| 5 | gumbel | 29.1313 | 2.3572 | 0.0937 | 1.0808 | 0.2099 |
| 6 | burr | 34.5062 | 7.7321 | 0.0064 | 1.0381 | 0.4344 |

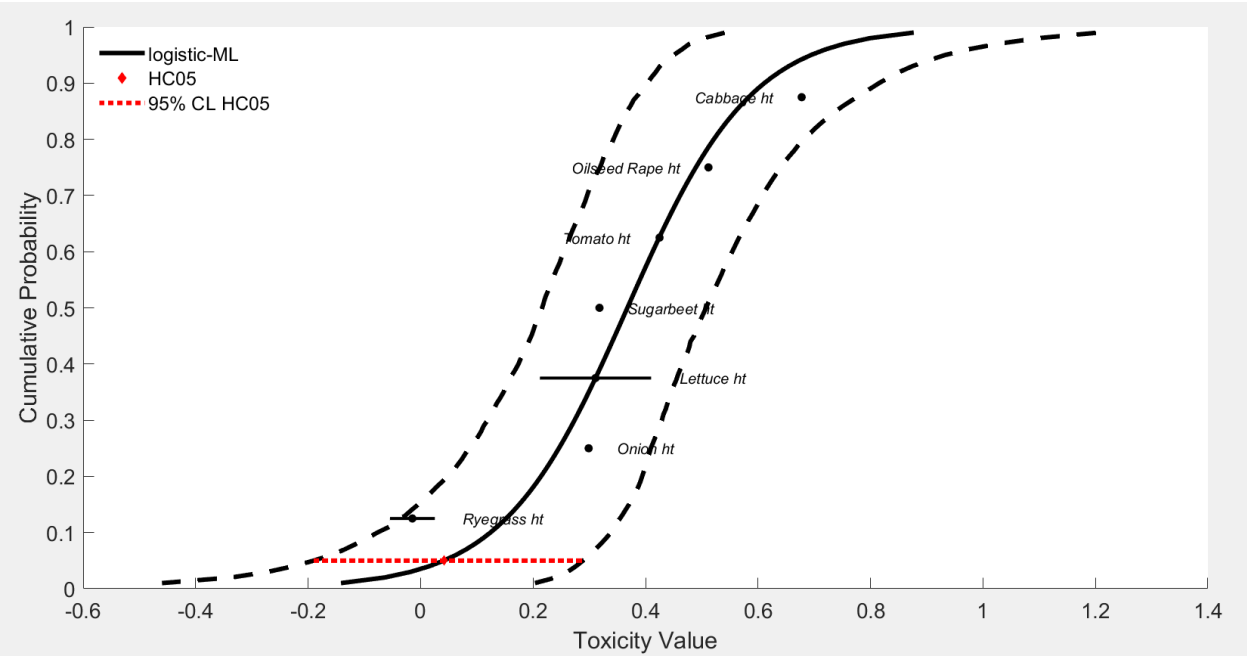
Based on the goodness of fit, EPA moved forward with triangular, normal, and logistic distributions, and ultimately selected the logistic distribution for the height data from the seedling emergence toxicity tests.




Triangular




Normal




Logistic (selected distribution)

*Seedling Emergence Dry Weight Data*

Goodness of fit:

Results:

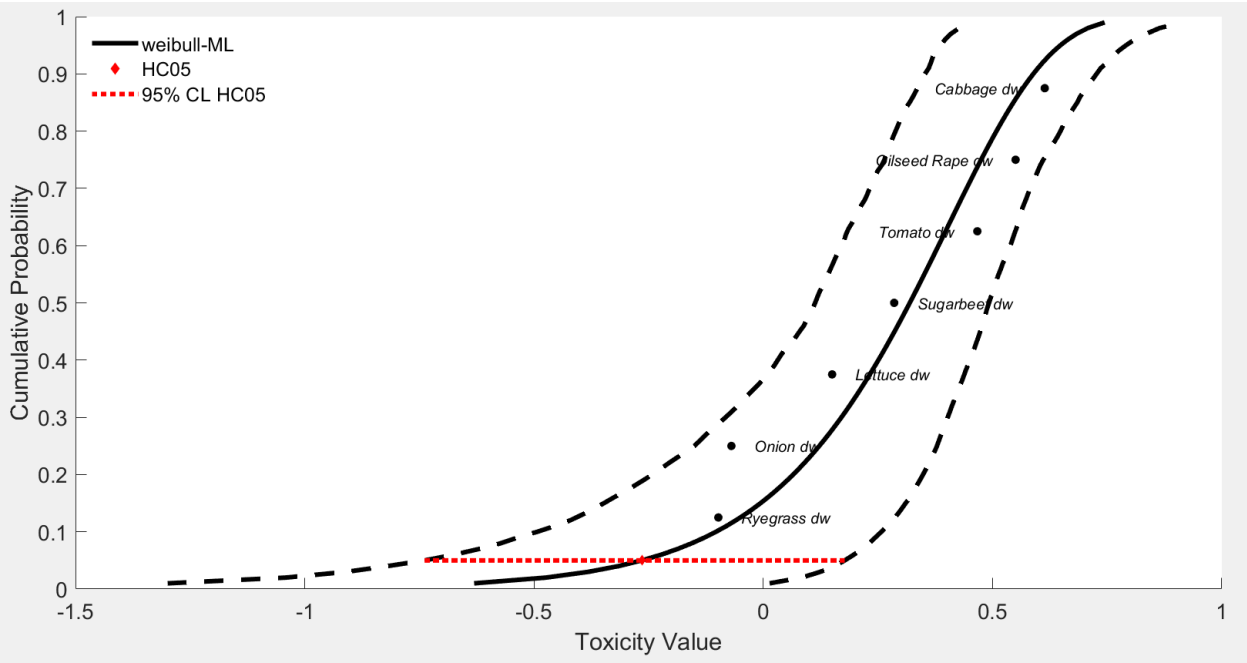
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.6782 | 0.4226 |
| 2 | logistic | ML | 0.6177 | 0.3377 |
| 3 | triangular | ML | 0.7870 | 0.4256 |
| 4 | gumbel | ML | 0.7381 | 0.3606 |
| 5 | weibull | ML | 0.5435 | 0.4286 |
| 6 | burr | ML | 0.7379 | 0.3337 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.68244 |
| Model-averaged SE of HCp: | 0.26537 |
| CV of HCp: | 0.38886 |

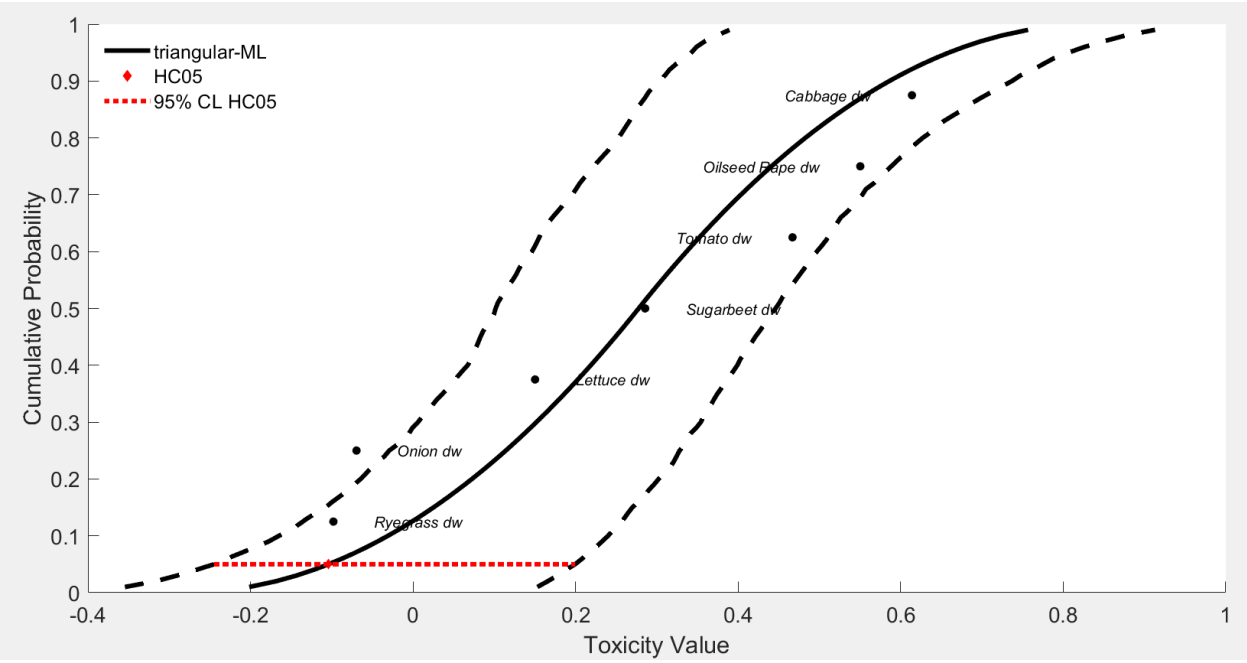
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 27.9999 | 0 | 0.2997 | 0.7870 | 0.2239 |
| 2 | weibull | 28.6400 | 0.6401 | 0.2176 | 0.5435 | 0.3100 |
| 3 | normal | 28.8254 | 0.8255 | 0.1983 | 0.6782 | 0.2421 |
| 4 | gumbel | 29.4339 | 1.4340 | 0.1463 | 0.7381 | 0.1763 |
| 5 | logistic | 29.6142 | 1.6143 | 0.1337 | 0.6177 | 0.2687 |
| 6 | burr | 36.4344 | 8.4345 | 0.0044 | 0.7379 | 0.1763 |

Based on the goodness of fit, EPA moved forward with Weibull and triangular distributions, and ultimately selected the Weibull distribution for the dry weight data from the seedling emergence toxicity tests.




Weibull (selected distribution)




Triangular

### *Vegetative Vigor Height Data*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0125 | 0.0370 |
| 2 | logistic | ML | 0.0086 | 0.0340 |
| 3 | triangular | ML | 0.0156 | 0.0969 |
| 4 | gumbel | ML | 0.0225 | 0.0490 |
| 5 | weibull | ML | 0.0034 | 0.0519 |
| 6 | burr | ML | 0.0224 | 0.0380 |

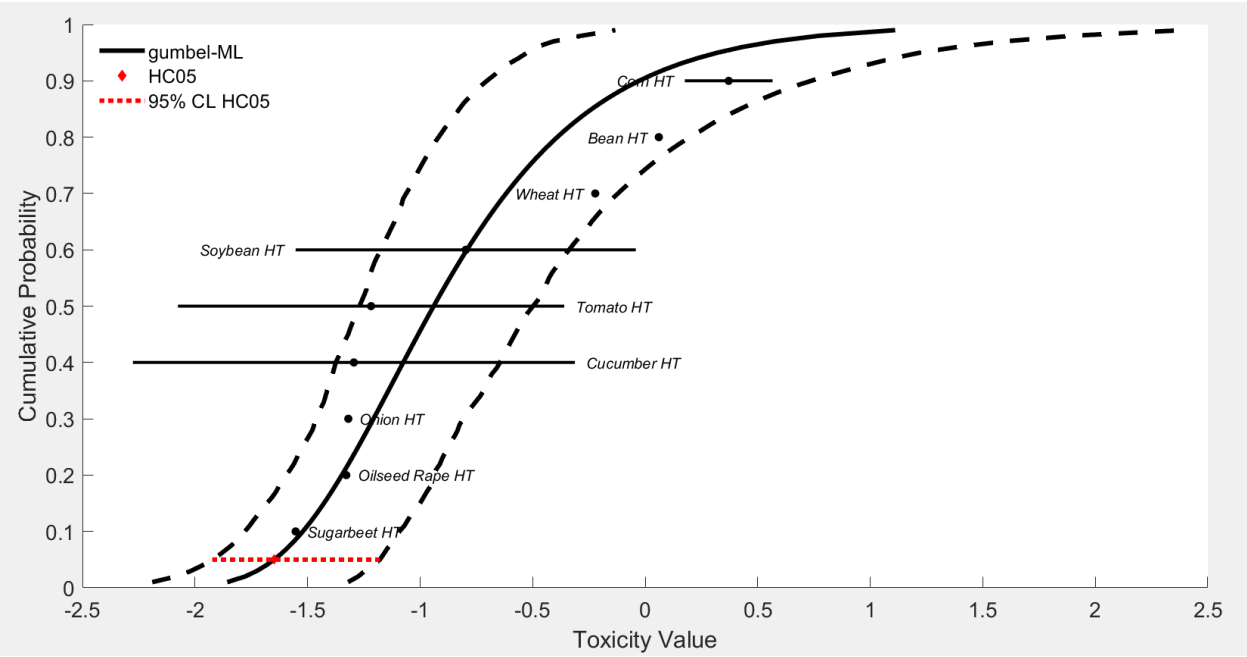
Significant lack of fit for all distributions except triangular and Weibull.

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.01669 |
| Model-averaged SE of HCp: | 0.012186 |
| CV of HCp: | 0.73013 |

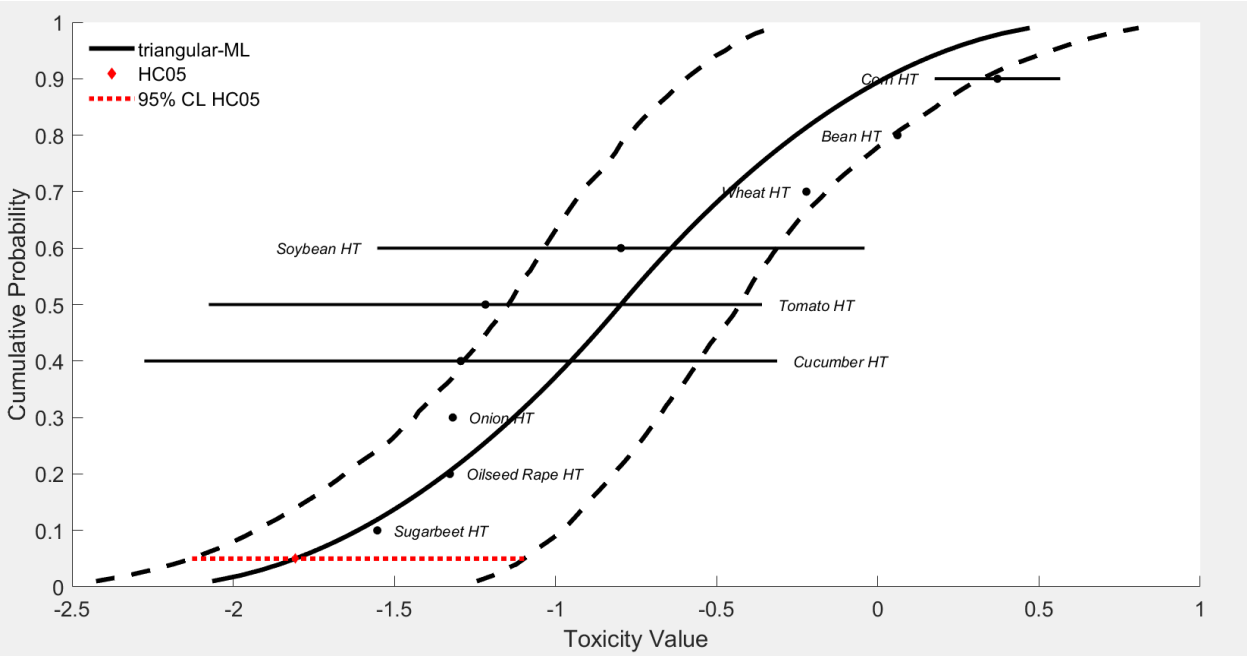
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | 3.7310 | 0 | 0.4110 | 0.0225 | 0.0099 |
| 2 | triangular | 4.9628 | 1.2318 | 0.2220 | 0.0156 | 0.0145 |
| 3 | normal | 5.5950 | 1.8640 | 0.1618 | 0.0125 | 0.0098 |
| 4 | logistic | 6.3584 | 2.6274 | 0.1105 | 0.0086 | 0.0074 |
| 5 | weibull | 7.6623 | 3.9313 | 0.0576 | 0.0034 | 0.0049 |
| 6 | burr | 8.5344 | 4.8034 | 0.0372 | 0.0224 | 0.0098 |

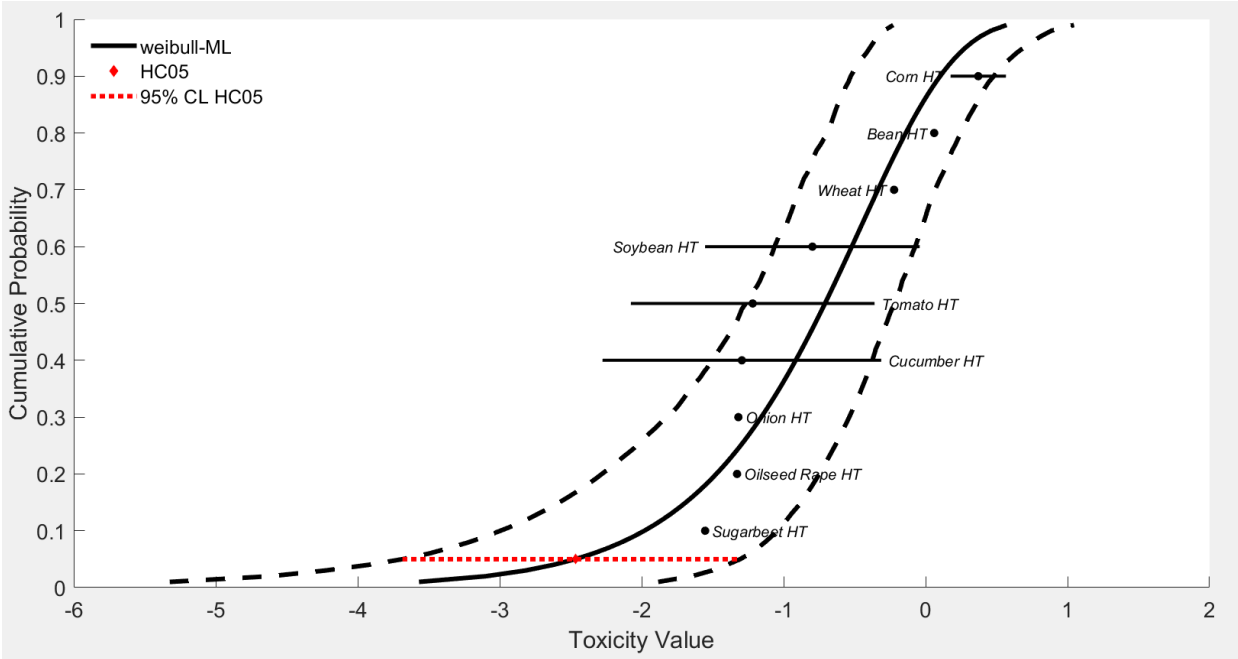
Based on the goodness of fit, EPA moved forward with Gumbel, Weibull, and triangular distributions, and ultimately selected the Gumbel distribution for the height data from the vegetative vigor toxicity tests.




Gumbel (selected distribution)




Triangular




Weibull

### *Vegetative Vigor Dry Weight Data*

Goodness of fit:

Results:

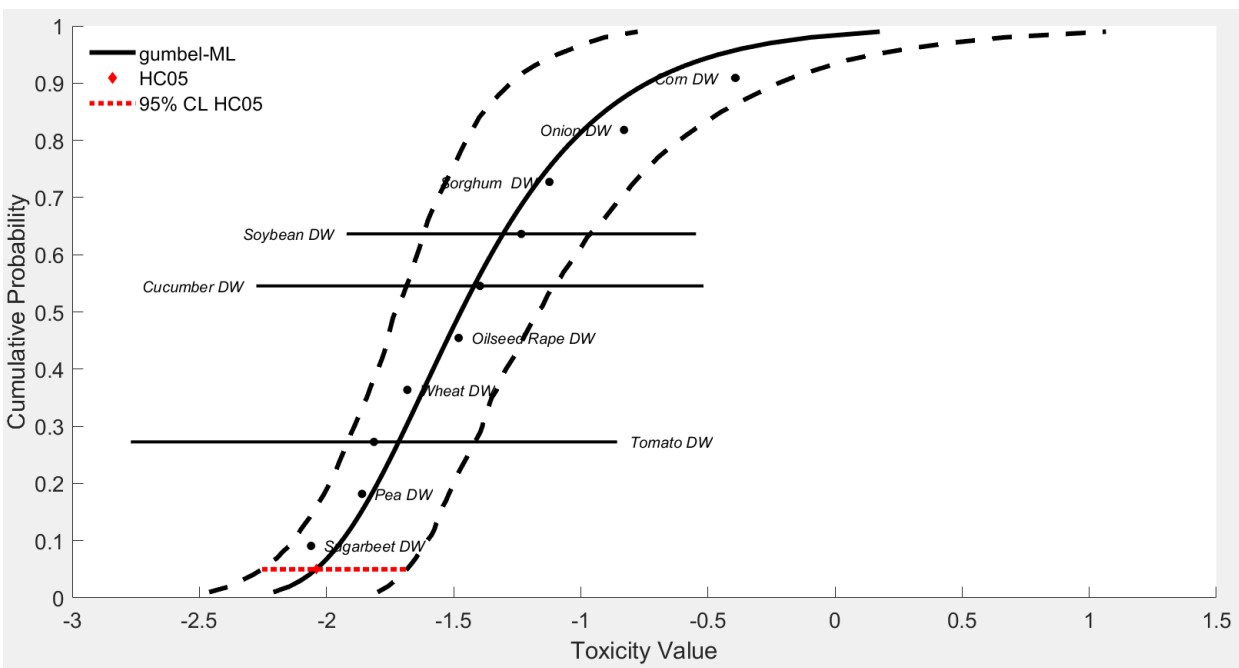
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0065 | 0.8991 |
| 2 | logistic | ML | 0.0056 | 0.8921 |
| 3 | triangular | ML | 0.0077 | 0.7373 |
| 4 | gumbel | ML | 0.0091 | 0.9281 |
| 5 | weibull | ML | 0.0022 | 0.6274 |
| 6 | burr | ML | 0.0091 | 0.9151 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0074016 |
| Model-averaged SE of HCp: | 0.0039737 |
| CV of HCp: | 0.53687 |

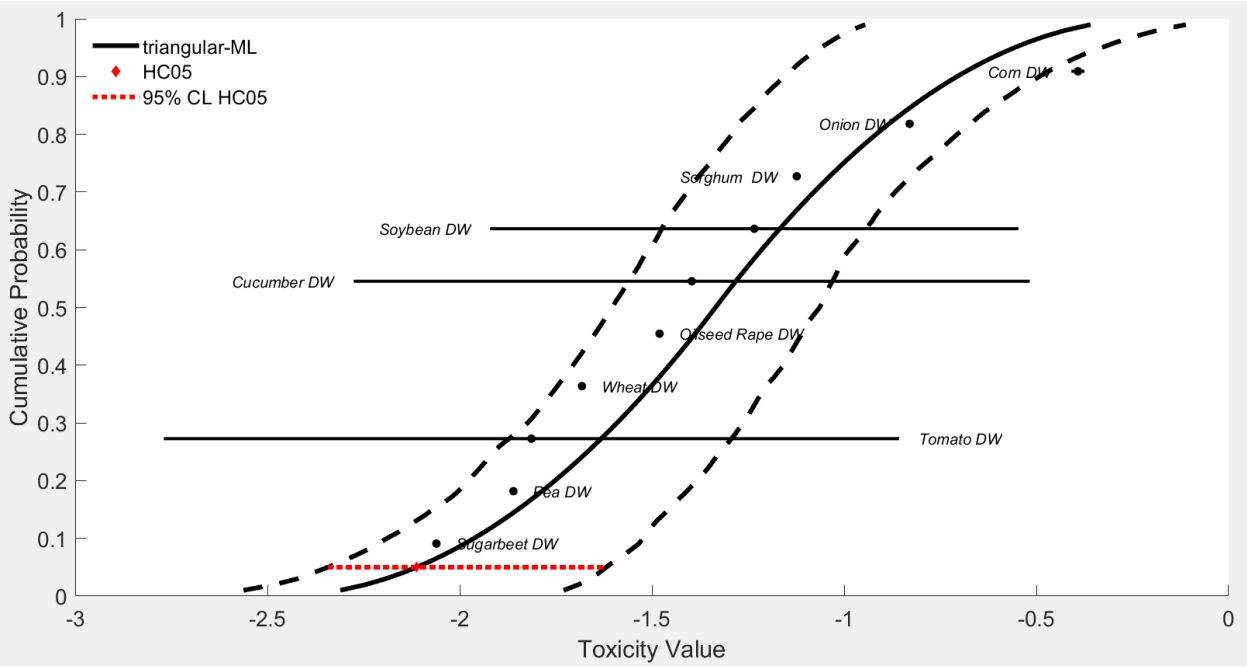
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -28.6802 | 0 | 0.3240 | 0.0091 | 0.0029 |
| 2 | triangular | -28.1266 | 0.5536 | 0.2457 | 0.0077 | 0.0046 |
| 3 | normal | -27.5906 | 1.0896 | 0.1879 | 0.0065 | 0.0035 |
| 4 | logistic | -27.2097 | 1.4705 | 0.1553 | 0.0056 | 0.0033 |
| 5 | weibull | -24.9073 | 3.7729 | 0.0491 | 0.0022 | 0.0022 |
| 6 | burr | -24.3932 | 4.2870 | 0.0380 | 0.0091 | 0.0029 |

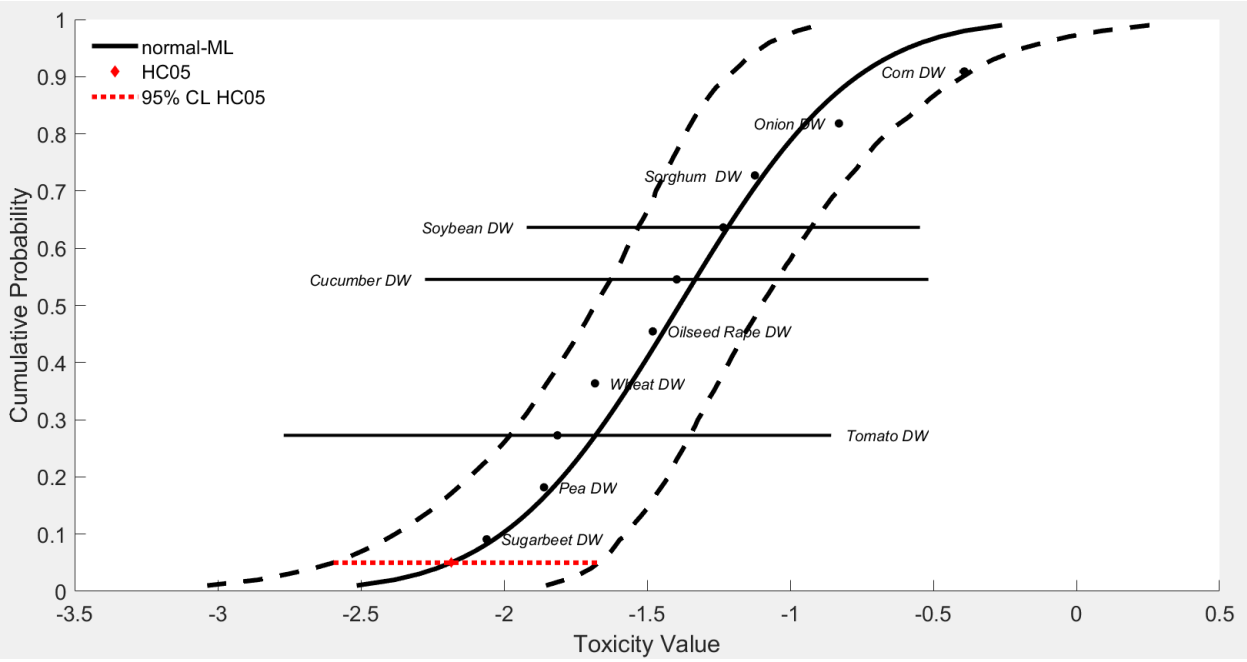
Based on the goodness of fit, EPA moved forward with Gumbel, normal, and triangular distributions, and ultimately selected the Gumbel distribution for the dry weight data from the vegetative vigor toxicity tests.




Gumbel (selected distribution)




Triangular




Normal

## 8.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 8-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| Application Rate of 8.0 lb a.i./A (maximum application rate for use on grape) | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted | | | 75 | 20 | 10 | 5 |
| Application Rate of 6.4 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate) | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted | | | 50 | 20 | 10 | 5 |
| Application Rate of 3.2 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate) | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted | | | 20 | 10 | 5 | <5 |
| Application Rate of 1.6 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate) | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 20 | 20 | 20 | 10 | 5 | 0 * | 0 * |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 3.08 µg a.i./L for green algae, *Raphidocelis subcapitata* (MRID 42218401). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For diuron, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 8.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 8-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 8.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 439.5 | 439.5 | 439.5 | 927.7 | 896.1 | 890.4 | 886.1 | 418.7 |
| 10 | 295.8 | 265.7 | 243.8 | 230.8 | 82.2 | 40.8 | 24.4 | 202.6 |
| 20 | 219.8 | 176.2 | 151.1 | 116.3 | 38.9 | 22.0 | 13.3 | 114.1 |
| 25 | 188.0 | 143.0 | 118.4 | 85.6 | 28.9 | 17.4 | 10.5 | 82.5 |
| 50 | 147.5 | 95.0 | 62.8 | 41.7 | 14.8 | 10.1 | 6.2 | 30.0 |
| 75 | 103.6 | 64.1 | 41.4 | 27.7 | 10.3 | 7.4 | 4.6 | 14.4 |
| 100 | 87.5 | 51.1 | 32.4 | 22.2 | 8.4 | 6.2 | 3.9 | 9.3 |
| 125 | 65.3 | 37.7 | 24.2 | 17.4 | 6.9 | 5.2 | 3.3 | 5.7 |
| 150 | 54.8 | 30.1 | 18.8 | 14.3 | 5.8 | 4.4 | 2.9 | 3.8 |
| 175 | 45.7 | 25.1 | 15.4 | 12.0 | 5.0 | 3.9 | 2.5 | 2.7 |
| 200 | 40.6 | 22.0 | 13.2 | 10.7 | 4.6 | 3.6 | 2.3 | 2.1 |
| 225 | 36.9 | 18.8 | 11.1 | 9.3 | 4.1 | 3.2 | 2.1 | 1.6 |
| 250 | 32.3 | 16.2 | 9.6 | 8.2 | 3.7 | 2.9 | 1.9 | 1.2 |
| 275 | 29.4 | 14.3 | 8.5 | 7.3 | 3.3 | 2.6 | 1.8 | 1.0 |
| 300 | 26.7 | 12.8 | 7.7 | 6.6 | 3.1 | 2.4 | 1.7 | 0.8 |
| 325 | 24.4 | 11.6 | 7.0 | 5.9 | 2.8 | 2.3 | 1.5 | 0.7 |
| 350 | 23.0 | 10.8 | 6.6 | 5.5 | 2.7 | 2.1 | 1.5 | 0.6 |
| 375 | 21.4 | 10.0 | 6.2 | 5.0 | 2.5 | 2.0 | 1.4 | 0.5 |
| 400 | 19.9 | 9.3 | 5.8 | 4.6 | 2.3 | 1.9 | 1.3 | 0.4 |
| 500 | 16.5 | 7.6 | 4.7 | 2.5 | 0.9 | 0.8 | 0.5 | 0.3 |
| 600 | 14.2 | 6.6 | 4.0 | 1.9 | 0.8 | 0.6 | 0.4 | 0.2 |
| 700 | 12.7 | 5.9 | 3.5 | 1.4 | 0.6 | 0.5 | 0.4 | 0.1 |
| 800 | 11.7 | 5.4 | 3.2 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 |
| 900 | 11.0 | 5.0 | 2.9 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 1000 | 10.4 | 4.7 | 2.8 | 0.8 | 0.4 | 0.3 | 0.2 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0091 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 8.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 222.2 | 222.2 | 222.2 | 469.0 | 453.0 | 450.1 | 447.9 | 211.7 |
| 10 | 149.6 | 134.3 | 123.2 | 116.7 | 41.6 | 20.6 | 12.4 | 102.4 |
| 20 | 111.1 | 89.1 | 76.4 | 58.8 | 19.7 | 11.1 | 6.7 | 57.7 |
| 25 | 95.0 | 72.3 | 59.9 | 43.3 | 14.6 | 8.8 | 5.3 | 41.7 |
| 50 | 74.6 | 48.0 | 31.7 | 21.1 | 7.5 | 5.1 | 3.2 | 15.2 |
| 75 | 52.4 | 32.4 | 20.9 | 14.0 | 5.2 | 3.7 | 2.3 | 7.3 |
| 100 | 44.2 | 25.8 | 16.4 | 11.2 | 4.3 | 3.1 | 2.0 | 4.7 |
| 125 | 33.0 | 19.1 | 12.2 | 8.8 | 3.5 | 2.6 | 1.7 | 2.9 |
| 150 | 27.7 | 15.2 | 9.5 | 7.2 | 2.9 | 2.2 | 1.5 | 1.9 |
| 175 | 23.1 | 12.7 | 7.8 | 6.1 | 2.5 | 2.0 | 1.3 | 1.4 |
| 200 | 20.5 | 11.1 | 6.7 | 5.4 | 2.3 | 1.8 | 1.2 | 1.1 |
| 225 | 18.6 | 9.5 | 5.6 | 4.7 | 2.1 | 1.6 | 1.1 | 0.8 |
| 250 | 16.3 | 8.2 | 4.9 | 4.2 | 1.9 | 1.5 | 1.0 | 0.6 |
| 275 | 14.9 | 7.2 | 4.3 | 3.7 | 1.7 | 1.3 | 0.9 | 0.5 |
| 300 | 13.5 | 6.4 | 3.9 | 3.3 | 1.5 | 1.2 | 0.8 | 0.4 |
| 325 | 12.4 | 5.8 | 3.6 | 3.0 | 1.4 | 1.1 | 0.8 | 0.3 |
| 350 | 11.6 | 5.5 | 3.4 | 2.8 | 1.3 | 1.1 | 0.7 | 0.3 |
| 375 | 10.8 | 5.1 | 3.1 | 2.5 | 1.3 | 1.0 | 0.7 | 0.2 |
| 400 | 10.1 | 4.7 | 2.9 | 2.3 | 1.2 | 0.9 | 0.7 | 0.2 |
| 500 | 8.3 | 3.8 | 2.4 | 1.3 | 0.5 | 0.4 | 0.3 | 0.1 |
| 600 | 7.2 | 3.3 | 2.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 700 | 6.4 | 3.0 | 1.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 800 | 5.9 | 2.7 | 1.6 | 0.6 | 0.3 | 0.2 | 0.2 | <0.1 |
| 900 | 5.6 | 2.5 | 1.5 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 1000 | 5.3 | 2.4 | 1.4 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.018 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 6.4 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 351.6 | 351.6 | 351.6 | 742.1 | 716.9 | 712.3 | 708.8 | 335.0 |
| 10 | 236.7 | 212.5 | 195.0 | 184.6 | 65.8 | 32.6 | 19.6 | 162.1 |
| 20 | 175.9 | 141.0 | 120.8 | 93.1 | 31.2 | 17.6 | 10.6 | 91.3 |
| 25 | 150.4 | 114.4 | 94.7 | 68.5 | 23.1 | 13.9 | 8.4 | 66.0 |
| 50 | 118.0 | 76.0 | 50.2 | 33.3 | 11.8 | 8.1 | 5.0 | 24.0 |
| 75 | 82.9 | 51.3 | 33.1 | 22.2 | 8.2 | 5.9 | 3.7 | 11.5 |
| 100 | 70.0 | 40.9 | 25.9 | 17.7 | 6.8 | 5.0 | 3.2 | 7.5 |
| 125 | 52.2 | 30.2 | 19.3 | 13.9 | 5.5 | 4.1 | 2.7 | 4.6 |
| 150 | 43.8 | 24.1 | 15.1 | 11.5 | 4.6 | 3.5 | 2.3 | 3.0 |
| 175 | 36.6 | 20.1 | 12.3 | 9.6 | 4.0 | 3.1 | 2.0 | 2.1 |
| 200 | 32.5 | 17.6 | 10.6 | 8.6 | 3.7 | 2.8 | 1.9 | 1.7 |
| 225 | 29.5 | 15.0 | 8.9 | 7.5 | 3.2 | 2.6 | 1.7 | 1.3 |
| 250 | 25.9 | 13.0 | 7.7 | 6.6 | 2.9 | 2.3 | 1.6 | 1.0 |
| 275 | 23.5 | 11.4 | 6.8 | 5.9 | 2.7 | 2.1 | 1.4 | 0.8 |
| 300 | 21.4 | 10.2 | 6.1 | 5.3 | 2.4 | 1.9 | 1.3 | 0.6 |
| 325 | 19.5 | 9.3 | 5.6 | 4.7 | 2.3 | 1.8 | 1.2 | 0.5 |
| 350 | 18.4 | 8.7 | 5.3 | 4.4 | 2.1 | 1.7 | 1.2 | 0.5 |
| 375 | 17.1 | 8.0 | 4.9 | 4.0 | 2.0 | 1.6 | 1.1 | 0.4 |
| 400 | 16.0 | 7.4 | 4.6 | 3.7 | 1.8 | 1.5 | 1.0 | 0.3 |
| 500 | 13.2 | 6.1 | 3.7 | 2.0 | 0.7 | 0.6 | 0.4 | 0.2 |
| 600 | 11.4 | 5.3 | 3.2 | 1.5 | 0.6 | 0.5 | 0.3 | 0.1 |
| 700 | 10.2 | 4.7 | 2.8 | 1.2 | 0.5 | 0.4 | 0.3 | 0.1 |
| 800 | 9.4 | 4.3 | 2.5 | 0.9 | 0.4 | 0.4 | 0.3 | 0.1 |
| 900 | 8.8 | 4.0 | 2.4 | 0.7 | 0.4 | 0.3 | 0.2 | <0.1 |
| 1000 | 8.3 | 3.8 | 2.2 | 0.6 | 0.3 | 0.3 | 0.2 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0091 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 6.4 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 177.8 | 177.7 | 177.7 | 375.2 | 362.4 | 360.1 | 358.4 | 169.3 |
| 10 | 119.6 | 107.4 | 98.6 | 93.3 | 33.2 | 16.5 | 9.9 | 82.0 |
| 20 | 88.9 | 71.3 | 61.1 | 47.1 | 15.8 | 8.9 | 5.4 | 46.2 |
| 25 | 76.0 | 57.8 | 47.9 | 34.6 | 11.7 | 7.0 | 4.3 | 33.4 |
| 50 | 59.7 | 38.4 | 25.4 | 16.9 | 6.0 | 4.1 | 2.5 | 12.1 |
| 75 | 41.9 | 25.9 | 16.7 | 11.2 | 4.2 | 3.0 | 1.9 | 5.8 |
| 100 | 35.4 | 20.7 | 13.1 | 9.0 | 3.4 | 2.5 | 1.6 | 3.8 |
| 125 | 26.4 | 15.3 | 9.8 | 7.0 | 2.8 | 2.1 | 1.3 | 2.3 |
| 150 | 22.2 | 12.2 | 7.6 | 5.8 | 2.3 | 1.8 | 1.2 | 1.5 |
| 175 | 18.5 | 10.2 | 6.2 | 4.9 | 2.0 | 1.6 | 1.0 | 1.1 |
| 200 | 16.4 | 8.9 | 5.4 | 4.3 | 1.8 | 1.4 | 0.9 | 0.9 |
| 225 | 14.9 | 7.6 | 4.5 | 3.8 | 1.6 | 1.3 | 0.9 | 0.6 |
| 250 | 13.1 | 6.6 | 3.9 | 3.3 | 1.5 | 1.2 | 0.8 | 0.5 |
| 275 | 11.9 | 5.8 | 3.5 | 3.0 | 1.3 | 1.1 | 0.7 | 0.4 |
| 300 | 10.8 | 5.2 | 3.1 | 2.7 | 1.2 | 1.0 | 0.7 | 0.3 |
| 325 | 9.9 | 4.7 | 2.8 | 2.4 | 1.1 | 0.9 | 0.6 | 0.3 |
| 350 | 9.3 | 4.4 | 2.7 | 2.2 | 1.1 | 0.9 | 0.6 | 0.2 |
| 375 | 8.6 | 4.0 | 2.5 | 2.0 | 1.0 | 0.8 | 0.6 | 0.2 |
| 400 | 8.1 | 3.8 | 2.3 | 1.9 | 0.9 | 0.8 | 0.5 | 0.2 |
| 500 | 6.7 | 3.1 | 1.9 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 600 | 5.8 | 2.7 | 1.6 | 0.8 | 0.3 | 0.3 | 0.2 | 0.1 |
| 700 | 5.2 | 2.4 | 1.4 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 |
| 800 | 4.7 | 2.2 | 1.3 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 900 | 4.4 | 2.0 | 1.2 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 1000 | 4.2 | 1.9 | 1.1 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.018 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 3.2 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 175.8 | 175.8 | 175.8 | 371.1 | 358.4 | 356.2 | 354.4 | 167.5 |
| 10 | 118.3 | 106.3 | 97.5 | 92.3 | 32.9 | 16.3 | 9.8 | 81.1 |
| 20 | 87.9 | 70.5 | 60.4 | 46.5 | 15.6 | 8.8 | 5.3 | 45.7 |
| 25 | 75.2 | 57.2 | 47.4 | 34.3 | 11.6 | 7.0 | 4.2 | 33.0 |
| 50 | 59.0 | 38.0 | 25.1 | 16.7 | 5.9 | 4.0 | 2.5 | 12.0 |
| 75 | 41.4 | 25.7 | 16.6 | 11.1 | 4.1 | 3.0 | 1.9 | 5.8 |
| 100 | 35.0 | 20.4 | 13.0 | 8.9 | 3.4 | 2.5 | 1.6 | 3.7 |
| 125 | 26.1 | 15.1 | 9.7 | 7.0 | 2.7 | 2.1 | 1.3 | 2.3 |
| 150 | 21.9 | 12.1 | 7.5 | 5.7 | 2.3 | 1.8 | 1.1 | 1.5 |
| 175 | 18.3 | 10.0 | 6.1 | 4.8 | 2.0 | 1.6 | 1.0 | 1.1 |
| 200 | 16.3 | 8.8 | 5.3 | 4.3 | 1.8 | 1.4 | 0.9 | 0.8 |
| 225 | 14.7 | 7.5 | 4.5 | 3.7 | 1.6 | 1.3 | 0.9 | 0.6 |
| 250 | 12.9 | 6.5 | 3.9 | 3.3 | 1.5 | 1.2 | 0.8 | 0.5 |
| 275 | 11.8 | 5.7 | 3.4 | 2.9 | 1.3 | 1.1 | 0.7 | 0.4 |
| 300 | 10.7 | 5.1 | 3.1 | 2.6 | 1.2 | 1.0 | 0.7 | 0.3 |
| 325 | 9.8 | 4.6 | 2.8 | 2.4 | 1.1 | 0.9 | 0.6 | 0.3 |
| 350 | 9.2 | 4.3 | 2.7 | 2.2 | 1.1 | 0.9 | 0.6 | 0.2 |
| 375 | 8.5 | 4.0 | 2.5 | 2.0 | 1.0 | 0.8 | 0.6 | 0.2 |
| 400 | 8.0 | 3.7 | 2.3 | 1.8 | 0.9 | 0.7 | 0.5 | 0.2 |
| 500 | 6.6 | 3.0 | 1.9 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 600 | 5.7 | 2.6 | 1.6 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 700 | 5.1 | 2.4 | 1.4 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 |
| 800 | 4.7 | 2.2 | 1.3 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 900 | 4.4 | 2.0 | 1.2 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 1000 | 4.2 | 1.9 | 1.1 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0091 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 3.2 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 88.9 | 88.9 | 88.9 | 187.6 | 181.2 | 180.1 | 179.2 | 84.7 |
| 10 | 59.8 | 53.7 | 49.3 | 46.7 | 16.6 | 8.2 | 4.9 | 41.0 |
| 20 | 44.5 | 35.6 | 30.5 | 23.5 | 7.9 | 4.4 | 2.7 | 23.1 |
| 25 | 38.0 | 28.9 | 23.9 | 17.3 | 5.8 | 3.5 | 2.1 | 16.7 |
| 50 | 29.8 | 19.2 | 12.7 | 8.4 | 3.0 | 2.0 | 1.3 | 6.1 |
| 75 | 21.0 | 13.0 | 8.4 | 5.6 | 2.1 | 1.5 | 0.9 | 2.9 |
| 100 | 17.7 | 10.3 | 6.6 | 4.5 | 1.7 | 1.3 | 0.8 | 1.9 |
| 125 | 13.2 | 7.6 | 4.9 | 3.5 | 1.4 | 1.0 | 0.7 | 1.2 |
| 150 | 11.1 | 6.1 | 3.8 | 2.9 | 1.2 | 0.9 | 0.6 | 0.8 |
| 175 | 9.2 | 5.1 | 3.1 | 2.4 | 1.0 | 0.8 | 0.5 | 0.5 |
| 200 | 8.2 | 4.4 | 2.7 | 2.2 | 0.9 | 0.7 | 0.5 | 0.4 |
| 225 | 7.5 | 3.8 | 2.3 | 1.9 | 0.8 | 0.6 | 0.4 | 0.3 |
| 250 | 6.5 | 3.3 | 1.9 | 1.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| 275 | 5.9 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.4 | 0.2 |
| 300 | 5.4 | 2.6 | 1.6 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 325 | 4.9 | 2.3 | 1.4 | 1.2 | 0.6 | 0.5 | 0.3 | 0.1 |
| 350 | 4.6 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 400 | 4.0 | 1.9 | 1.2 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 500 | 3.3 | 1.5 | 0.9 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 600 | 2.9 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 700 | 2.6 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.4 | 1.1 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.2 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.018 lb a.i./A

[2] Although aerial application is not permitted on the diuron labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 8.3.3.1** and **8.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.6 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 87.9 | 87.9 | 87.9 | 185.5 | 179.2 | 178.1 | 177.2 | 83.7 |
| 10 | 59.2 | 53.1 | 48.8 | 46.2 | 16.4 | 8.2 | 4.9 | 40.5 |
| 20 | 44.0 | 35.2 | 30.2 | 23.3 | 7.8 | 4.4 | 2.7 | 22.8 |
| 25 | 37.6 | 28.6 | 23.7 | 17.1 | 5.8 | 3.5 | 2.1 | 16.5 |
| 50 | 29.5 | 19.0 | 12.6 | 8.3 | 3.0 | 2.0 | 1.2 | 6.0 |
| 75 | 20.7 | 12.8 | 8.3 | 5.5 | 2.1 | 1.5 | 0.9 | 2.9 |
| 100 | 17.5 | 10.2 | 6.5 | 4.4 | 1.7 | 1.2 | 0.8 | 1.9 |
| 125 | 13.1 | 7.5 | 4.8 | 3.5 | 1.4 | 1.0 | 0.7 | 1.1 |
| 150 | 11.0 | 6.0 | 3.8 | 2.9 | 1.2 | 0.9 | 0.6 | 0.8 |
| 175 | 9.1 | 5.0 | 3.1 | 2.4 | 1.0 | 0.8 | 0.5 | 0.5 |
| 200 | 8.1 | 4.4 | 2.6 | 2.1 | 0.9 | 0.7 | 0.5 | 0.4 |
| 225 | 7.4 | 3.8 | 2.2 | 1.9 | 0.8 | 0.6 | 0.4 | 0.3 |
| 250 | 6.5 | 3.2 | 1.9 | 1.6 | 0.7 | 0.6 | 0.4 | 0.2 |
| 275 | 5.9 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.4 | 0.2 |
| 300 | 5.3 | 2.6 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 325 | 4.9 | 2.3 | 1.4 | 1.2 | 0.6 | 0.5 | 0.3 | 0.1 |
| 350 | 4.6 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 400 | 4.0 | 1.9 | 1.2 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 500 | 3.3 | 1.5 | 0.9 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 600 | 2.8 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 700 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.3 | 1.1 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.2 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 2.1 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0091 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 8-32. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.6 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 44.4 | 44.4 | 44.4 | 93.8 | 90.6 | 90.0 | 89.6 | 42.3 |
| 10 | 29.9 | 26.9 | 24.6 | 23.3 | 8.3 | 4.1 | 2.5 | 20.5 |
| 20 | 22.2 | 17.8 | 15.3 | 11.8 | 3.9 | 2.2 | 1.3 | 11.5 |
| 25 | 19.0 | 14.5 | 12.0 | 8.7 | 2.9 | 1.8 | 1.1 | 8.3 |
| 50 | 14.9 | 9.6 | 6.3 | 4.2 | 1.5 | 1.0 | 0.6 | 3.0 |
| 75 | 10.5 | 6.5 | 4.2 | 2.8 | 1.0 | 0.7 | 0.5 | 1.5 |
| 100 | 8.8 | 5.2 | 3.3 | 2.2 | 0.9 | 0.6 | 0.4 | 0.9 |
| 125 | 6.6 | 3.8 | 2.4 | 1.8 | 0.7 | 0.5 | 0.3 | 0.6 |
| 150 | 5.5 | 3.0 | 1.9 | 1.4 | 0.6 | 0.4 | 0.3 | 0.4 |
| 175 | 4.6 | 2.5 | 1.6 | 1.2 | 0.5 | 0.4 | 0.3 | 0.3 |
| 200 | 4.1 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.2 | 0.2 |
| 225 | 3.7 | 1.9 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 250 | 3.3 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 3.0 | 1.4 | 0.9 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 300 | 2.7 | 1.3 | 0.8 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 325 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 350 | 2.3 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 375 | 2.2 | 1.0 | 0.6 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 |
| 400 | 2.0 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.7 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.4 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.3 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.2 | 0.5 | 0.3 | 0.1 | 0.1 | 0.0 | <0.1 | <0.1 |
| 900 | 1.1 | 0.5 | 0.3 | 0.1 | 0.0 | 0.0 | <0.1 | <0.1 |
| 1000 | 1.1 | 0.5 | 0.3 | 0.1 | 0.0 | 0.0 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.018 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 9 MCPA Case Study Example (PC Codes 030501, 030502, 030516, 030564)

## 9.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 9.2 Use Information

MCPA (2-methyl-4-chlorophenoxyacetic acid) is a selective, post-emergence systemic herbicide used for the control of annual and perennial broadleaf weeds. MCPA belongs to the phenoxy carboxylic acid family which acts by mimicking the action of natural hormones and produces uncontrolled cell division and plant growth. MCPA is absorbed by the foliage and roots and translocated throughout the weed. The mechanism of action of MCPA appears to affect the cell wall plasticity and nucleic acids (DNA, RNA) metabolism. End-use products of MCPA are available in salt, ester, or amine forms. MCPA is used in mixture with many other herbicides to achieve a wider spectrum of weed control.

MCPA has four primary active ingredient form associations: MCPA acid (PC Code 030501), MCPA sodium salt (PC Code 030502), MCPA dimethylamine salt (MCPA DMAS; PC Code 030516), and MCPA 2-ethylhexyl ester (MCPA 2-EHE; PC Code 030564). All active ingredients rapidly convert to the free acid in the environment via dissociation (for MCPA DMAS) or via

hydrolysis and microbial degradation in soil (for MCPA 2-EHE). Therefore, EPA assumed that MCPA acid is the active moiety. Within this document, EPA referred to all four active ingredients collectively as 'MCPA'. EPA converted and presented all application rates and toxicity data in terms of acid equivalents (a.e.).

MCPA is moderately stable and mobile (overall $K_{f\text{-}ads}$ = 0.021-1.2 and $K_{foc}$ = 8.9-59 mL/g). In soil environment, MCPA dissipates mainly through aerobic soil metabolism, and in aquatic environments through photodegradation and aerobic aquatic metabolism. MCPA appears to be stable to hydrolysis, anaerobic aquatic metabolism, and anaerobic soil degradation. In various terrestrial field dissipation studies, MCPA, its salts, and ester dissipated with half-lives ranging from 3.3 to 23 days. Currently available volatility data for MCPA 2-EHE suggest only limited volatilization off soil under some soil conditions, and MCPA had no observed volatility. The atmospheric transport mechanism is hypothesized to be through MCPA adsorption to particles dispersed in the atmosphere.

MCPA's registered agricultural uses that EPA considered in this case study include legumes and peas, alfalfa, various grains (*e.g.,* wheat, barley, etc.), as well as fallow agricultural fields. Applications can be made by ground or air, with spot treatments allowed for some use patterns. MCPA can be applied any time of year, but for best efficacy, application is recommended in early spring and early fall.

Currently registered MCPA products have various application restrictions. MCPA applications are restricted to when wind speeds are 2 to 10 mph and at temperatures up to 85 °F. MCPA sodium salt products (EPA Reg. No. 11685-20 and 228-199) application instructions state to not spray grain in the boot to dough stage. MCPA drift restrictions include maximum release high of 4 ft for ground application and 10 ft for aerial application, applications only when wind speed is 2 to 10 mph, and ASABE droplet size of medium or coarser. The majority of MCPA DMAS and MCPA 2-EHE labels require droplet size of medium or coarser, and restrict applications when wind speed is 2 to 10 mph. In a several instances, MCPA DMAS and MCPA 2-EHE product labels specify a requirement for 25 ft buffer from estuarine and freshwater waterbodies. In a few cases, MCPA 2-EHE product labels have a requirement for 300 ft buffer from occupied structures for aerial applications. In some instances, MCPA product labels specify that maximum number of applications should not be done at maximum application rate.

**Table 9-1** includes the use information from the 2018 Draft Risk Assessment (DRA; DP446320) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for MCPA, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Interim Decision in October 2020) are not considered at this time but would be considered when EPA conducts assessments for MCPA for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2020 assessment. **Table 9-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 5** of this document. The UDLs are

spatial representations of potential pesticide use sites; for example, the UDL for use on wheat is the Wheat UDL and the UDL for use on barley is the Other Grains UDL.

EPA estimated exposures using the modeling for estimating environmental exposure relied upon the selected[92] uses and application information provided in **Table 9-1**. The selected uses do not necessarily represent all registered uses of MCPA and instead include large acreage uses sites (*e.g.,* wheat) and the agricultural use sites where MCPA usage is most common. These selected uses are examples to illustrate the draft Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of MCPA as this application method represents the greatest source of potential offsite movement. Although granular formulations of MCPA are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

**Table 9-1. Summary of the Selected Labeled Use Patterns for MCPA (2018 Draft Risk Assessment for Registration Review, DP446320)[1]**

| Use Site (Use Data Layer) | Application Method on Foliage/Plant[A] | | Application Rate Information | | | |
|---|---|---|---|---|---|---|
| | App Type | App Equip | Max App Single Rate (lb a.e./acre) | MRI (d)[B] | Max # App/Yr. | Max Annual or CC App Rate (lb a.e./acre/Yr or CC)[B] |
| Wheat (Wheat UDL) | Broadcast | A, G | 0.75[C] | 21 | 2/NS[D] | 0.75[C] |
| Barley, Oats, Rye, Triticale (Other Grains UDL) | Broadcast | A, G | 0.75[C] | 21 | 2/NS[D] | 0.75[C] |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture (Wheat, Other Crops, Other Grains UDLs) | Broadcast | A, G | 0.25 | 21 | 3/NS[D] | 0.75[C] |
| Oats-Legume Mixture (Other Grains, Other Crops UDLs) | Broadcast | A, G | 0.25/0.488 | 21 | 1/2/NS[D] | 0.75 |

[92] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2018 Draft Risk Assessment for Registration Review (DP446320) for MCPA. Any uses not evaluated in the 2018 assessment and any new uses since this assessment are not included in this example case study for the Herbicide Strategy.

| Use Site (Use Data Layer) | Application Method on Foliage/Plant[A] | | Application Rate Information | | | |
|---|---|---|---|---|---|---|
| | App Type | App Equip | Max App Single Rate (lb a.e./acre) | MRI (d)[B] | Max # App/Yr. | Max Annual or CC App Rate (lb a.e./acre/Yr or CC) [B] |
| Peas (unspecified) (Vegetables and Ground Fruit UDL) | Broadcast | A, G | 0.375 | 21 | 2/NS[D] | NS/0.375 |
| Flax (Other Grains UDL) | Broadcast & Spot treatment | A, G | 0.25 | NS | 2 | 0.25 |
| | | | 0.514 | | 1/CC | |
| Alfalfa (Alfalfa UDL) | Broadcast & Spot treatment | A, G | 0.5 | 21 | 2 | 0.5 |
| Clover (Other Crops UDL) | Broadcast & Spot treatment | A, G | 0.5 | NS | 2 | 0.5 |
| Fallow Land (Wheat, Other Crops, Other Grains, Alfalfa UDLs) | Broadcast | A, G | 1.5 | 21 | NS | 1.5 |

App=application; equip=equipment; a.e.=acid equivalents; MRI = Minimum retreatment interval; d=day; CC=crop cycle; UDL=Use Data Layer; A=aerial; G=ground; NS=not specified on the label

[A] All applications are post emergence, made when pest occurs, but exact application dates are not specified.

[B] EPA assumed a uniform Maximum Reapplication Interval (MRI) for all uses on a crop in the case where some labels specify an MRI while others do not (designated as NS). This applies to labels that allow multiple applications.

[C] The calculated rate was 0.768 lb a.e./acre, while the label rate was 0.75 lb a.e./acre.

[D] Some labels did not specify (NS) the maximum number of applications per year/crop cycle.

[1] The use information presented in this table is identical to the agricultural uses included in the 2018 Draft Risk Assessment for Registration Review (DP44632).

## 9.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of MCPA (**Section 9.3.1**), reported incidents (**Section 9.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 9.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 9.3.1 Toxicity Information

**Table 9-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for MCPA.

**Table 9-2. Summary of the Most Sensitive Toxicity Endpoints for MCPA (As Summarized in the 2018 Draft Risk Assessment for Registration Review, DP446320)**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Onion (*Allium cepa*) | NOAEC = 0.012 lb a.e./A<br>$IC_{25}$ = 0.028 lb a.e./A | 43083205 Acceptable | Test with TGAI of MCPA acid; Based on reduction in shoot length |
| | Dicot: Cabbage (*Brassica oleracea*) | NOAEC = 0.0027 lb a.e./A<br>$IC_{25}$ = 0.0080 lb a.e./A | | Test with TGAI of MCPA acid; Based on reduction in shoot length |
| Vegetative Vigor | Monocot: Onion (*Allium cepa*) | NOAEC = 0.046 lb a.e./A<br>$IC_{25}$ = 0.092 lb a.e./A | 43083205 Acceptable | Test with TGAI of MCPA acid; Based on reduction in shoot length |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.00038 lb a.e./A<br>$IC_{25}$ = 0.003 lb a.e./A | 47216806 Supplemental (Quantitative) | Test with DMAS (41.3% a.e.); Based on reduction in dry weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 7 µg a.e./L<br>$IC_{50}$ = 20 µg a.e./L | 43083214 Acceptable | Test with EHE; Based on impacts on biomass. EHE rapidly transforms to acid in water. |
| | | NOAEC = 13 µg a.e./L<br>**$IC_{50}$ = 130 µg a.e./L** | 44903501 Acceptable | Test with DMAS; Based on impacts to frond number |
| Aquatic Nonvascular Plant | Marine diatom (*Skeletonema costatum*) | NOAEC < 1.9 µg a.e./L<br>$IC_{50}$ = 56 µg a.e./L | 43083212 Acceptable[2] | Test with EHE; Based on impacts on cell density. EHE rapidly transforms to acid in water. |
| | | NOAEC < 27 µg a.e./L<br>**$IC_{50}$ = 160 µg a.e./L** | 42461301 Acceptable | Test with DMAS; Based on impacts to cell density |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}/_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.e.=acid equivalents; TGAI=technical grade active ingredient; DMAS=MCPA dimethylamine salt (PC Code 030516); EHE=MCPA 2-ethylhexyl ester (PC Code 030564)

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants. EPA used the toxicity endpoints for tests conducted with DMAS instead of those from tests with EHE because EHE rapidly degrades to the acid in water.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the MCPA seedling emergence and vegetative vigor tests. See **Table 9-3** and **Figure 9-1** for the SSD results.

[2] EPA incorrectly reported the MRID for this study in the 2018 Draft Risk Assessment for Registration Review (DP446320) but corrected it in the corresponding Response to Comments (DP452045). Additionally, EPA upgraded this studied from supplemental to "core" (now called "acceptable") in 1995 per a memo titled "MCPA Plant Data - Registrant Response to Previous EEB Reviews (D213408)".

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height, weight, and survival (seedling emergence test only) endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). See **Section 9.7** for the data used to generate the SSDs and **Section 9.8** for the process for calculating the SSDs. In total, EPA calculated five SSDs for MCPA by combining the results for tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to MCPA.

Specifically, as summarized in **Section 9.7**, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the seedling emergence and vegetative vigor studies overlap when considering all definitive values available. Additionally, with the exception of the vegetative vigor weight data, the mean $IC/EC_{25}$ values for monocots and dicots only differ by a factor of 5 or less when EPA compared the data for the same biological endpoint (height, weight, or survival) within the same test design (seedling emergence or vegetative vigor). The mean $IC_{25}$ value for monocot dry weight is 10 times greater than the mean for dicot dry weight for the vegetative vigor test. The median $IC/EC_{25}$ values are similar, differing by a factor of 5 or less for three of the datasets (all seedling emergence results) for monocots and dicots. Given these considerations, EPA did not create separate SSDs for monocots and dicots.

**Figure 9-1** shows the five SSDs that EPA generated. The SSD based on the seedling emergence weight data resulted in the most sensitive 25$^{th}$ percentile $IC_{25}$ value (represented as a black dot in **Figure 9-1**). EPA used the resulting 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values from the seedling emergence weight SSD to calculate the ratio of EEC to toxicity endpoint (**Table 9-3** and **Table 9-4**; see **Section 9.3.3**).[93] By combining the monocot and dicot data, these 5$^{th}$ and 25$^{th}$ percentile values represent the sensitivities of both types of flowering plants to MCPA.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[94] are available to evaluate potential impacts of MCPA on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 9-2** and **Table 9-4)** to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[95].

**Table 9-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for MCPA**

| Percentile | Seedling Emergence Test | | | Vegetative Vigor Test | |
|---|---|---|---|---|---|
| | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** | **Survival: x Percentile $EC_{25}$ from SSD (C.I.), lb a.e./A** | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.e./A** |
| 5 | **0.010** (0.0076 – 0.017) | 0.0085 (0.0041 – 0.021) | 0.062 (0.021 – 0.29) | 0.0064 (0.0023 – 0.023) | 0.013 (0.0038 – 0.047) |
| 25 | **0.016** (0.012 – 0.024) | 0.020 (0.011 – 0.038) | 0.22 (0.096 – 0.66) | 0.25 (0.012 – 0.061) | 0.058 (0.023 – 0.15) |

[93] Although the 5$^{th}$ percentile of the SSD is more sensitive for seedling emergence height and vegetative vigor weight data, EPA selected the SSD for this case study example based on the most sensitive 25$^{th}$ percentile of the SSD.

[94] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[95] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1** in the **Case Study Summary and Process** document.

| | | | | | |
|---|---|---|---|---|---|
| 50 | 0.023<br>(0.016 – 0.036) | 0.037<br>(0.021 – 0.062) | 0.55<br>(0.23 – 1.3) | 0.066<br>(0.030 – 0.15) | 0.17<br>(0.073 – 0.39) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

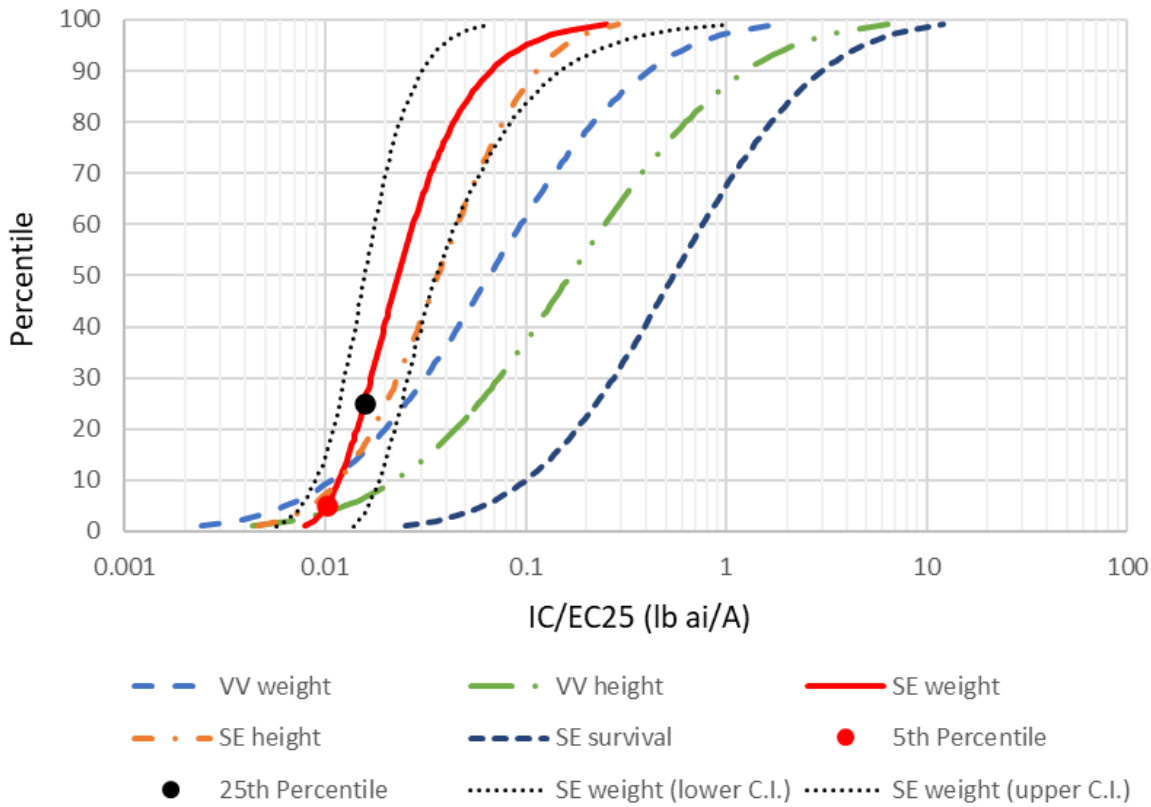



**Figure 9-1. Vegetative Vigor (VV) and Seedling Emergence (SE) Study Species Sensitivity Distributions (SSD) representing the Distributions of the Plant Height and Weight IC25s and Survival EC25s for MCPA. The Upper and Lower Confidence Intervals (C.I.) are plotted for the SE plant weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 9.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on these plants[96], EPA calculated the magnitude of difference as a ratio of the EEC to the 5$^{th}$ percentile of the seedling emergence plant weight SSD (**Table 9-4)**. For listed animals that

[96] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.

generally rely upon terrestrial or wetland plants for diet or habitat[97] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25th percentile of the SSD (**Table 9-4**). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Table 9-4**).

**Table 9-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for MCPA[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.010 lb a.e./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.010 lb a.e./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.010 lb a.e./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.010 lb a.e./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.010 lb a.e./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.016 lb a.e./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 0.016 lb a.e./A |
| | | Based on aquatic plant endpoints: 130 µg a.e./L (Vascular) 160 µg a.e./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 130 µg a.e./L Nonvascular: 160 µg a.e./L |

[1] See **Section 4.1** of the **Strategy Framework** document (specifically **Table 9-1**) for details on all possible magnitude of difference values that can be calculated for the draft Strategy. In this case study for MCPA, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.

[97] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 9.3.2 Incidents

The incident information from the 2018 Draft Risk Assessment for Registration Review (DP446320) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[98] (as discussed in **Section 9.3.3**), which informs the potential population-level impacts (**Section 9.6**), and to identify the proposed level of mitigation (see **Section 9.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 9.3.3.3**).[99] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the reported ecological incidents associated with pesticides, including those that have been aggregately reported to the EPA. As of January 18, 2018, there were 60 reported incidents in the Incident Data System for MCPA; seven for MCPA acid (PC Code 030501), 20 for MCPA DMAS (PC Code 030516) and 33 for MCPA 2-EHE (PC Code 030564). All of the reported incidents involved damage to plants, and most are ascribed to registered uses. Incidents were reported for agricultural, residential, and vegetative management uses. Additionally, EPA identified 68 incidents (across all forms) reported in the aggregate incident database, all for plant damage.

Because the plant incidents are relatively few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for MCPA. In other words, the MCPA incidents do not indicate an unexpected pathway of off-field exposure, nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 9.3.3.3**) are unaltered by the available MCPA incident data.

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[98] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[99] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

### 9.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *9.3.3.1* Spray *Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 9-5** demonstrates the impact of each of these variables on drift exposure when compared when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of MCPA ($5^{th}$ percentile of SSD = 0.010 lb a.e./A). **Table 9-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of MCPA ($25^{th}$ percentile of SSD = 0.016 lb a.i./A). Within **Table 9-5** and **Table 9-6**, the modeled application rates are representative of the maximum single application rate currently registered for MCPA use on fallow land (1.5 lb a.e./A) and reduced rates (0.75, 0.50, and 0.25 lb a.e./A) representative of maximum single application rates for other uses (**Table 9-1**). **Table 9-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 9-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 9.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Table 9-24**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 9-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb a.e./A (maximum application rate for use of fallow land)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 700 | 400 | 325 | 150 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **4.6** [300] | **2.2** [300] | **2.3** [200] | **1.8** [200] | **1.4** [100] | **1.1** [100] | 0.7 [100] |
| **Application Rate of 0.75 lb a.e./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 800 | 325 | 225 | 175 | 75 | 50 | 25 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.3** [300] | **1.1** [300] | **1.1** [200] | 0.9 [200] | 0.7 [100] | 0.5 [100] | 0.3 [100] |
| **Application Rate of 0.50 lb a.e./A (maximum application rate for use on alfalfa and clover and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 450 | 250 | 175 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.5** [300] | 0.7 [300] | 0.8 [200] | 0.6 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |
| **Application Rate of 0.25 lb a.e./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 225 | 150 | 100 | 75 | 25 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.8 [300] | 0.4 [300] | 0.4 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For MCPA, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 9.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 9.9** contains the full output of results

**Table 9-6. Spray Drift Distances to the Population-Level Impacts Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb a.e./A (maximum application rate for use of fallow land)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 400 | 250 | 225 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.8** [300] | **1.4** [300] | **1.4** [200] | **1.1** [200] | 0.9 [100] | 0.7 [100] | 0.4 [100] |
| **Application Rate of 0.75 lb a.e./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 500 | 250 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.4** [300] | 0.7 [300] | 0.7 [200] | 0.6 [200] | 0.5 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 0.50 lb a.e./A (maximum application rate for use on alfalfa and clover and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 300 | 175 | 125 | 100 | 50 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.9 [300] | 0.5 [300] | 0.5 [200] | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.1 [100] |
| **Application Rate of 0.25 lb a.e./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 175 | 100 | 75 | 50 | 20 | 10 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.5 [300] | 0.2 [300] | 0.2 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For MCPA, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 9.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 9.9** contains the full output of results

#### *9.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 9-7** through **Table 9-11** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 9-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure to Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Wheat, Barley, Oats, Rye, Triticale | 2.0 – 22 | 0.02 – 0.17 | 0.01 – 0.14 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 2.1 – 2 | 0.02 – 0.16 | 0.01 – 0.13 |
| Oats-Legume Mixture | 2.0 – 18 | 0.02 – 0.14 | 0.01 – 0.12 |
| Peas | 0.98 – 10 | 0.01 – 0.08 | 0.01 – 0.06 |
| Flax | 0.79 – 7.0 | 0.01 – 0.05 | <0.01 – 0.04 |
| Alfalfa/Clover | 1.6 – 20 | 0.01 – 0.05 | 0.01 – 0.12 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for MCPA, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 9-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure to Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.13 | 2.0 – 13 | 26 – 970 | 0.20 – 7.5 | 0.16 – 6.1 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.13 | 1.6 – 13 | 17 – 610 | 0.13 – 4.7 | 0.11 – 3.8 |
| Oats-Legume Mixture | 0.02 – 0.13 | 2.0 – 13 | 25 – 660 | 0.19 – 5.1 | 0.16 – 4.1 |
| Peas | 0.01 – 0.06 | 1.1 – 6.3 | 22 – 400 | 0.17 – 3.1 | 0.14 – 2.5 |
| Flax | <0.01 – 0.04 | 0.77 – 4.4 | 8.7 – 320 | 0.07 – 2.5 | 0.05 – 2.0 |
| Alfalfa/Clover | 0.02 – 0.09 | 2.1 – 8.7 | 23 – 610 | 0.18 – 4.7 | 0.15 – 3.8 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 9-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.13 | 1.3 – 8.2 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.13 | 0.99 – 8.1 |
| Oats-Legume Mixture | 0.02 – 0.13 | 1.3 – 8.0 |
| Peas | 0.01 – 0.06 | 0.69 – 3.9 |
| Flax | <0.01 – 0.04 | 0.48 – 2.7 |
| Alfalfa/Clover | 0.02 – 0.09 | 1.3 – 5.5 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 9-8**
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

### Table 9-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.14 | 1.8 – 14 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.12 | 1.5 – 12 |
| Oats-Legume Mixture | 0.02 – 0.12 | 1.7 – 12 |
| Peas (unspecified) | <0.01 – 0.07 | 0.86 – 6.8 |
| Flax | <0.01 – 0.05 | 0.60 – 4.7 |
| Alfalfa/Clover | 0.02 – 0.10 | 1.6 – 9.9 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

### Table 9-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.14 | 1.1 – 8.8 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.12 | 0.96 – 7.8 |
| Oats-Legume Mixture | 0.02 – 0.12 | 1.1 – 7.6 |
| Peas (unspecified) | <0.01 – 0.07 | 0.54 – 4.2 |
| Flax | <0.01 – 0.05 | 0.37 – 2.9 |
| Alfalfa/Clover | 0.02 – 0.10 | 1.0 – 6.2 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### 9.3.3.3 Magnitude of Effect

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 9-12**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 9.3.3.1** and **9.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 9.4**) and conducting a population-level impact analysis (**Section 9.6**).

For MCPA, given the toxicity profile (including only about a 1.6X difference between the 5th and 25th percentiles of the most sensitive SSD with a steep slope for this SSD (**Figure 9-1**)[100], EPA assigned a low magnitude of effect in **Table 9-12** on a use basis to groups of listed species and critical habitats (CHs)[101] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned medium or high magnitude of effect in **Table 9-12** when the magnitude of difference is from 1 up to 10 or 10 up to 100, respectively.

**Table 9-12. Use-Based Magnitude of Effect for MCPA.[1]**

| Use | Terrestrial | | Wetland and Smaller Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Wheat, Barley, Oats, Rye, Triticale | High | Medium | High | Medium | Low | Low |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | Medium | Medium | Medium | Medium | Low | Low |
| Oats-Legume Mixture | Medium | Medium | Medium | Medium | Low | Low |
| Peas | Medium | Medium | Medium | Medium | Low | Low |
| Flax | Medium | Medium | Medium | Medium | Low | Low |
| Alfalfa/Clover | Medium | Medium | Medium | Medium | Low | Low |

CH=designated critical habitat

[100] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[101] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 9.4**) and to conduct the population-level impacts analysis (**Section 9.6**). If the magnitude of effect is medium or higher for MCPA, EPA determined that there is a potential for population-level impacts.
[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).
[4] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.
[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 9.4 Framework Step 2: Identify Mitigation Measures

**Section 9.4** outlines the mitigation measures identified for MCPA for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 9.4.1**) and runoff/erosion (**Section 9.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 9.4.1 Spray Drift Mitigation Measures Identified

**Table 9-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 9-14** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds**.**

**Table 9-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ae/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.5 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 75[f,g,h] |
| 0.75 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 175[e,g,h] | 75[g,h] | 50[g,h] | 25[i] |
| 0.50 | 300[a,b,c] | 250[a,b,c] | 175[a,b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| 0.25 | 225[a,b] | 150[b,d] | 100[b,d] | 75[g,h] | 25[i] | 20[i] | 10[i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[3] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 9-1**
[3] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 9-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ae/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.5 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,f,g] | 100[e,f,g] | 75[f,g] | 50[f,g] |
| 0.75 | 300[a,b,c] | 250[a,b,c] | 150[b,d] | 125[e,f,g] | 50[f,g] | 25[h] | 20[h] |
| 0.50 | 300[a,b,c] | 175[a,b,d] | 125[b,d] | 100[e,f,g] | 50[f,g] | 20[h] | 10[h] |
| 0.25 | 175[a,b,d] | 100[b,d] | 75[b,d] | 50[f,g] | 20[h] | 10[h] | 10[h] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half. | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the | | | |

| | | |
|---|---|---|
| Buffer Distances[3] | [c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | windbreak/hedgerow) or hooded sprayers alone without a buffer. |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 9-1.**
[3] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 9.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts and minimize the potential for future take differs across uses and, as shown in Figure 7-3**,** the level of mitigation is dependent upon the toxicity endpoint and representative species (*e.g.,* listed plants (5$^{th}$ percentile endpoint), generalists (25$^{th}$ percentile endpoint)). Figure 7-3 visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for MCPA.

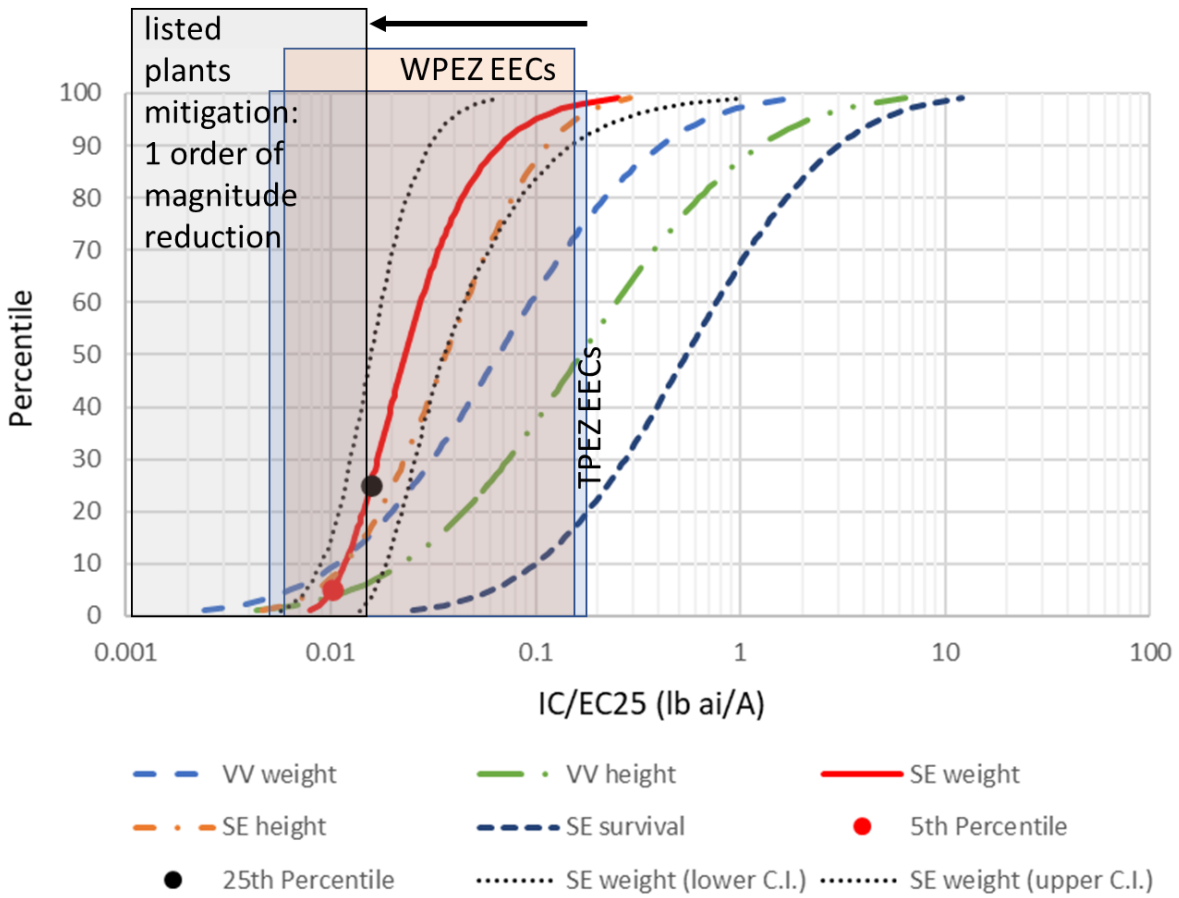


**Figure 9-2. MCPA Vegetative Vigor (VV) and Seedling Emergence (SE) Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5th percentile (represents listed plants and animals with obligate relationships to plants) and the 25th percentile (represents generalists and designated critical habitats) from the SE weight SSD. Upper and lower confidence intervals (C.I.) are provided for the SE weight SSD.**

For MCPA, see **Section 9.4** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of MCPA is <1,000 L/kg-o.c. (mean $K_d$ = 0.6 L/kg-o.c.)[102], higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

[102] A $K_d$ of 0.6 L/kg-o.c. is approximately equal to a $K_{OC}$ of 60 L/kg-o.c. based on a standard conversion factor of 100.

As described in the **Strategy Framework,** EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would be applicable and if it is between 100 and 1,000, high mitigation would be applicable. If the magnitude of difference exceeds 1,000, then very high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high/very high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For MCPA, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for MCPA, EPA identified proposed runoff/erosion mitigations for at least one taxon for all registered uses considered in this document.

- For listed species in waterbodies similar in size to the EPA farm pond or larger[103], EPA identified no mitigation for all of the evaluated uses of MCPA for listed aquatic plants and animals that depend on aquatic plants[104] (**Table 9-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies (**Table 9-15**).
- For use on wheat, barley, oats, rye, and triticale, the mitigation category[105] is medium for semi-aquatic/wetland monocots and dicots and animals that obligately depend on these plants[106]. For all other uses, EPA only identified low mitigation for wetland flowering plants and animals that obligately rely on these plants (**Table 9-16**).
- For aquatic plants in wetlands or small waterbodies[107] and for animals that rely depend on these plants (both obligately[106] and generally[108]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants, and the resulting mitigation category is low for all uses except use on flax, for which EPA identified no mitigation (**Table 9-16**).
- For terrestrial plants and animals that obligately rely on terrestrial plants[106], the mitigation category is low for all uses except use on wheat, barley, oats, rye, and triticale, for which the mitigation category is medium (**Table 9-18**).

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[103] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** in the **Case Study Summary and Process** document for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[104] None of the listed aquatic animals have obligate relationships to plants.
[105] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).
[106] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[107] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[108] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

- For listed animals that generally rely on wetland or terrestrial monocots or dicots[108], EPA identified low mitigation for all evaluated uses of MCPA (**Table 9-17** and **Table 9-19**).

**Table 9-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.e./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Wheat, Barley, Oats, Rye, Triticale | 2.0 – 22 | 0.02 – 0.17 | No mitigation | 0.01 – 0.14 | No mitigation |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 2.1 – 2 | 0.02 – 0.16 | No mitigation | 0.01 – 0.13 | No mitigation |
| Oats-Legume Mixture | 2.0 – 18 | 0.02 – 0.14 | No mitigation | 0.01 – 0.12 | No mitigation |
| Peas | 0.98 – 10 | 0.01 – 0.08 | No mitigation | 0.01 – 0.06 | No mitigation |
| Flax | 0.79 – 7.0 | 0.01 – 0.05 | No mitigation | <0.01 – 0.04 | No mitigation |
| Alfalfa/Clover | 1.6 – 20 | 0.01 – 0.05 | No mitigation | 0.01 – 0.12 | No mitigation |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for MCPA, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.

[2] The ranges EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 9-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.e./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.e./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category | | Range of Magnitude of Difference[3] | Mitigation Category | Range of Magnitude of Difference[3] | Mitigation Category |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.13 | 2.0 – 13 | Medium | 26 – 970 | 0.20 – 7.5 | Low | 0.16 – 6.1 | Low |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.13 | 1.6 – 13 | Low[5] | 17 – 610 | 0.13 – 4.7 | Low | 0.11 – 3.8 | Low |
| Oats-Legume Mixture | 0.02 – 0.13 | 2.0 – 13 | Low[5] | 25 – 660 | 0.19 – 5.1 | Low | 0.16 – 4.1 | Low |
| Peas | 0.01 – 0.06 | 1.1 – 6.3 | Low | 22 – 400 | 0.17 – 3.1 | Low | 0.14 – 2.5 | Low |
| Flax | <0.01 – 0.04 | 0.77 – 4.4 | Low | 8.7 – 320 | 0.07 – 2.5 | No mitigation[5] | 0.05 – 2.0 | No mitigation[5] |
| Alfalfa/Clover | 0.02 – 0.09 | 2.1 – 8.7 | Low | 23 – 610 | 0.18 – 4.7 | Low | 0.15 – 3.8 | Low |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A or µg a.e./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 9-16** outlines the proposed mitigation categories for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[109]**.** In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[110]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. . For MCPA, EPA determined the proposed mitigation categories presented in **Table 9-16** based on the weight of evidence discussed below, which is specifically relevant for use on grain-legume mixtures, oat-legume mixtures, and flax.

For listed wetland monocots and dicots, the range of magnitude of difference is 1.6 to 13 for use on grain-legume mixtures. Only six scenarios out of 154 modeled have magnitude of difference values that exceed 10. Given that 96% of the scenarios indicated low mitigation with only 4% indicating medium mitigation, EPA set the mitigation category as low for listed wetland monocots, dicots, and animals that depend on these plants.

For use on oat-legume mixtures, the range of magnitude of difference is 2.0 to 13 for listed wetland monocots and dicots. Only five scenarios out of 84 modeled have magnitude of difference values that exceed 10. Given that 94% of the scenarios had magnitude of difference values below 10 with only 6% indicating medium mitigation, EPA set the mitigation category as low for listed wetland monocots, dicots, and animals that depend on these plants.

For use on flax, the range of magnitude of difference is 0.07 to 2.5 for aquatic vascular plants and 0.05 to 2.0. Of the 42 scenarios modeled for use on flax, only six magnitude of difference values exceed 1.0 for vascular plants and only three exceed 1.0 for nonvascular plants. Given that 86% and 93% of the scenarios for vascular plants and nonvascular plants, respectively, indicate no mitigation, EPA set the mitigation category as no mitigation for use on flax to protect listed aquatic vascular and nonvascular plants and animals that rely on these plants in wetlands and small waterbodies.

**Table 9-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.e./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |

[109] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.e./A or µg a.e./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.
[110] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2**.

| | | | |
|---|---|---|---|
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.13 | 1.3 – 8.2 | Low |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.13 | 0.99 – 8.1 | Low |
| Oats-Legume Mixture | 0.02 – 0.13 | 1.3 – 8.0 | Low |
| Peas | 0.01 – 0.06 | 0.69 – 3.9 | Low |
| Flax | <0.01 – 0.04 | 0.48 – 2.7 | Low |
| Alfalfa/Clover | 0.02 – 0.09 | 1.3 – 5.5 | Low |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.e./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 9-16**.
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

### Table 9-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants

| Use | Range of EECs (lb a.e./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.14 | 1.8 – 14 | Medium |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.12 | 1.5 – 12 | Low[3] |
| Oats-Legume Mixture | 0.02 – 0.12 | 1.7 – 12 | Low[3] |
| Peas (unspecified) | <0.01 – 0.07 | 0.86 – 6.8 | Low |
| Flax | <0.01 – 0.05 | 0.60 – 4.7 | Low |
| Alfalfa/Clover | 0.02 – 0.10 | 1.6 – 9.9 | Low |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 9-18** outlines the proposed mitigation categories identified for listed terrestrial monocots and dicots and animals that obligately rely on terrestrial monocots or dicots. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in the **Strategy Framework.** For MCPA, EPA determined the proposed mitigation categories presented in

**Table 9-18** based on the weight of evidence discussed below, which is specifically relevant for use on grain-legume mixtures and oat-legume mixtures.

For use on grain-legume mixtures, the range of magnitude of difference is 1.5 to 12 for listed terrestrial monocots and dicots. Of the 154 scenarios modeled for these uses, only four magnitude of difference values exceed 10. Given that 97% of the scenarios indicate that low mitigation with only 3% indicating medium mitigation, EPA set the mitigation category as low mitigation for these uses to protect listed terrestrial flowering plants and listed animals that obligately rely on these plants.

For use on oat-legume mixtures, the range of magnitude of difference is 1.7 to 12 for terrestrial monocots and dicots. Of the 84 scenarios modeled for these uses, only four magnitude of difference values exceed 10. Given that 95% of the scenarios indicate low mitigation with only 5% indicating medium mitigation, EPA set the mitigation category as low mitigation for use on oat-legume mixtures to protect listed terrestrial flowering plants and listed animals that obligately rely on these plants.

**Table 9-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.e./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Wheat, Barley, Oats, Rye, Triticale | 0.02 – 0.14 | 1.1 – 8.8 | Low |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 0.02 – 0.12 | 0.96 – 7.8 | Low |
| Oats-Legume Mixture | 0.02 – 0.12 | 1.1 – 7.6 | Low |
| Peas (unspecified) | <0.01 – 0.07 | 0.54 – 4.2 | Low |
| Flax | <0.01 – 0.05 | 0.37 – 2.9 | Low |
| Alfalfa/Clover | 0.02 – 0.10 | 1.0 – 6.2 | Low |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 9-15** and **Table 9-16**) and wetland plants (**Table 9-16** and **Table 9-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the habitat is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (

**Table 9-18**) and for generalist animals (**Table 9-19**). **Table 9-20** and **Table 9-21** provide the runoff/erosion mitigation points identified for each evaluated use of MCPA.

**Table 9-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Wheat, Barley, Oats, Rye, Triticale | Medium (6 pts) | Low (3 pts) |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | Low (3 pts) | Low (3 pts) |
| Oats-Legume Mixture | Low (3 pts) | Low (3 pts) |
| Peas (unspecified) | Low (3 pts) | Low (3 pts) |
| Flax | Low (3 pts) | Low (3 pts) |
| Alfalfa/Clover | Low (3 pts) | Low (3 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 9-15** and **Table 9-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 9-15** and **Table 9-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 9-15**, **Table 9-16**, and **Table 9-17**).

**Table 9-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Wheat, Barley, Oats, Rye, Triticale | Medium (6 pts) | Low (3 pts) |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | Low (3 pts) | Low (3 pts) |
| Oats-Legume Mixture | Low (3 pts) | Low (3 pts) |
| Peas (unspecified) | Low (3 pts) | Low (3 pts) |
| Flax | Low (3 pts) | Low (3 pts) |
| Alfalfa/Clover | Low (3 pts) | Low (3 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (

**Table 9-18**), listed animals that obligately depend on terrestrial plants (

**Table 9-18**), and listed animals that generally depend on terrestrial plants (**Table 9-19**).

## 9.5 Framework Step 3: Identify Extent of Mitigation Practices

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for MCPA are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 9-13**) and one for generalist animals that depend on plants (**Table 9-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are slightly different for these two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For MCPA, the less restrictive mitigations relevant to generalist animals that are depicted in **Table 9-14** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 9-13** would be

applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For both sets of habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 9-20** and **Table 9-21**). **Table 9-22** summarizes the points identified for the different MCPA uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by the four PULAs. All four PULAs are grouped because the same mitigations would be applied to monocots and dicots in terrestrial, wetland, and aquatic habitats; this is supported by MCPA's similar toxicity to both monocots and dicots (see **Section 8.3.1**).

**Table 9-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | Geographically Specific Mitigation Points |
|---|---|---|
| | Terrestrial, Aquatic, and Wetland Habitats | PULAs 1,2, 3 and 4 (Terrestrial, Aquatic, and Wetland Habitats) |
| Wheat, Barley, Oats, Rye, Triticale | 6 | 3 |
| Wheat-Legume Mixture, Barley-Legume Mixture, & Rye-Legume Mixture | 3 | 3 |
| Oats-Legume Mixture | 3 | 3 |
| Peas (unspecified) | 3 | 3 |
| Flax | 3 | 3 |
| Alfalfa/Clover | 3 | 3 |

## 9.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Sections 1-5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 9.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of MCPA. For major crops (*e.g.,* wheat), the crop-specific UDLs were selected. For other uses such as on peas and barley, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented

by a 300 m (1000 ft) extension around the individual UDLs representing potential MCPA use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 9-12**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 9-23** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected MCPA UDLs[111] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For MCPA's UDLs, fewer species (355) and CHs (74) have overlap >5%. An important consideration for the purposes of this example is that EPA did not necessarily evaluate all registered uses of MCPA (see **Section 9.2**), so additional species could be identified in the future for MCPA. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of MCPA; however, the PULAs include some species and CHs that have <5% overlap with MCPA's potential exposure area for the considered uses.

[111] The selected use data layers (UDLs) do not necessarily represent every registered use of MCPA. See **Section 9.2** for more information on the uses evaluated in this example.

**Table 9-23. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for MCPA Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Wheat | 469 / 142 | 182 | 41 |
| Other Grains | | 236 | 51 |
| Other Crops | | 324 | 63 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Alfalfa | | 141 | 42 |
| Total across all UDLs above[2] | | 355 | 74 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Wheat | 534 / 316 | 267 | 116 |
| Other Grains | | 255 | 118 |
| Other Crops | | 370 | 171 |
| Vegetables and Ground Fruit | | 152 | 74 |
| Alfalfa | | 140 | 75 |
| Total across all UDLs above[2] | | 385 | 185 |
| Cultivated | | 412 | 199 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for MCPA. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for MCPA (excluding the Cultivated UDL, which is summarized below this row).

## 9.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.012 to 0.19 lb a.e./A (excluding non-definitive endpoints) for monocots and 0.006 to 0.047 lb a.e./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.081 and 0.021 lb a.e./A, respectively. Similarly, the ranges of $IC_{25}$ values for dry weight data in the vegetative vigor studies are 0.058 to 2.8 lb a.e./A (excluding non-definitive endpoints) for monocots and 0.003 to 0.61 lb a.e./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.78 and 0.077 lb a.e./A, respectively.

For the seedling emergence survival data, the ranges of $EC_{25}$ values are 0.29 to 4.7 lb a.e./A (excluding non-definitive endpoints) for monocots and 0.074 to 2.4 lb a.e./A (excluding non-definitive endpoints) for dicots, with mean $EC_{25}$ values of 2.0 and 0.64 lb a.e./A, respectively.

## 9.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight, height, and survival (SE only) toxicity endpoints for plants exposed to each case study chemical. EPA developed separate SSDs for weight, height, and survival (SE only).

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height, weight, and/or survival SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the MCPA data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$)to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

## Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA made comparison of the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### *Seedling Emergence Height Data*

Goodness of fit:

Results:

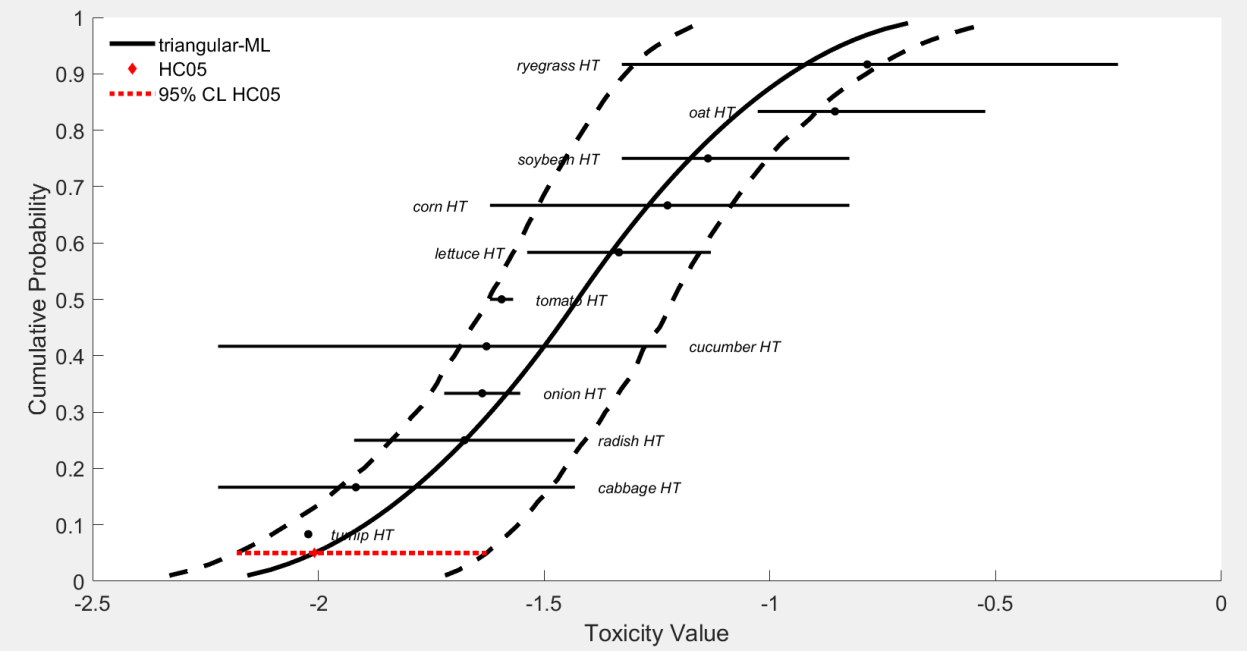
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0085 | 0.4735 |
| 2 | logistic | ML | 0.0073 | 0.3357 |
| 3 | triangular | ML | 0.0098 | 0.4835 |
| 4 | gumbel | ML | 0.0103 | 0.6354 |
| 5 | weibull | ML | 0.0045 | 0.3307 |
| 6 | burr | ML | 0.0103 | 0.5574 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0088425 |
| Model-averaged SE of HCp: | 0.0038848 |
| CV of HCp: | 0.43933 |

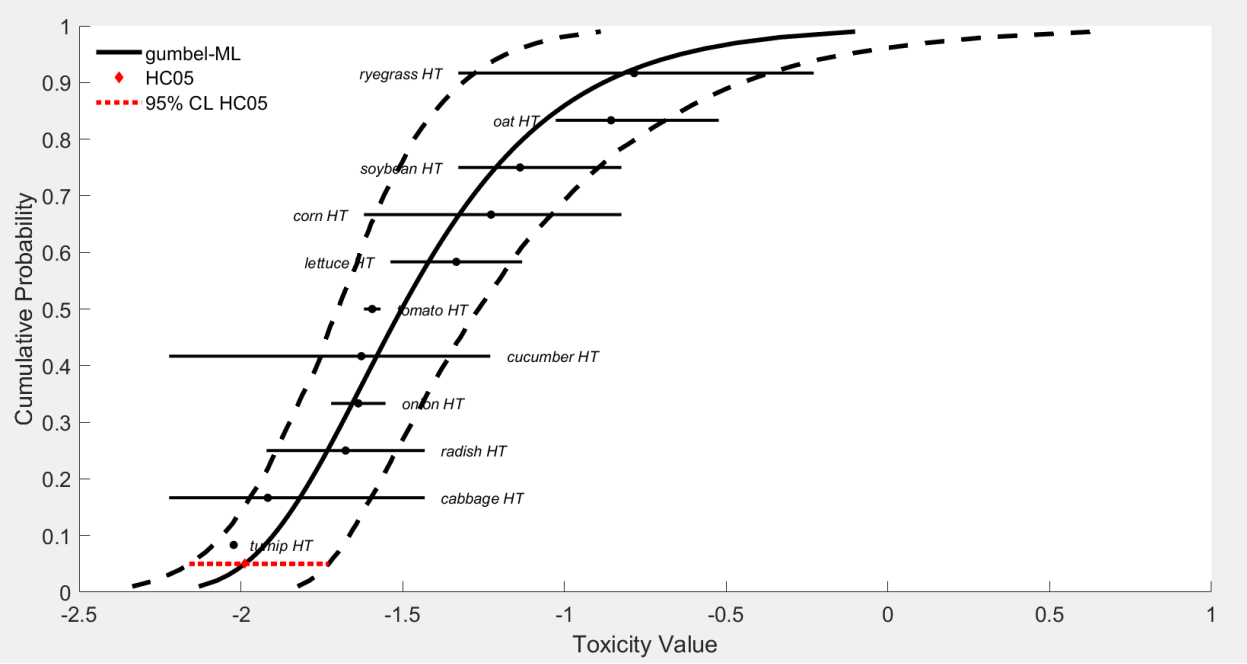
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -39.5265 | 0 | 0.3124 | 0.0098 | 0.0038 |
| 2 | gumbel | -38.8702 | 0.6563 | 0.2250 | 0.0103 | 0.0027 |
| 3 | normal | -38.6920 | 0.8345 | 0.2058 | 0.0085 | 0.0035 |
| 4 | logistic | -37.8742 | 1.6523 | 0.1367 | 0.0073 | 0.0034 |
| 5 | weibull | -37.0056 | 2.5209 | 0.0886 | 0.0045 | 0.0032 |
| 6 | burr | -34.9390 | 4.5875 | 0.0315 | 0.0103 | 0.0058 |

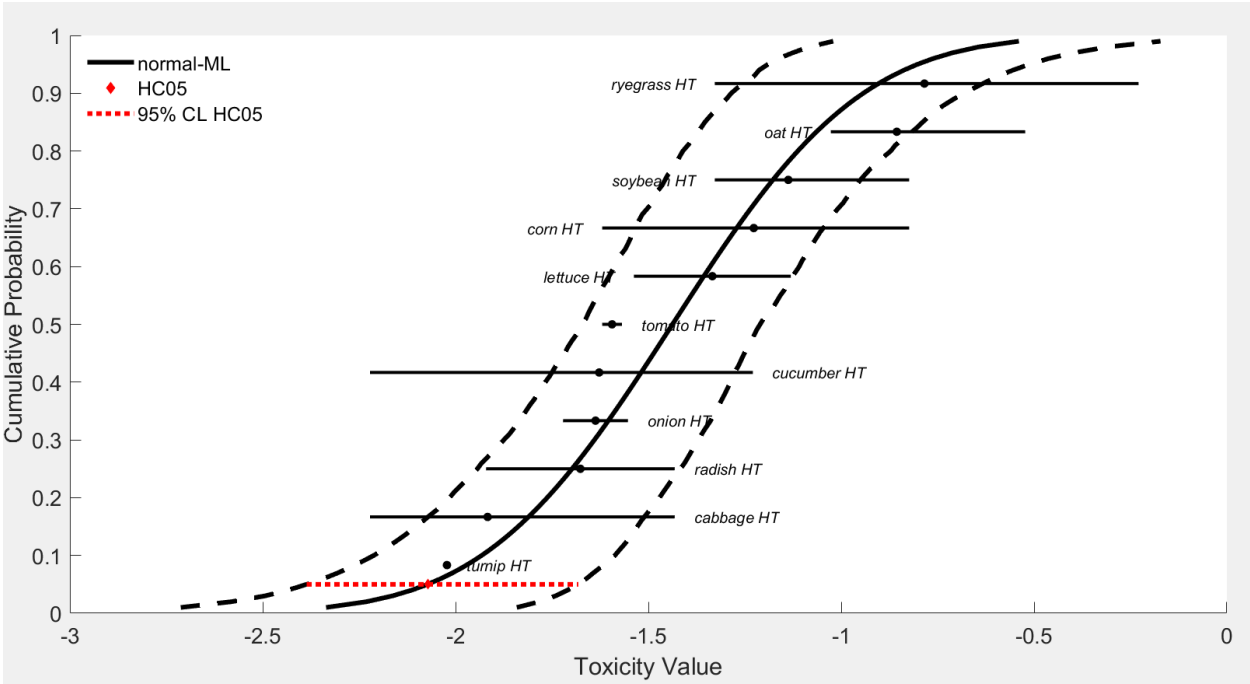
Based on the goodness of fit, EPA moved forward with triangular, normal, and Gumbel distributions, and ultimately selected the normal distribution for the height data from the seedling emergence toxicity tests.




Triangular




Gumbel




**Normal (selected distribution)**

### *Seedling Emergence Dry Weight Data*

Goodness of fit:

Results:

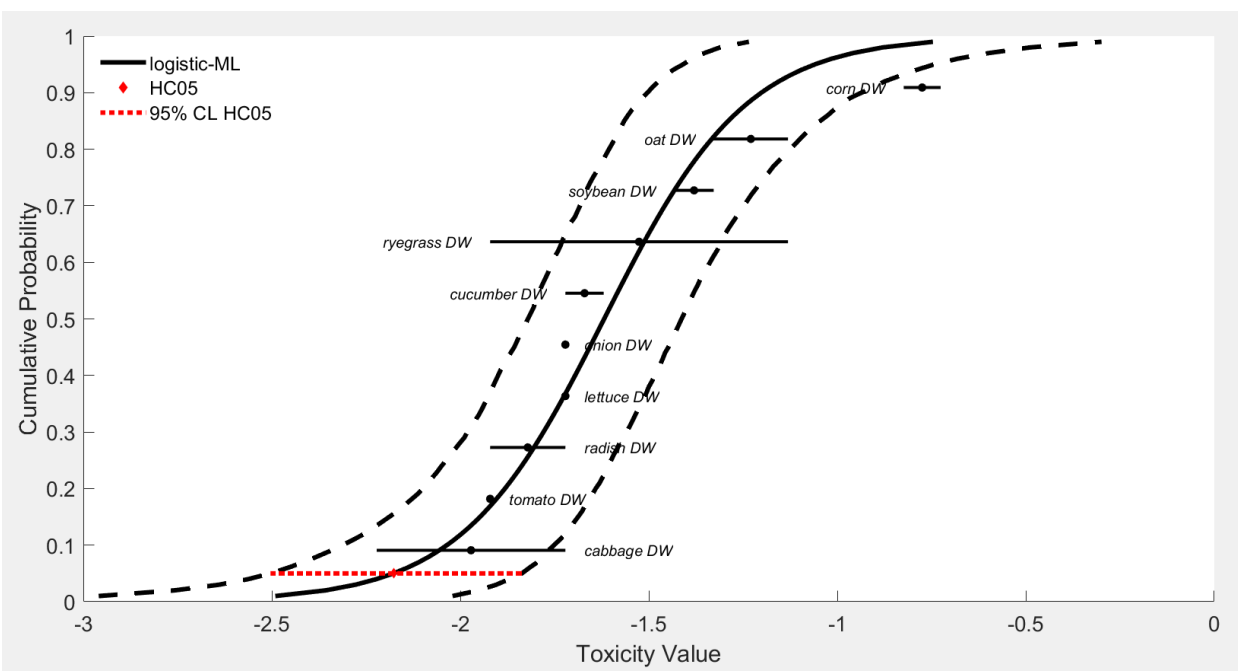
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0072 | 0.4505 |
| 2 | logistic | ML | 0.0066 | 0.6204 |
| 3 | triangular | ML | 0.0075 | 0.2867 |
| 4 | gumbel | ML | 0.0101 | 0.7882 |
| 5 | weibull | ML | 0.0027 | 0.1578 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0086885 |
| Model-averaged SE of HCp: | 0.0031093 |
| CV of HCp: | 0.35786 |

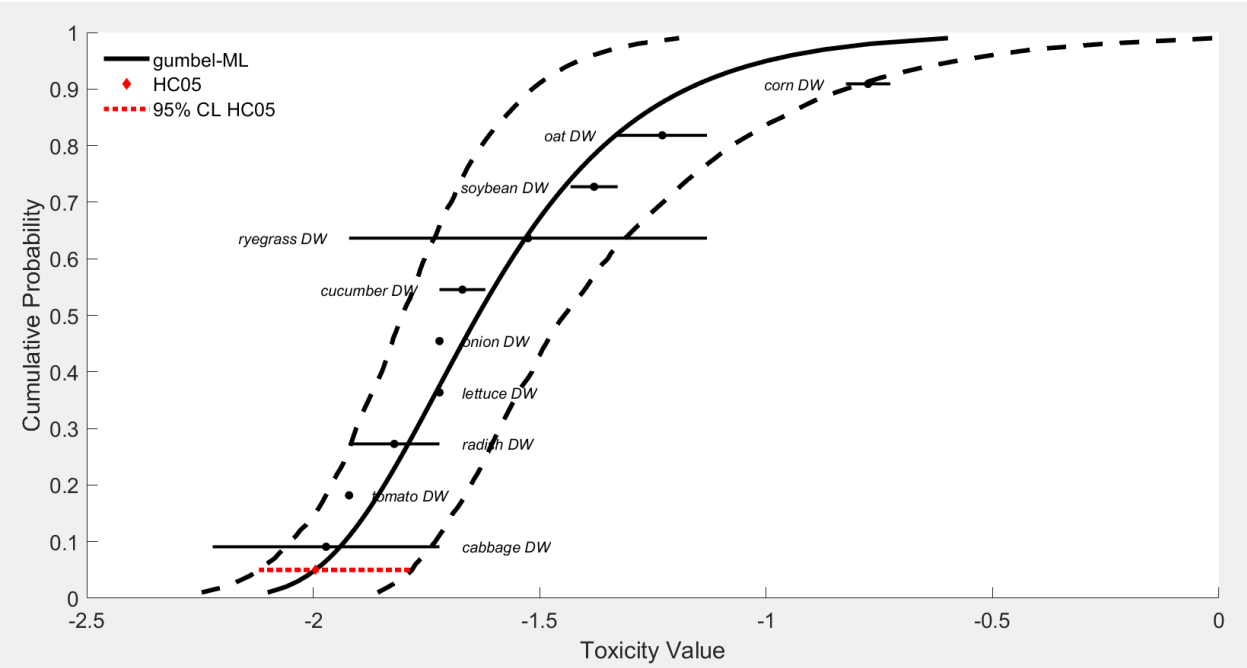
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -45.7457 | 0 | 0.5563 | 0.0101 | 0.0021 |
| 2 | logistic | -43.1945 | 2.5512 | 0.1554 | 0.0066 | 0.0026 |
| 3 | normal | -42.9855 | 2.7602 | 0.1399 | 0.0072 | 0.0028 |
| 4 | triangular | -42.8228 | 2.9229 | 0.1290 | 0.0075 | 0.0039 |
| 5 | weibull | -39.0276 | 6.7181 | 0.0193 | 0.0027 | 0.0021 |

Based on the goodness of fit, EPA moved forward the logistic and Gumbel distributions, and ultimately selected the Gumbel distribution for the dry weight data from the seedling emergence toxicity tests.



Logistic




**Gumbel (selected distribution)**

*Seedling Emergence Survival Data*

Goodness of fit:

Results:

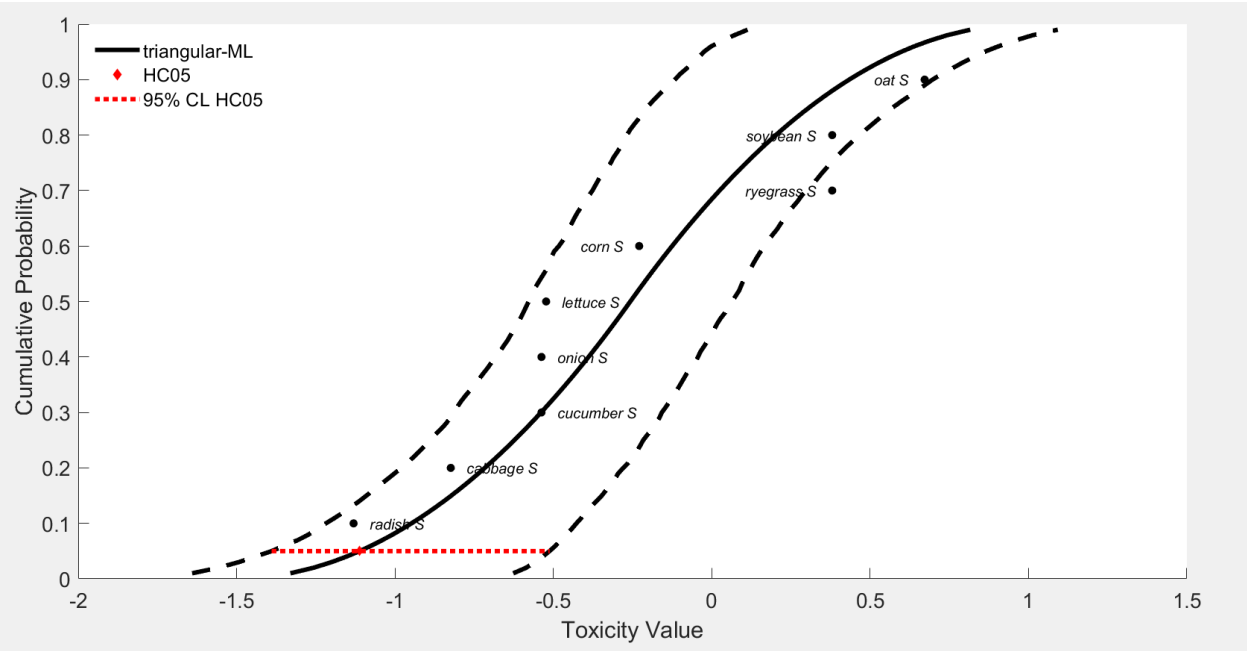
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0618 | 0.1888 |
| 2 | logistic | ML | 0.0478 | 0.1129 |
| 3 | triangular | ML | 0.0773 | 0.2747 |
| 4 | gumbel | ML | 0.0835 | 0.4705 |
| 5 | weibull | ML | 0.0255 | 0.0889 |
| 6 | burr | ML | 0.0837 | 0.3447 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.066056 |
| Model-averaged SE of HCp: | 0.042437 |
| CV of HCp: | 0.64244 |

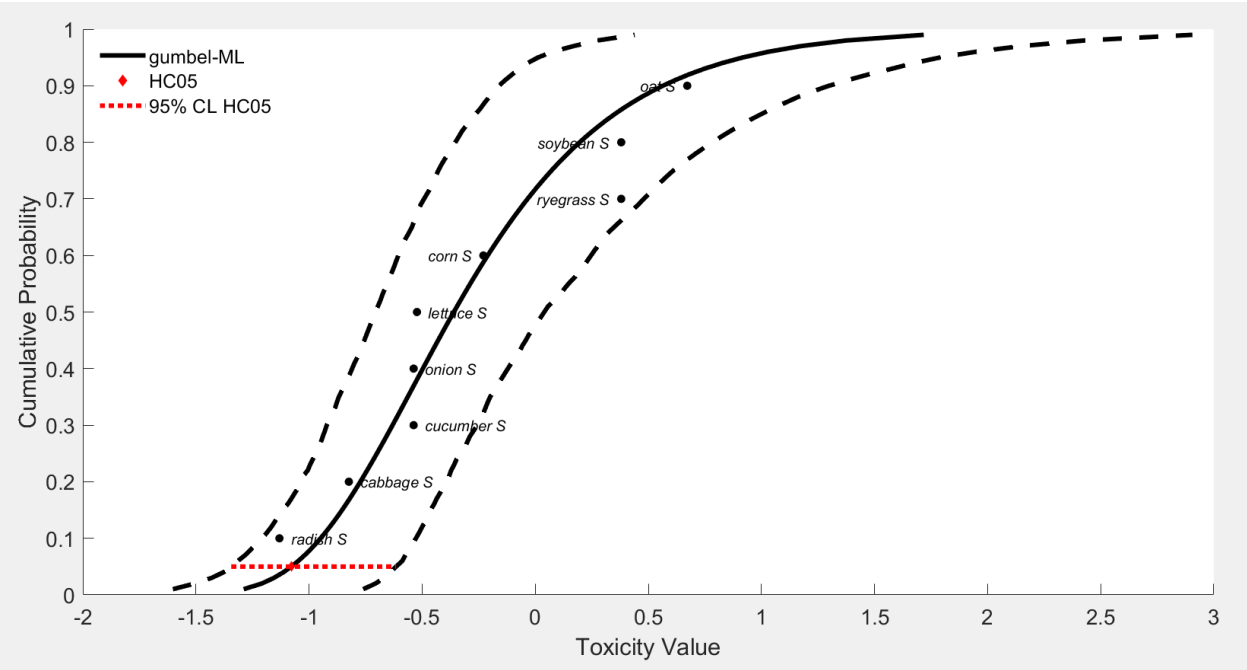
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 24.9311 | 0 | 0.3116 | 0.0773 | 0.0488 |
| 2 | gumbel | 25.6006 | 0.6695 | 0.2230 | 0.0835 | 0.0354 |
| 3 | normal | 25.8134 | 0.8824 | 0.2005 | 0.0618 | 0.0421 |
| 4 | logistic | 26.6036 | 1.6725 | 0.1350 | 0.0478 | 0.0368 |
| 5 | weibull | 27.0170 | 2.0860 | 0.1098 | 0.0255 | 0.0302 |
| 6 | burr | 30.4103 | 5.4792 | 0.0201 | 0.0837 | 0.0000 + ... |

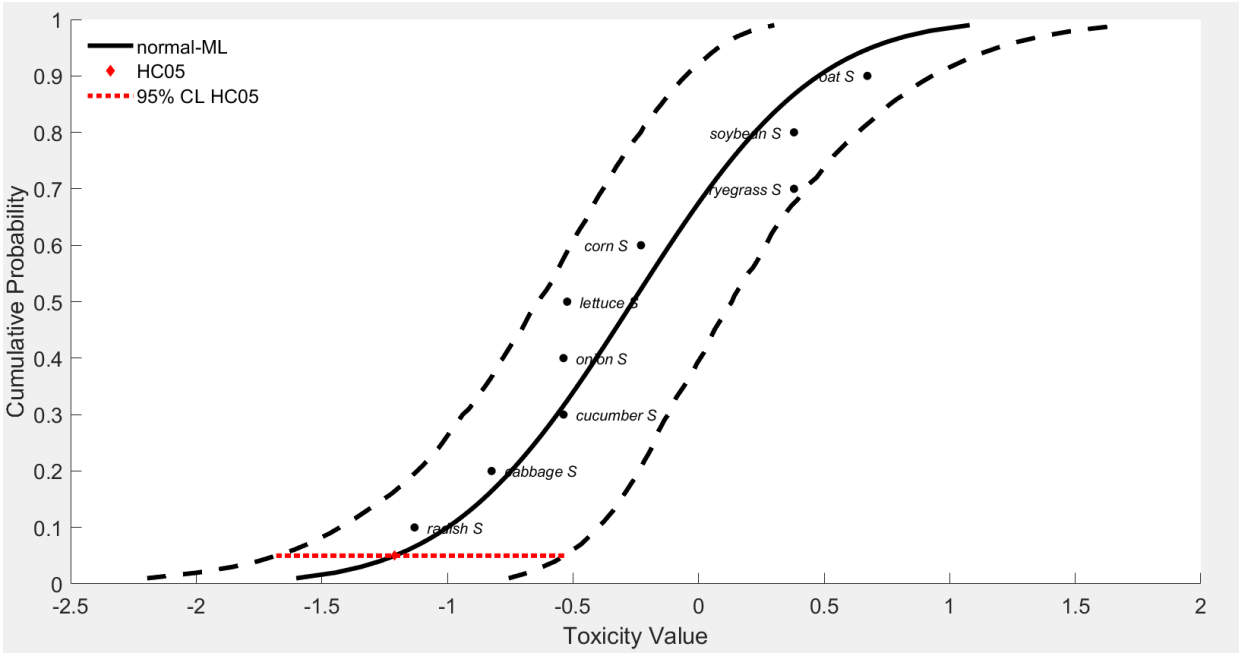
Based on the goodness of fit, EPA moved forward the triangular, normal, and Gumbel distributions, and ultimately selected the normal distribution for the survival data from the seedling emergence toxicity tests.




Triangular




Gumbel




**Normal (selected distribution)**

## 5.4 Vegetative Vigor Height Data

Goodness of fit:

Results:

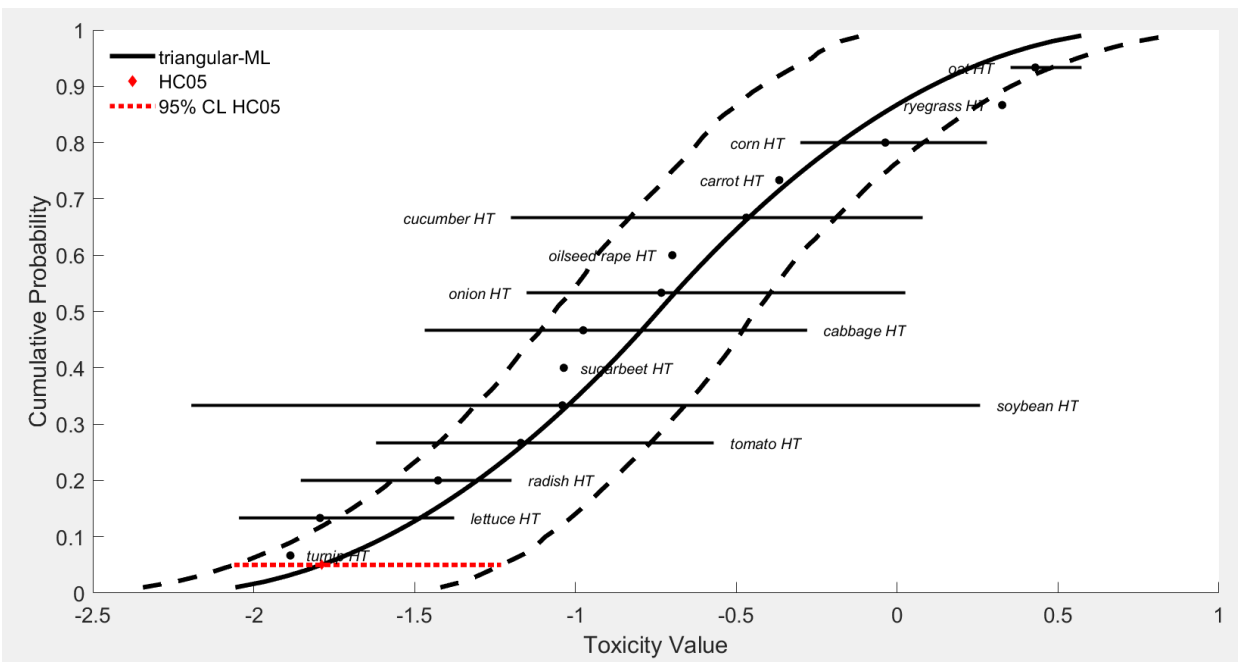
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0126 | 0.8571 |
| 2 | logistic | ML | 0.0106 | 0.8452 |
| 3 | triangular | ML | 0.0162 | 0.8342 |
| 4 | gumbel | ML | 0.0165 | 0.8891 |
| 5 | weibull | ML | 0.0040 | 0.4406 |
| 6 | burr | ML | 0.0153 | 0.8931 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.013897 |
| Model-averaged SE of HCp: | 0.0088447 |
| CV of HCp: | 0.63645 |

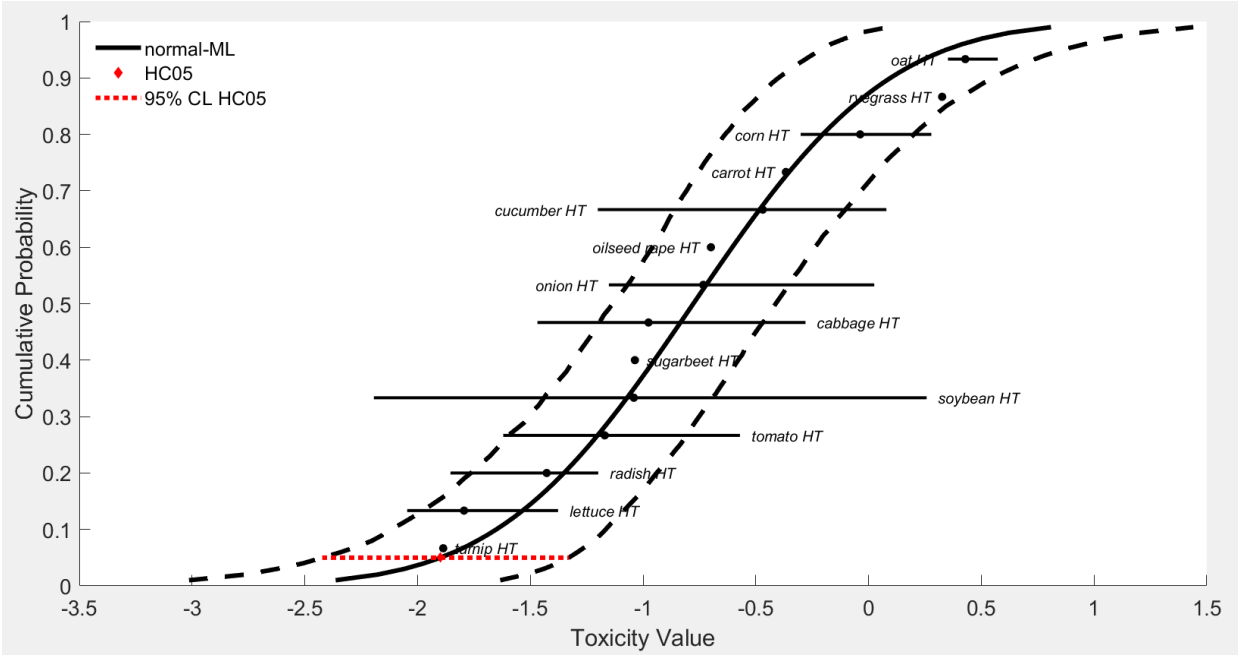
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 5.9237 | 0 | 0.4067 | 0.0162 | 0.0090 |
| 2 | normal | 7.3485 | 1.4247 | 0.1995 | 0.0126 | 0.0081 |
| 3 | gumbel | 7.8733 | 1.9496 | 0.1535 | 0.0165 | 0.0069 |
| 4 | logistic | 8.0935 | 2.1698 | 0.1375 | 0.0106 | 0.0077 |
| 5 | weibull | 9.4143 | 3.4906 | 0.0710 | 0.0040 | 0.0045 |
| 6 | burr | 11.0197 | 5.0959 | 0.0318 | 0.0153 | 0.0095 |

Based on the goodness of fit, EPA moved forward the triangular and normal distributions, and ultimately selected the normal distribution for the height data from the vegetative vigor toxicity tests.




Triangular




**Normal (selected distribution)**

## 5.5 Vegetative Vigor Dry Weight Data

Goodness of fit:

Results:

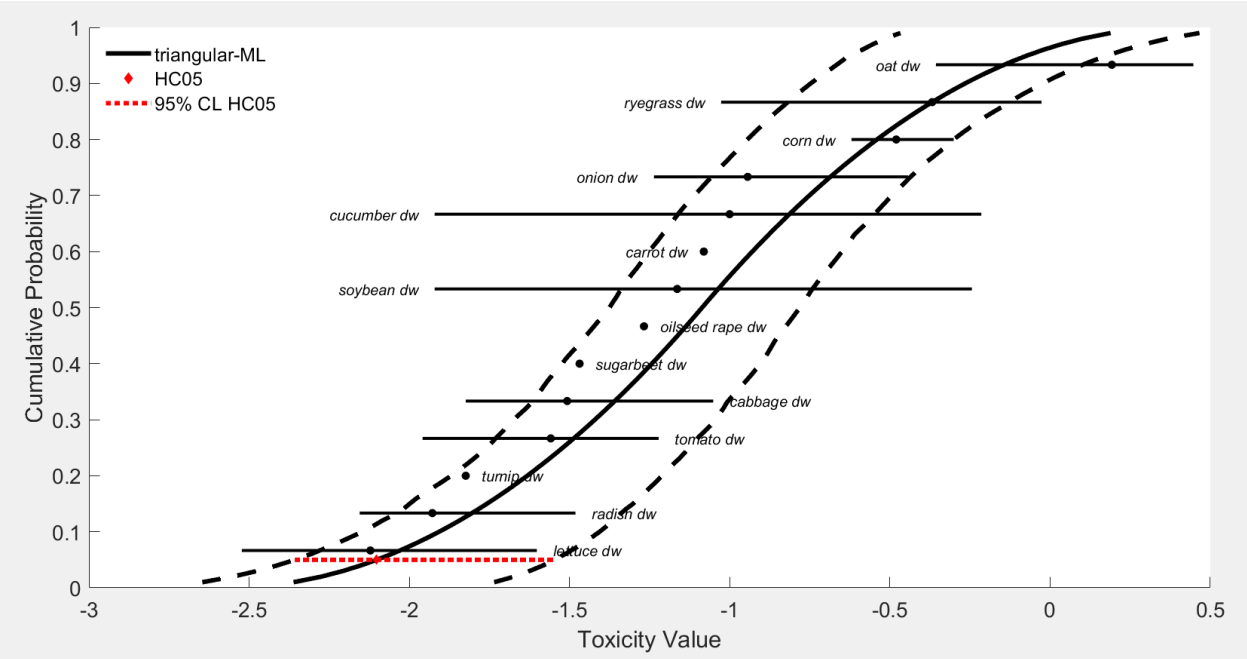
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0064 | 0.8262 |
| 2 | logistic | ML | 0.0055 | 0.8861 |
| 3 | triangular | ML | 0.0079 | 0.4086 |
| 4 | gumbel | ML | 0.0093 | 0.9550 |
| 5 | weibull | ML | 0.0015 | 0.2817 |
| 6 | burr | ML | 0.0092 | 0.9520 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0075903 |
| Model-averaged SE of HCp: | 0.0042381 |
| CV of HCp: | 0.55835 |

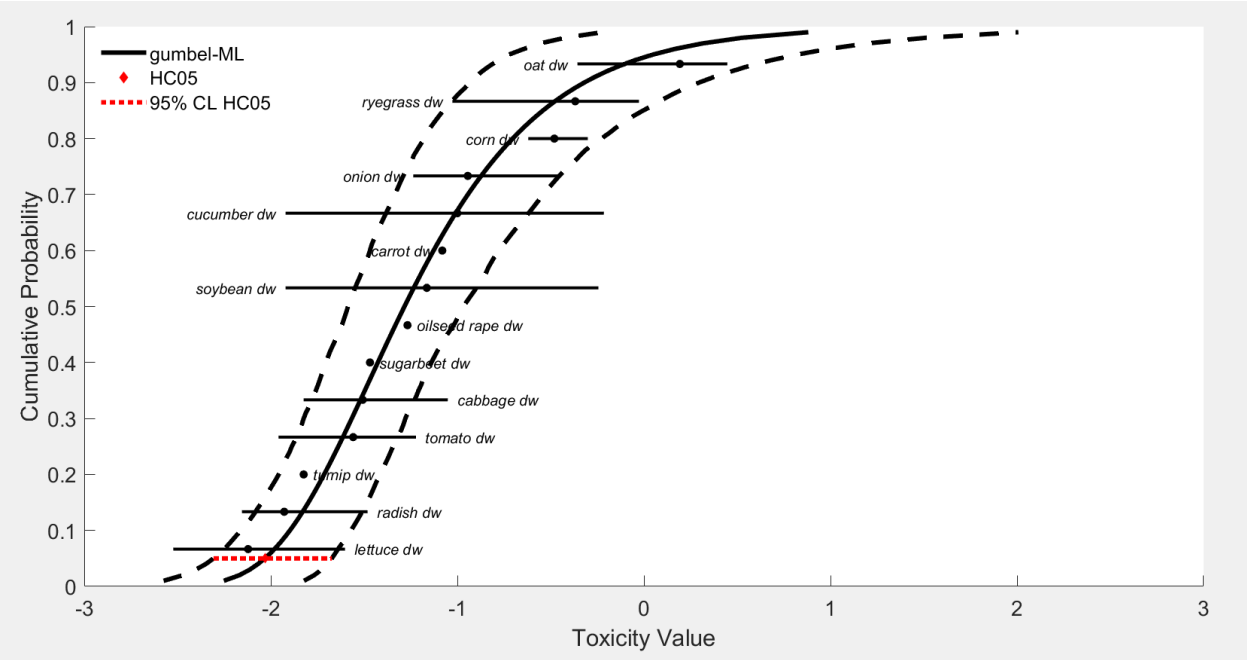
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -22.4756 | 0 | 0.3136 | 0.0093 | 0.0033 |
| 2 | triangular | -22.0844 | 0.3912 | 0.2579 | 0.0079 | 0.0050 |
| 3 | normal | -21.4168 | 1.0588 | 0.1847 | 0.0064 | 0.0037 |
| 4 | logistic | -21.1035 | 1.3721 | 0.1579 | 0.0055 | 0.0035 |
| 5 | burr | -19.1556 | 3.3200 | 0.0596 | 0.0092 | 0.0033 |
| 6 | weibull | -17.5228 | 4.9528 | 0.0264 | 0.0015 | 0.0017 |

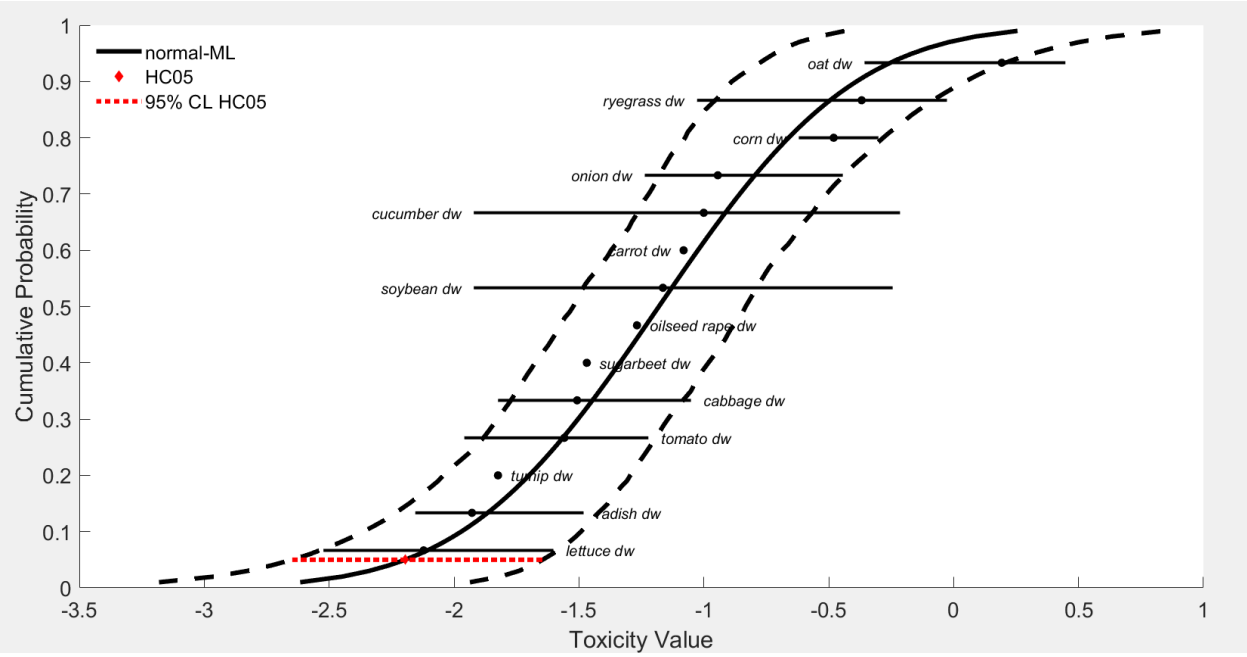
Based on the goodness of fit, EPA moved forward the triangular, normal, and Gumbel distributions, and ultimately selected the normal distribution for the weight data from the vegetative vigor toxicity tests.




Triangular




Gumbel




**Normal (selected distribution).**

## 9.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 9-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb a.e./A (maximum application rate for use of fallow land)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 0* | 0* | 0* | 0* | 0* | 0* | 0* |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 130 µg a.e./L for duckweed, *Lemna gibba*, in the toxicity test with DMAS (MRID 44903501). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For MCPA, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 9.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table were estimated using a $K_{OC}$ of 60 L/kg-o.c. (based on the $K_d$ of 0.60 L/kg-o.c. and a conversion factor of 100).

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 9-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.5 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 75.0 | 75.0 | 75.0 | 158.3 | 152.9 | 151.9 | 151.2 | 71.4 |
| 10 | 50.5 | 45.3 | 41.6 | 39.4 | 14.0 | 7.0 | 4.2 | 34.6 |
| 20 | 37.5 | 30.1 | 25.8 | 19.8 | 6.6 | 3.8 | 2.3 | 19.5 |
| 25 | 32.1 | 24.4 | 20.2 | 14.6 | 4.9 | 3.0 | 1.8 | 14.1 |
| 50 | 25.2 | 16.2 | 10.7 | 7.1 | 2.5 | 1.7 | 1.1 | 5.1 |
| 75 | 17.7 | 10.9 | 7.1 | 4.7 | 1.8 | 1.3 | 0.8 | 2.5 |
| 100 | 14.9 | 8.7 | 5.5 | 3.8 | 1.4 | 1.1 | 0.7 | 1.6 |
| 125 | 11.1 | 6.4 | 4.1 | 3.0 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.4 | 5.1 | 3.2 | 2.4 | 1.0 | 0.8 | 0.5 | 0.6 |
| 175 | 7.8 | 4.3 | 2.6 | 2.1 | 0.9 | 0.7 | 0.4 | 0.5 |
| 200 | 6.9 | 3.7 | 2.3 | 1.8 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.3 | 3.2 | 1.9 | 1.6 | 0.7 | 0.5 | 0.4 | 0.3 |
| 250 | 5.5 | 2.8 | 1.6 | 1.4 | 0.6 | 0.5 | 0.3 | 0.2 |
| 275 | 5.0 | 2.4 | 1.5 | 1.2 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.6 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.2 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 3.9 | 1.8 | 1.1 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.6 | 1.7 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.4 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.8 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 |
| 600 | 2.4 | 1.1 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.2 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.0 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.8 | 0.8 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.010 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.5 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 46.9 | 46.9 | 46.9 | 98.9 | 95.6 | 95.0 | 94.5 | 44.6 |
| 10 | 31.5 | 28.3 | 26.0 | 24.6 | 8.8 | 4.4 | 2.6 | 21.6 |
| 20 | 23.4 | 18.8 | 16.1 | 12.4 | 4.2 | 2.3 | 1.4 | 12.2 |
| 25 | 20.0 | 15.2 | 12.6 | 9.1 | 3.1 | 1.9 | 1.1 | 8.8 |
| 50 | 15.7 | 10.1 | 6.7 | 4.4 | 1.6 | 1.1 | 0.7 | 3.2 |
| 75 | 11.0 | 6.8 | 4.4 | 3.0 | 1.1 | 0.8 | 0.5 | 1.5 |
| 100 | 9.3 | 5.5 | 3.5 | 2.4 | 0.9 | 0.7 | 0.4 | 1.0 |
| 125 | 7.0 | 4.0 | 2.6 | 1.9 | 0.7 | 0.6 | 0.4 | 0.6 |
| 150 | 5.8 | 3.2 | 2.0 | 1.5 | 0.6 | 0.5 | 0.3 | 0.4 |
| 175 | 4.9 | 2.7 | 1.6 | 1.3 | 0.5 | 0.4 | 0.3 | 0.3 |
| 200 | 4.3 | 2.3 | 1.4 | 1.1 | 0.5 | 0.4 | 0.3 | 0.2 |
| 225 | 3.9 | 2.0 | 1.2 | 1.0 | 0.4 | 0.3 | 0.2 | 0.2 |
| 250 | 3.4 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 3.1 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 300 | 2.8 | 1.4 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 325 | 2.6 | 1.2 | 0.8 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 350 | 2.4 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 375 | 2.3 | 1.1 | 0.7 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 |
| 400 | 2.1 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.8 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.5 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.4 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.3 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 1.2 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.1 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.016 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.75 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 37.5 | 37.5 | 37.5 | 79.1 | 76.5 | 76.0 | 75.6 | 35.7 |
| 10 | 25.2 | 22.7 | 20.8 | 19.7 | 7.0 | 3.5 | 2.1 | 17.3 |
| 20 | 18.8 | 15.0 | 12.9 | 9.9 | 3.3 | 1.9 | 1.1 | 9.7 |
| 25 | 16.0 | 12.2 | 10.1 | 7.3 | 2.5 | 1.5 | 0.9 | 7.0 |
| 50 | 12.6 | 8.1 | 5.4 | 3.6 | 1.3 | 0.9 | 0.5 | 2.6 |
| 75 | 8.8 | 5.5 | 3.5 | 2.4 | 0.9 | 0.6 | 0.4 | 1.2 |
| 100 | 7.5 | 4.4 | 2.8 | 1.9 | 0.7 | 0.5 | 0.3 | 0.8 |
| 125 | 5.6 | 3.2 | 2.1 | 1.5 | 0.6 | 0.4 | 0.3 | 0.5 |
| 150 | 4.7 | 2.6 | 1.6 | 1.2 | 0.5 | 0.4 | 0.2 | 0.3 |
| 175 | 3.9 | 2.1 | 1.3 | 1.0 | 0.4 | 0.3 | 0.2 | 0.2 |
| 200 | 3.5 | 1.9 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 225 | 3.1 | 1.6 | 0.9 | 0.8 | 0.3 | 0.3 | 0.2 | 0.1 |
| 250 | 2.8 | 1.4 | 0.8 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 275 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 300 | 2.3 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 325 | 2.1 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 350 | 2.0 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 375 | 1.8 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 400 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.4 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 1.2 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.1 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 1.0 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.9 | 0.4 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.010 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.75 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 23.4 | 23.4 | 23.4 | 49.5 | 47.8 | 47.5 | 47.2 | 22.3 |
| 10 | 15.8 | 14.2 | 13.0 | 12.3 | 4.4 | 2.2 | 1.3 | 10.8 |
| 20 | 11.7 | 9.4 | 8.1 | 6.2 | 2.1 | 1.2 | 0.7 | 6.1 |
| 25 | 10.0 | 7.6 | 6.3 | 4.6 | 1.5 | 0.9 | 0.6 | 4.4 |
| 50 | 7.9 | 5.1 | 3.3 | 2.2 | 0.8 | 0.5 | 0.3 | 1.6 |
| 75 | 5.5 | 3.4 | 2.2 | 1.5 | 0.5 | 0.4 | 0.2 | 0.8 |
| 100 | 4.7 | 2.7 | 1.7 | 1.2 | 0.5 | 0.3 | 0.2 | 0.5 |
| 125 | 3.5 | 2.0 | 1.3 | 0.9 | 0.4 | 0.3 | 0.2 | 0.3 |
| 150 | 2.9 | 1.6 | 1.0 | 0.8 | 0.3 | 0.2 | 0.2 | 0.2 |
| 175 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 200 | 2.2 | 1.2 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 2.0 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.7 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 300 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.1 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.016 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.50 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 25.0 | 25.0 | 25.0 | 52.8 | 51.0 | 50.6 | 50.4 | 23.8 |
| 10 | 16.8 | 15.1 | 13.9 | 13.1 | 4.7 | 2.3 | 1.4 | 11.5 |
| 20 | 12.5 | 10.0 | 8.6 | 6.6 | 2.2 | 1.3 | 0.8 | 6.5 |
| 25 | 10.7 | 8.1 | 6.7 | 4.9 | 1.6 | 1.0 | 0.6 | 4.7 |
| 50 | 8.4 | 5.4 | 3.6 | 2.4 | 0.8 | 0.6 | 0.4 | 1.7 |
| 75 | 5.9 | 3.6 | 2.4 | 1.6 | 0.6 | 0.4 | 0.3 | 0.8 |
| 100 | 5.0 | 2.9 | 1.8 | 1.3 | 0.5 | 0.4 | 0.2 | 0.5 |
| 125 | 3.7 | 2.1 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 | 0.3 |
| 150 | 3.1 | 1.7 | 1.1 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 175 | 2.6 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 200 | 2.3 | 1.2 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 225 | 2.1 | 1.1 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.8 | 0.9 | 0.5 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.9 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.010 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.50 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 15.6 | 15.6 | 15.6 | 33.0 | 31.9 | 31.7 | 31.5 | 14.9 |
| 10 | 10.5 | 9.4 | 8.7 | 8.2 | 2.9 | 1.5 | 0.9 | 7.2 |
| 20 | 7.8 | 6.3 | 5.4 | 4.1 | 1.4 | 0.8 | 0.5 | 4.1 |
| 25 | 6.7 | 5.1 | 4.2 | 3.0 | 1.0 | 0.6 | 0.4 | 2.9 |
| 50 | 5.2 | 3.4 | 2.2 | 1.5 | 0.5 | 0.4 | 0.2 | 1.1 |
| 75 | 3.7 | 2.3 | 1.5 | 1.0 | 0.4 | 0.3 | 0.2 | 0.5 |
| 100 | 3.1 | 1.8 | 1.2 | 0.8 | 0.3 | 0.2 | 0.1 | 0.3 |
| 125 | 2.3 | 1.3 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 150 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 175 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 200 | 1.4 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 250 | 1.1 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 500 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.016 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.25 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 12.5 | 12.5 | 12.5 | 26.4 | 25.5 | 25.3 | 25.2 | 11.9 |
| 10 | 8.4 | 7.6 | 6.9 | 6.6 | 2.3 | 1.2 | 0.7 | 5.8 |
| 20 | 6.3 | 5.0 | 4.3 | 3.3 | 1.1 | 0.6 | 0.4 | 3.2 |
| 25 | 5.3 | 4.1 | 3.4 | 2.4 | 0.8 | 0.5 | 0.3 | 2.3 |
| 50 | 4.2 | 2.7 | 1.8 | 1.2 | 0.4 | 0.3 | 0.2 | 0.9 |
| 75 | 2.9 | 1.8 | 1.2 | 0.8 | 0.3 | 0.2 | 0.1 | 0.4 |
| 100 | 2.5 | 1.5 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 125 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 150 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 175 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 225 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 250 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 350 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 500 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.010 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 9-32. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.25 lb a.e./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 7.8 | 7.8 | 7.8 | 16.5 | 15.9 | 15.8 | 15.7 | 7.4 |
| 10 | 5.3 | 4.7 | 4.3 | 4.1 | 1.5 | 0.7 | 0.4 | 3.6 |
| 20 | 3.9 | 3.1 | 2.7 | 2.1 | 0.7 | 0.4 | 0.2 | 2.0 |
| 25 | 3.3 | 2.5 | 2.1 | 1.5 | 0.5 | 0.3 | 0.2 | 1.5 |
| 50 | 2.6 | 1.7 | 1.1 | 0.7 | 0.3 | 0.2 | 0.1 | 0.5 |
| 75 | 1.8 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.3 |
| 100 | 1.6 | 0.9 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 150 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 200 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 225 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.016 lb a.e./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 10 Metolachlor and (*S*)-Metolachlor Case Study Example (PC Codes 108801, 108800)

## 10.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft draft Strategy (HStrategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 10.2 Use Information

Metolachlor and its enantiomer (*S*)-metolachlor (referred to collectively as 'metolachlor' in this document) is a broad-spectrum chloroacetamide herbicide that acts by inhibiting seedling shoot and meristematic growth (*i.e.,* seedling growth inhibitor). It ranges from non-persistent to persistent, depending on the specific environmental conditions, and it is systemic in plants. Metolachlor can be applied pre-plant, pre-emergence, or early post-plant (pre-crop emergence or post-crop emergence/post-transplant) to control seedling grasses and certain broadleaf weeds such as nightshade, lambsquarter, and pigweeds, in a wide range of agricultural and non-agricultural crops, primarily corn, soybeans, sorghum, and cotton. Applications may be made as ground or aerial sprays or through chemigation. Per the 2019 Draft Risk Assessment (DP448940) for registration review, typical label restrictions include: aerial application release

height (≤10 ft) and wind speed (≤10 mph[112]); spray drift buffer zones between the treated field and adjacent water bodies; variable application rates depending on soil texture and organic matter content; and geographic restrictions (such as those in **Table 10-1**).

**Table 10-1** includes the use information from the 2019 Draft Risk Assessment (DRA; DP448940) for Registration Review. EPA only included the uses which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Strategy would be implemented for metalochlor, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Interim Decision in December 2020) are not considered at this time but would be considered when EPA conducts assessments for metolachlor for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2019 assessment. **Table 10-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in Section 6.6. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5**.

EPA estimated exposures using the selected[113] uses and application information provided in **Table 10-1**. The selected uses do not represent all registered uses of metolachlor and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where metolachlor usage is most common. These selected uses are examples to illustrate the draft Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of metolachlor as this application method represents the greatest source of potential offsite movement. Although granular formulations of metolachlor are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

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[112] Wind speed and boom length mitigations have become standard revisions to labels in the Registration Review process. The restrictions described here may not reflect current labeling for this chemical.

[113] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2019 Draft Risk Assessment (DP448940) for Registration Review for metolachlor and (*S*)-metolachlor, with the exception of alfalfa grown for seed. Use on alfalfa grown for seed is not included in the proposed Herbicide Strategy at this time given that it is registered as a Special Local Need only and that only ground applications with 3 inches of soil incorporation would apply (reducing the potential drift and runoff exposure).

**Table 10-1 Summary of the Selected Agricultural Use Patterns Labeled for Metolachlor (2019 Draft Risk Assessment for Registration Review, DP448940)[1]**

| Use Site (Use Data Layer) | App Target | App Type | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr* | Max Annual Rate (lb ai/A/yr*) | MRI (d) | Comments (*e.g.* geographic/ application timing restrictions, pollinator specific language) |
|---|---|---|---|---|---|---|---|---|---|
| Corn (Corn UDL) | Foliar or soil | Broadcast, soil broadcast | A, G, C | Spring/Fall | 2.1 | NS (2) | 4.00 | NS | LA only |
| | Soil | Broadcast, Soil Broadcast, Soil Band, Chemigation | A, G, C | Pre-emergence | 2.67 | NS (2) | 3.87 | NS | Not for use in Nassau or Suffolk County, New York |
| | Soil | Soil Incorp. to 2 inches | G | Pre-plant | | | | | Not for use in Nassau or Suffolk County, New York |
| | Foliar | Broadcast, soil broadcast | A, G | Post-emergence lay-by | 1.9 | NS (2) | 3.8 | NS | Disallowed in specific counties[2] in New York |
| Cotton (Cotton UDL) | Foliar | Broadcast | A | Preplant incorp., pre-emergence post-emergence | 1.33 | NS (3) | 3.98 | NS | NC, AZ, KS, VA, MS, AK, CA, TX, OK, TN, NM, FL, SC, AL, GA, MO, LA Only, Preplant in NM, OK, TX only |
| | Soil | Soil Band | G | | | | | | |
| | Soil | Soil broadcast | | | | | | | |
| | Soil or Foliar | Broadcast | A | Fall/ Spring | 2.1 | 2 | 4.00 | | LA Only |
| | Soil | Soil Broadcast | G | | | | | | |
| | Soil | Soil Broadcast | G | | | | | | |
| Sorghum (Other Grains UDL) | Soil | Soil surface | G | Pre-plant | 1.67 | NS (1) | NS (1.67) | NS | NS |
| | Soil | Broadcast | A | Pre-emergence | 1.67 | NS (1) | NS (1.67) | NS | Disallowed in NY |
| Soybeans (Soybeans UDL) | Soil or Foliar | Broadcast, soil broadcast | A, G | Post-emergence | 1.26 | NS (2) | 1.63 | NS | NS |
| | Soil | Soil Incorp. to 2 inches | G, soil incorp | Pre-plant | 2.74 | NS (1) | 2.74 | NS | Disallowed in specific counties[2] and California |
| | Soil or Foliar | Broadcast, Chemigation, Soil broadcast | A, C, G | Pre-emergence | 2.74 | NS (1) | 2.74 | NS | Disallowed in specific counties[2] and New York |

| Use Site (Use Data Layer) | App Target | App Type | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr* | Max Annual Rate (lb ai/A/yr*) | MRI (d) | Comments (*e.g.* geographic/ application timing restrictions, pollinator specific language) |
|---|---|---|---|---|---|---|---|---|---|
| Tomatoes (Vegetables and Ground Fruit UDL) | Soil | Soil broadcast treatment, Soil Incorp, Soil band | G, soil incorp | Pre-plant | 1.99 | NS (3) | NS (5.97) | NS | Disallowed in specific counties[2] |
| | Soil | Directed Spray | G | Post-emergence | 1.99 | NS (3) | NS (5.97) | NS | Disallowed in specific counties[2] |

App=application; equip=equipment; MRI = Minimum retreatment interval; UDL=Use Data Layer; A=aerial; C=chemigation; G=ground; incorp.=incorporated; ai=active ingredient; CC=crop cycle; d=day; NS=not specified on the label; () Values in parenthesis were calculated based on other information provided on the label. These values are not on the label.

* Information is provided on an annual basis, unless otherwise specified.

Some labels do not specify a maximum single application rate but specify a maximum annual application rate. Other labels do not specify a maximum annual application rate but do specify a maximum single application rate. For these labels with non-specified information, application information was assumed to be the information provided on labels with a complete use pattern. Fewer applications are often permitted at lower single application rates as long as the maximum annual application rate is not exceeded.

[1] The use information presented in this table is identical to the agricultural uses included in the 2019 Draft Risk Assessment for Registration Review (DP448940), with the exception of alfalfa grown for seed, which was not included in the draft Herbicide Strategy at this time.

[2] The counties where use of metolachlor is disallowed are not specified in the 2019 Draft Risk Assessment (DP448940).

## 10.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of metolachlor (**Section 10.3.1**), reported incidents (**Section 10.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 10.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 10.3.1 Toxicity Information

**Table 10-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for metolachlor. In herbicide risk assessments, the available data often contain results from toxicity tests with co-formulated end-use products that contain more than one active ingredient; this is applicable for the available metolachlor plant toxicity data as shown in **Table 10-2**. For this case study, EPA evaluated the toxicity data on face value and did not complete a comparative toxicity evaluation between active ingredients and the co-formulated product data.[114] As outlined below, EPA included the co-formulation data in the generation of the Species Sensitivity Distributions.

**Table 10-2. Summary of the Most Sensitive Toxicity Endpoints for Metolachlor (As Summarized in the 2019 Draft Risk Assessment for Registration Review, DP448940)**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Ryegrass (*Lolium perenne*) | NOAEC = 0.0010 lb a.i./A<br>$IC_{25}$ = 0.0048 lb a.i./A | 43928932 Supplemental | Test with TGAI; based on phytotoxicity |
| | Dicot: Turnip (*Brassica rapa*) | NOAEC = 0.0048 lb a.i./A<br>$IC_{25}$ = 0.00546 lb a.i./A | 50102115 Acceptable | Test with a co-formulation with dicamba; based on effects on dry weight |
| Vegetative Vigor | Monocot: Ryegrass (*Lolium perenne*) | NOAEC = 0.0031 lb a.i./A<br>$IC_{25}$ = 0.016 lb a.i./A | 43487108 Acceptable | Test with TGAI; based on effects on dry weight |
| | Dicot: Tomato (*Solanum lycopersicum*) | NOAEC = 0.0020 lb a.i./A<br>$IC_{25}$ = 0.00409 lb a.i./A | 50102116 Acceptable | Test with a co-formulation with dicamba; based on effects on dry weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 4.4 µg a.i./L<br>**$IC_{50}$ = 14.0 µg a.i./L** | 43928931 Supplemental | Most sensitive endpoint based on the $IC_{50}$ was biomass with 25% reduction at the LOAEC (7.6 µg a.i./L)<br><br>Solvent interaction reduced both growth measures significantly as compared to |

[114] In standard risk assessments, EPA risk assessors evaluate the relative contribution of toxicity from each of the included active ingredients in the tested co-formulation. Using this information, the assessor considers whether to use the co-formulation data in the assessment for calculation of risk estimates.

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| | | | | negative control. All endpoints are based on comparisons to the negative control. |
| Aquatic Nonvascular Plant | Green alga (*Selenastrum capricornutum*) | NOAEC = 1.5 µg a.i./L **$IC_{50}$ = 8.0 µg a.i./L** | 43928929 Acceptable | Based on cell density, reduced 7% at the LOAEC (3.0 µg a.i./L) |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}/_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the metolachlor seedling emergence and vegetative vigor tests. See Table 10-3 and **Figure 10-1** for the SSD results.

Using all of the toxicity data available (including data from tests with co-formulated products), EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). See **Section 10.7** for the data used to generate the SSDs and **Section 10.8** for the process for calculating the SSDs. In total, EPA calculated four SSDs for metolachlor by combining the results for tested monocot and dicot species because monocots and dicots do not appear to differ substantially in sensitivity to metolachlor. Specifically, as summarized in **Section 10.7**, the range of the growth toxicity endpoints (*i.e.,* the concentrations resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the seedling emergence and vegetative vigor studies typically overlap when considering all definitive values available. Additionally, the mean and median $IC_{25}$ values for monocots and dicots only differ by factors of 2 and 5, respectively, when data are compared for the same biological endpoint (height or weight) within the same test design (seedling emergence or vegetative vigor), indicating that monocots and dicots do not differ substantially in sensitivity. Therefore, EPA did not create separate SSDs for monocots and dicots.

**Figure 10-1** shows the four SSDs that EPA generated. The SSD based on the seedling emergence weight data resulted in the most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values (represented as red and black dots in **Figure 10-1**, respectively). EPA used the resulting most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values from the SSD to calculate the ratio of EEC to toxicity endpoint (**Table 10-3 Table 10-4**; see **Section 10.3.3**). By combining the monocot and dicot data, these $5^{th}$ and $25^{th}$ percentile values represent the sensitivities of both types of flowering plants to metolachlor.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the

Code of Federal Regulations at 40 CFR Part 158[115] are available to evaluate potential impacts of metolachlor on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 10-2** and **Table 10-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[116].

**Table 10-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Metolachlor**

| Percentile (x) | Seedling Emergence Test | | Vegetative Vigor Test | |
|---|---|---|---|---|
| | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** |
| 5 | **0.0037** (0.00033 – 0.040) | 0.015 (0.0026 – 0.099) | 0.035 (0.012 – 0.13) | 0.044 (0.0062 – 0.34) |
| 25 | **0.064** (0.0144 – 0.25) | 0.13 (0.043 – 0.36) | 0.15 (0.065 – 0.37) | 0.45 (0.13 – 1.4) |
| 50 | 0.27 (0.088 – 0.69) | 0.37 (0.16 – 0.76) | 0.41 (0.19 – 0.89) | 1.4 (0.57 – 3.1) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

[115] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[116] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

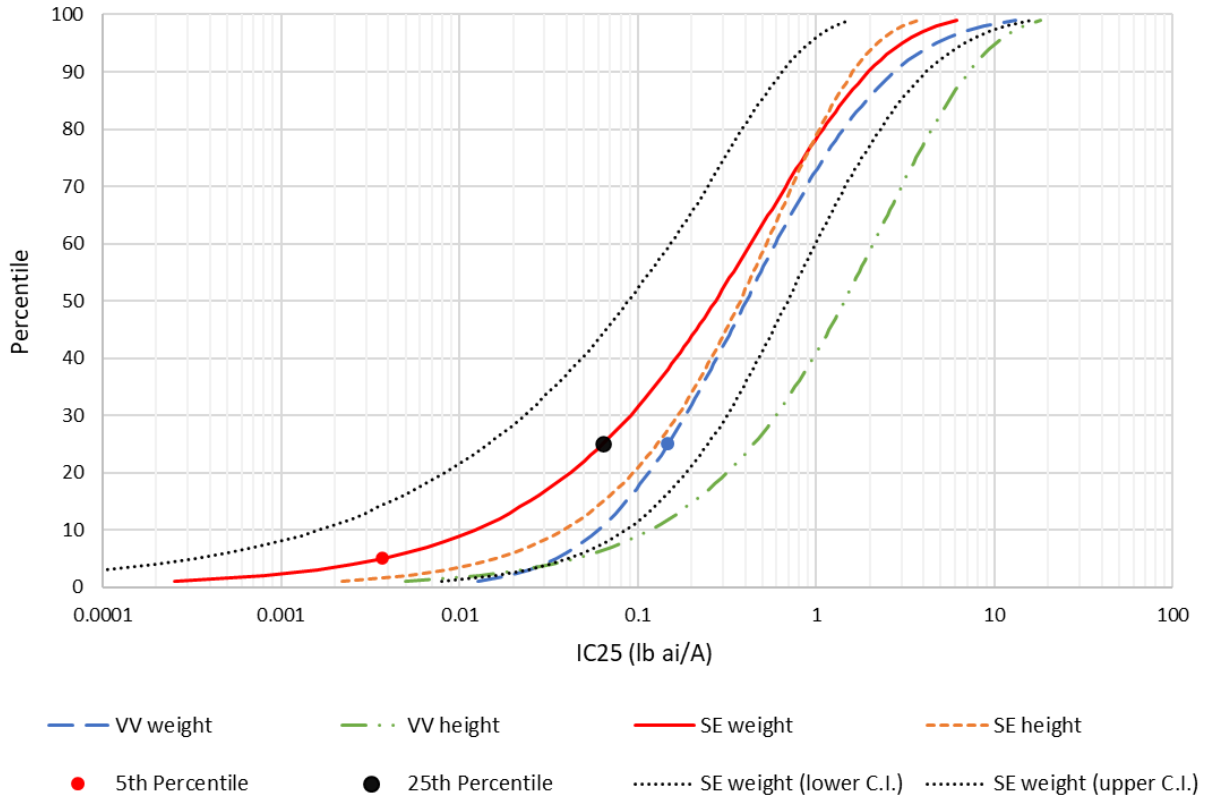


**Figure 10-1. Vegetative Vigor (VV) and Seedling Emergence (SE) Study Species Sensitivity Distributions (SSDs) representing the Distributions of the Plant Height and Weight IC25s for Metolachlor. The Upper and Lower Confidence Intervals (C.I.) are plotted for the SE plant weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 10.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on these plants[117], EPA calculated the magnitude of difference as a ratio of the EEC to the 5$^{th}$ percentile of the seedling emergence plant weight SSD (**Table 10-4**). For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[118] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25$^{th}$

[117] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[118] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

percentile of the SSD (**Table 10-4**). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Table 10-4**).

**Table 10-4. Toxicity Endpoints Used to Calculate the Magnitude of Difference for Metolachlor[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.0037 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.0037 lb a.i./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.0037 lb a.i./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.0037 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.0037 lb a.i./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.064 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 0.064 lb a.i./A |
| | | Based on aquatic plant endpoints: 14.0 µg a.i./L (Vascular), 8.0 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 14.0 µg a.i./L<br>Nonvascular: 8.0 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Herbicide Strategy. In this case study for metolachlor, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 10.3.2 Incidents

The incident information from the 2019 Draft Risk Assessment (DP448940) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[119] (as discussed in **Section 10.3.3.3**), which informs the potential population-level impacts (**Section 10.6**), and to identify the proposed level of mitigation (see **Section 10.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 10.3.3.3**).[120] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA. Starting from the registration of metolachlor to when EPA searched the database on June 5, 2019, IDS indicated a total of 623 reported ecological incidents associated with the use of (*S*)-metolachlor and metolachlor. The 2014 Registration Review Problem Formulation (DP420467) provided a detailed discussion of most of the incidents. In short, focusing on the plant incidents, a total of 597 incidents were related to crop (*e.g.,* corn, cotton, and soybean) damage following direct treatment of an agricultural field. Because the incidents are limited to damage to crops on the treated field and listed plants and animals obligately depending on plants for food/habitat are not expected to occur on treated fields, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for metolachlor. In other words, the metolachlor incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 10.3.3.3**) are unaltered by the available metolachlor incident data.

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[119] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[120] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

### 10.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *10.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 10-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of metolachlor ($5^{th}$ percentile of SSD = 0.0037 lb a.i./A). **Table 10-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of metolachlor ($25^{th}$ percentile of SSD = 0.064 lb a.i./A). Within **Table 10-5** and **Table 10-6**, the modeled application rates are representative of the highest single application rate currently registered for metolachlor use on corn (2.67 lb a.i./A) and reduced rates (1.9 and 1.2 lb a.i./A) representative of maximum single application rates for other uses (**Table 10-1)**. **Table 10-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 10-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size, as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 10.4.1**).

Spray drift exposures to aquatic habitats results in shorter off-field distances (results provided in **Section 10.7**) than the spray drift distances estimated for terrestrial/wetland plants. This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for

aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 10-5. Spray Drift Distances to the 10 Times the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.67 lb a.i./A (maximum application rate for use on corn)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 750 | 325 | 225 | 175 | 75 | 50 | 25 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **22** [300] | **11** [300] | **11** [200] | 8.8 [200] | 6.9 [100] | 5.1 [100] | 3.2 [100] |
| **Application Rate of 1.9 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 475 | 250 | 175 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **16** [300] | 7.4 [300] | 7.7 [200] | 6.3 [200] | 4.9 [100] | 3.6 [100] | 2.3 [100] |
| **Application Rate of 1.2 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 300 | 175 | 125 | 75 | 50 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 9.8 [300] | 4.7 [300] | 4.9 [200] | 4.0 [200] | 3.1 [100] | 2.3 [100] | 1.5 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 10 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon the 10 times the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For metolachlor, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 10. This is explained further in **Section 10.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than an order of magnitude (*i.e.,* >10). When the MoE is medium or greater at the maximum buffer distance, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25 ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 10.9** contains the full output of results.

**Table 10-6. Spray Drift Distances to 10 Times the Population-Level Impacts Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Ratio of the Spray Drift EEC to the Endpoint at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.67 lb a.i./A (maximum application rate for use on corn)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 25 | 20 | 20 | 20 | <10 | <10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 1.3 [300] | 0.6 [300] | 0.6 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 1.9 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 10 | 10 | 10 | <10 | <10 | <10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.9 [300] | 0.4 [300] | 0.4 [200] | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.1 [100] |
| **Application Rate of 1.2 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 10 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon 10 times the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For metolachlor, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 10. This is explained further in **Section 10.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than an order of magnitude (*i.e.,* >10). When the MoE is medium or greater at the maximum buffer distance, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25 ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 10.9** contains the full output of results.

#### *10.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 10-7 t**hrough **Table 10-11** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 10-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Corn | 29 – 120 | 2.1 – 8.5 | 3.7 – 15 |
| Cotton | 4.9 – 100 | 0.35 – 7.4 | 0.61 – 13 |
| Sorghum | 28 – 32 | 2.0 – 2.3 | 3.5 – 4.0 |
| Soybean | 25 – 160 | 1.8 – 12 | 3.1 – 20 |
| Tomato | 12 – 150 | 0.84 – 11 | 1.5 – 19 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for metolachlor, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 10-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Corn | 0.38 – 2.3 | 100 – 610 | 190 – 1200 | 14 – 83 | 24 – 150 |
| Cotton | 0.12 – 1.3 | 31= – 350 | 150 – 1700 | 11 – 120 | 19 – 210 |
| Sorghum | 0.37 – 0.45 | 100 – 120 | 220 – 320 | 16 – 23 | 28 – 40 |
| Soybean | 0.22 – 1.3 | 60 – 360 | 130 – 510 | 9.5 – 36 | 17 – 64 |
| Tomato | 0.22 – 0.78 | 60 – 210 | 120 – 1000 | 8.6 – 72 | 15 – 130 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 10-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots |
|---|---|---|

| | | Range of Magnitude of Difference[4] |
|---|---|---|
| Corn | 0.38 – 2.3 | 5.9 – 35 |
| Cotton | 0.12 – 1.3 | 1.8 – 21 |
| Sorghum | 0.37 – 0.45 | 5.8 – 7.0 |
| Soybean | 0.22 – 1.3 | 3.5 – 21 |
| Tomato | 0.22 – 0.78 | 3.4 – 12 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 10-7**
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 10-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Corn | 0.41 – 1.1 | 110 – 290 |
| Cotton | 0.13 – 0.86 | 36 – 230 |
| Sorghum | 0.33 – 0.34 | 89 – 91 |
| Soybean | 0.23 – 0.87 | 63 – 240 |
| Tomato | 0.24 – 0.65 | 65 – 180 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 10-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Corn | 0.41 – 1.1 | 6.4 – 17 |
| Cotton | 0.13 – 0.86 | 2.1 – 13 |
| Sorghum | 0.33 – 0.34 | 5.1 – 5.3 |
| Soybean | 0.23 – 0.87 | 3.7 – 14 |
| Tomato | 0.24 – 0.65 | 3.8 – 10 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *10.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 10-12**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 10.3.3.1**and **10.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 10.3.3.3**) and conducting a population-level impact analysis (**Section 10.6**).

For metolachlor, given the toxicity profile (including an order of magnitude difference between the 5th and 25th percentiles of the most sensitive SSD (**Table 10-3**), confidence intervals around these percentiles spanning one to two orders of magnitude, and similar shallow slopes across all of the SSDs (**Figure 10-1)** and the lack of incidents to plants off the treated field[121], EPA assigned a low magnitude of effect in **Table 10-12** on a use basis to groups of listed species and critical habitats (CHs)[122] when the magnitude of difference is from 1 up to 10. For low magnitude of effect, population-level impacts are not expected. EPA assigned medium or high magnitude of effect on a use basis to groups of species and CHs based on a magnitude of difference from 10 up to 100 or 100 up to 1,000, respectively. For a medium or high magnitude of effect, population-level impacts are expected.

**Table 10-12. Use-Based Magnitude of Effect for Metolachlor.[1]**

| Use | Terrestrial | | Wetland and Smaller Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Corn | High | Medium | High | High | Medium | Medium |
| Cotton | High | Medium | High | High | Medium | Medium |
| Sorghum | Medium | Low | High | Medium | Low | Low |
| Soybean | High | Medium | High | Medium | Medium | Medium |
| Tomato | High | Medium | High | High | Medium | Medium |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 10.3.3.3**) and to conduct the population-level impacts analysis (**Section 10.6**). If the magnitude of effect is medium or higher for metolachlor, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[121] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[122] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

[4] All listed aquatic plants are also found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.
[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 10.4 Framework Step 2: Identify Mitigation Measures

**Section 10.3.3.3** outlines the mitigation measures identified for metolachlor for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 10.4.1**) and runoff/erosion (**Section 10.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1, regardless of the magnitude of effect.[123] For metolachlor, when the magnitude of difference is between 1 and 10, the magnitude of effect is low and population-level impacts are not expected (see **Section 10.3.3.3**). However, even when the magnitude of difference is less than 10 but greater than 1, EPA is still proposing mitigations for metolachlor to avoid take of listed obligate animal species.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 10.4.1 Spray Drift Mitigation Measures Identified

Table **10-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 10-14** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 10-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, | Very Fine-Fine, | Fine-Medium/ Coarse, | Fine-Medium/ Coarse, |

[123] See **Table 5-2 in the Strategy Framework document for details on how the magnitude of difference, magnitude of effect, potential population-level impacts**, and mitigation categories are related.

| | | | | High Boom | Low Boom | High Boom | Low Boom |
|---|---|---|---|---|---|---|---|
| 2.67 | 300 ft + windbreak[3] | 300 ft + windbreak[3] | 200 ft + windbreak[3] | 175 [e,g,h] | 75 [g,h] | 50 [g,h] | 25 [i] |
| 1.9 – 2.0 | 300 ft + windbreak[3] | 250 [a,b,c] | 175 [a,b,d] | 125 [e,g,h] | 50 [g,h] | 25 [i] | 20 [i] |
| 1.0 – 1.2 | 300 [a,b,c] | 175 [a,b,d] | 125 [b,d] | 75 [g,h] | 50 [g,h] | 20 [i] | 10 [i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 10-1**
[3] Additional mitigation measures (*e.g.,* windbreak, hedgerow) would apply for aerial applications at this rate using this droplet size because the magnitude of difference exceeds 10 at the maximum buffer distance. Use of these additional mitigation measures do not result in reduced buffer distances.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### Table 10-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.67 | 25[a] | 20[a] | 20[a] | 20[b] | None[3] | None[3] | None[3] |
| 1.9 – 2.0 | 10[a] | None[3] | None[3] | None[3] | None[3] | None[3] | None[3] |
| 1.0 – 1.2 | None[3] | None[3] | None[3] | None[3] | None[3] | None[3] | None[3] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] The applicator would achieve sufficient mitigation with a windbreak (release height below the top of the windbreak) alone without a buffer. | | | [b] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 10-1**

[3] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is <10 at 10 ft off the treated field.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 10.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of the runoff mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts and minimize the potential for future take differs across uses and, as shown in **Figure 10-2**, the level of mitigation is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed plants (5$^{th}$ percentile endpoint), generalists (25$^{th}$ percentile endpoint)). **Figure 10-2** visually represents the targeted reduction in EECs through the implementation of runoff mitigation for metolachlor.

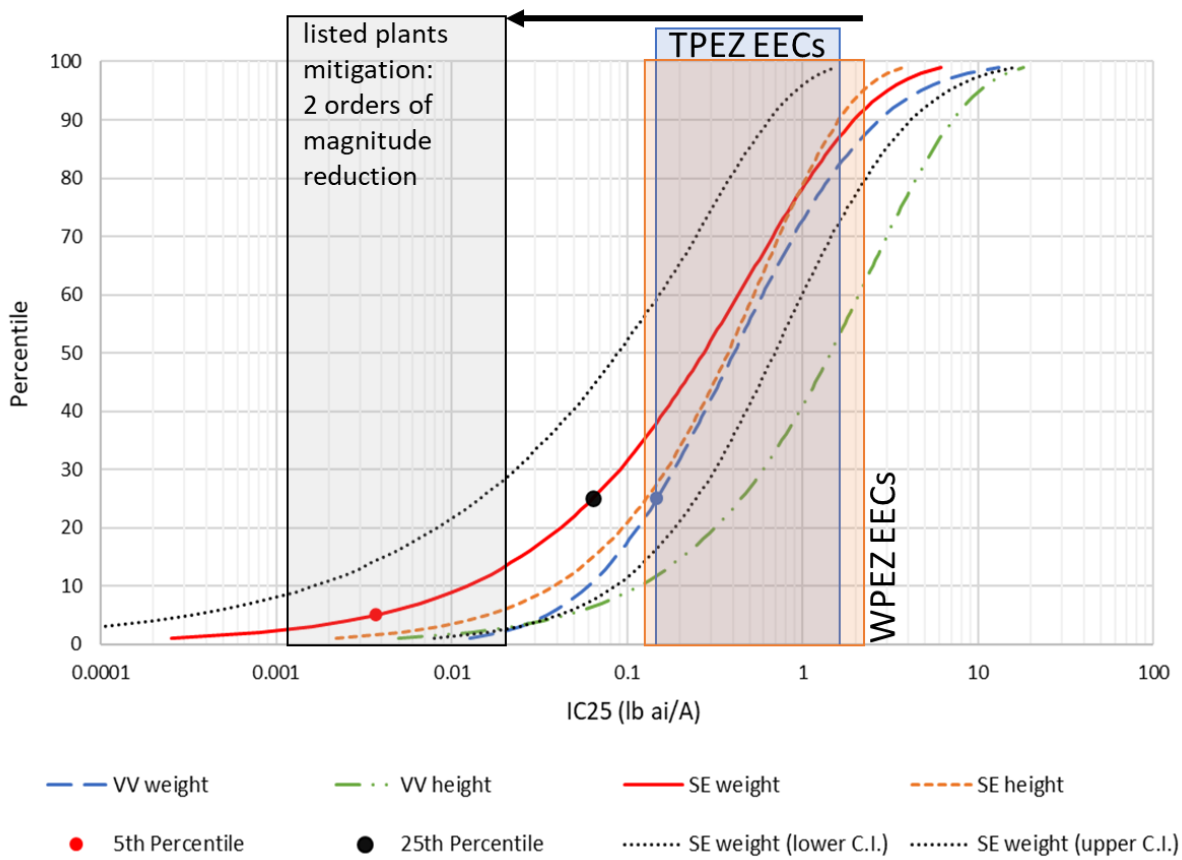


**Figure 10-2. Metolachlor Vegetative Vigor (VV) and Seedling Emergence (SE) Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5$^{th}$ percentile (represents listed plants and animals with obligate relationships to plants) and the 25$^{th}$ percentile (represents listed**

**generalists and designated critical habitats) from the SE weight SSD. Upper and lower confidence intervals (C.I.) are provided for the SE weight SSD.**

For metolachlor, see **Section 10.3.3.2** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of metolachlor is <1,000 L/kg-o.c. (mean $K_{OC}$ = 132.4 L/kg-o.c.), higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework**, EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would be applicable, and if it is between 100 and 1,000, high mitigation would be applicable. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For metolachlor, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for metolachlor, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed species in waterbodies similar in size to the EPA farm pond or larger[124], the mitigation category[125] is low for use on cotton, sorghum and tomato, and medium for use on corn and soybean for listed aquatic plants and animals that depend on these plants[126] (**Table 10-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies (**Table 10-15**).
- With the exception of metolachlor use on sorghum[127], the mitigation category is high for all modeled uses for wetland and terrestrial plants and animals that obligately depend on these plants[128] (**Table 10-16** and **Table 10-18**).

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[124] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.

[125] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios ≥1000), High (ratios ≥100 but <1000), Medium (ratios ≥10 but <100), Low (ratios ≥1 but <10), No Mitigation (ratios <1).

[126] None of the listed aquatic animals have obligate relationships to plants.

[127] For sorghum, the mitigation category is medium for listed terrestrial plants and high for listed semi-aquatic plants.

[128] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.

- For aquatic plants in wetlands or small water bodies[129] and for animals that depend on these plants (both obligately and generally), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. The resulting mitigation category is medium (**Table 10-16**).
- For animals that have a generalist relationship to wetland or terrestrial plants (*i.e.,* do not obligately depend on plants)[130], the mitigation category is medium (Table **10-17** and Table **10-19**), with the exception of metolachlor use on sorghum where the mitigation category is low. For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland and terrestrial plants and for animals that depend on wetland and/or terrestrial plants.

**Table 10-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Corn | 29 – 120 | 2.1 – 8.5 | Low | 3.7 – 15 | Medium |
| Cotton | 4.9 – 100 | 0.35 – 7.4 | Low | 0.61 – 13 | Low[5] |
| Sorghum | 28 – 32 | 2.0 – 2.3 | Low | 3.5 – 4.0 | Low |
| Soybean | 25 – 160 | 1.8 – 12 | Low[5] | 3.1 – 20 | Medium |
| Tomato | 12 – 150 | 0.84 – 11 | Low[5] | 1.5 – 19 | Low[5] |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for metolachlor, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.
[5] Based on the ratios and the infrequent exceedances of 10, the mitigation category is set as low. See the subsequent text for further explanations.

**Table 10-15** outlines the level of mitigation (low, medium, high) identified for listed aquatic plants and animals that rely on those plants in larger waterbodies[131]. In some instances, range

[129] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[130] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.
[131] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger. This correlates to aquatic bins 3, 4, 6, 7, 9, and 10 (as discussed in **Section 3.1**). For larger waterbodies, the EECs for EPA farm pond (in µg a.i./L) are compared to the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

of ratios of EEC to toxicity endpoint span nearly an order of magnitude when different application assumptions (*e.g.,* ground vs. aerial applications, different application timings) are modeled and when considering the different, relevant PWC scenarios available[132]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For metolachlor, EPA determined the proposed mitigation categories presented in **Table 10-15** based on the weight of evidence discussed below, which is specifically relevant for use on cotton, soybean, and tomato.

For use on cotton, the ranges of the ratios of the EECs compared to the aquatic plant toxicity endpoints span an order of magnitude. When comparing the EECs to the aquatic nonvascular plant toxicity endpoint, the highest ratios exceed 10 (indicating medium mitigation). However, this only occurred for 2 out of the 16 modeled application scenarios with a maximum ratio of 13, which is nearly equivalent to the threshold of 10. Therefore, EPA set the overall mitigation category as low.

For use on soybean, the ranges of the ratios of the EECs compared to the aquatic plant toxicity endpoints span nearly an order of magnitude. When comparing the EECs to the aquatic vascular plant toxicity endpoint, most of the application scenarios modeled (5 out of 7) resulted in ratios less than 10 (*i.e.,* low mitigation category) with a maximum ratio of 12, which is nearly equivalent to the threshold of 10; therefore, EPA set the overall mitigation category as low.

For use on tomato, the ranges of the ratios of the EECs compared to the aquatic plant toxicity endpoints span an order of magnitude. When comparing the EECs to the aquatic vascular plant toxicity endpoint, nearly all of the application scenarios modeled (17 out of 18) resulted in ratios less than 10 (*i.e.,* low mitigation category) with a maximum ratio of 11; therefore, EPA set the overall mitigation category as low. When comparing the EECs to the aquatic nonvascular plant toxicity endpoint, nearly all of the application scenarios modeled (16 out of 18) resulted in ratios less than 10 (*i.e.,* low mitigation category) with a maximum ratio of 19. Therefore, although the highest two ratios exceed 10, EPA set the mitigation category as low.

[132] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2**.

**Table 10-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category | | Range of Magnitude of Difference[3] | Mitigation Category | Range of Magnitude of Difference[3] | Mitigation Category |
| Corn | 0.38 – 2.3 | 100 – 610 | High | 190 – 1200 | 15 – 84 | Medium | 24 – 150 | Medium[5] |
| Cotton | 0.12 – 1.3 | 31 – 350 | High | 150 – 1700 | 12 – 120 | Medium[5] | 19 – 210 | Medium[5] |
| Sorghum | 0.37 – 0.45 | 100 – 120 | High | 220 – 320 | 16 – 23 | Medium | 28 – 40 | Medium |
| Soybean | 0.22 – 1.3 | 60 – 360 | High | 130 – 510 | 9.5 – 36 | Medium | 17 – 64 | Medium |
| Tomato | 0.22 – 0.78 | 60 – 210 | High | 120 – 1000 | 8.6 – 72 | Medium | 15 – 130 | Medium[5] |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

[5] Based on the ratios and the infrequent exceedances of 100, the mitigation category is set as medium. See the subsequent text for further explanation.

**Table 10-16** outlines the proposed mitigation categories identified for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[133]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications, different application timings) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For metolachlor, EPA determined the proposed mitigation categories presented in **Table 10-16** based on the weight of evidence discussed below, which is specifically relevant for use on corn, cotton, and tomato.

For use on corn, 52 scenarios were modeled. Although the highest ratio of EEC to nonvascular plant toxicity endpoint exceeds 100 (indicating high mitigation category), this only occurred in 7 out of the 52 modeled application scenarios (13%) with a maximum ratio of 150. Therefore, for nonvascular plants and animals that depend on such plants[134], EPA set the overall mitigation category as medium for use on corn.

For use on cotton, the ranges of the ratios of the EECs compared to the aquatic plant toxicity endpoints span an order of magnitude. When comparing the EECs (in µg a.i./L) to the aquatic plant toxicity endpoints, the highest ratio for aquatic vascular and nonvascular plants exceeds100 (indicating high mitigation category). However, this only occurred for 1 out of the 16 modeled application scenarios for vascular plants with a maximum ratio of 120; therefore, EPA set the overall mitigation category as medium. For nonvascular plants, 3 out of 16 modeled scenarios result in ratios that exceed 100 with a maximum ratio of 210. Although the maximum ratio is more than two times the threshold for the high mitigation category, EPA set the overall mitigation category as medium because this maximum ratio only resulted from one modeled scenario in California (CAcotton_WirrigSTD) with the second highest ratio of 120 being much closer to the threshold of 100.

For use on tomato, the ranges of the ratios of the EECs (in µg a.i./L) compared to the aquatic plant toxicity endpoints span about an order of magnitude. Although the highest ratio of EEC to nonvascular plant toxicity endpoint exceeds 100 (indicating high mitigation category), this only occurred in 3 out of the 18 modeled application scenarios with a maximum ratio of 130. Therefore, for nonvascular plants and animals that depend on such plants[135], EPA set the overall mitigation category as medium.

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[133] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[134] All currently listed animals have a generalist relationship to aquatic vascular and nonvascular plants. However, species could be listed in the future that obligately depend on such plants.

[135] All currently listed animals have a generalist relationship to aquatic vascular and nonvascular plants. However, species could be listed in the future that obligately depend on such plants.

**Table 10-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |
| Corn | 0.38 – 2.3 | 5.9 – 35 | Medium |
| Cotton | 0.12 – 1.3 | 1.8 – 21 | Medium |
| Sorghum | 0.37 – 0.45 | 5.8 – 7.0 | Low |
| Soybean | 0.22 – 1.3 | 3.5 – 21 | Medium |
| Tomato | 0.22 – 0.78 | 3.4 – 12 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in Table 10-16.
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 10-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Corn | 0.41 – 1.1 | 110 – 290 | High |
| Cotton | 0.13 – 0.86 | 36 – 230 | High |
| Sorghum | 0.33 – 0.34 | 89 – 91 | Medium |
| Soybean | 0.23 – 0.87 | 63 – 240 | High |
| Tomato | 0.24 – 0.65 | 65 – 180 | High |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 10-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Corn | 0.41 – 1.1 | 6.4 – 17 | Medium |
| Cotton | 0.13 – 0.86 | 2.1 – 13 | Medium |
| Sorghum | 0.33 – 0.34 | 5.1 – 5.3 | Low |

| | | | |
|---|---|---|---|
| Soybean | 0.23 – 0.87 | 3.7 – 14 | Medium |
| Tomato | 0.24 – 0.65 | 3.8 – 10 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, pre-emergence vs. post-emergence applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 10-15** and **Table 10-16**) and wetland plants (**Table 10-16** and **Table 10-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the habitat is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 10-18**) and for generalist animals (**Table 10-19**). **Table 10-20** and **Table 10-21** provide the runoff mitigation points identified for each evaluated use of metolachlor.

**Table 10-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Corn | High (9 pts) | Medium (6 pts) |
| Cotton | High (9 pts) | Medium (6 pts) |
| Sorghum | High (9 pts) | Medium (6 pts) |
| Soybean | High (9 pts) | Medium (6 pts) |
| Tomato | High (9 pts) | Medium (6 pts) |

CH=designated critical habitat
[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.
[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 10-15** and **Table 10-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 10-15** and **Table 10-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 10-15**, **Table 10-16**, and **Table 10-17**).

**Table 10-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |

| | | |
|---|---|---|
| Corn | High (9 pts) | Medium (6 pts) |
| Cotton | High (9 pts) | Medium (6 pts) |
| Sorghum | Medium (6 pts) | Low (1 pt) |
| Soybean | High (9 pts) | Medium (6 pts) |
| Tomato | High (9 pts) | Medium (6 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 10-18**), listed animals that obligately depend on terrestrial plants (**Table 10-18**), and listed animals that generally depend on terrestrial plants (**Table 10-19**).

## 10.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework** document, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for metolachlor are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 10-13**) and one for generalist animals that depend on plants (**Table 10-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are different for these two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For metolachlor, the less restrictive mitigations relevant to generalists animals that are depicted in **Table 10-14** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in Table 10-13 would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For both sets of habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 10-20** and **Table 10-21**).

**Table 10-22** summarizes the points identified for the different metolachlor uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by the four PULAs. PULAs 1

and 2 are grouped because the same mitigations would be applied to monocots and dicots in terrestrial habitats; this is supported by metolachlor's similar toxicity to both monocots and dicots (see **Section 10.3.1**). The same grouping and rational applies for PULAs 3 and 4, which represent monocots and dicots in wetland and aquatic habitats.

**Table 10-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | | Geographically Specific Mitigation Points | |
|---|---|---|---|---|
| | Terrestrial Habitats | Aquatic and Wetland Habitats | PULAs 1,2, 3 and 4 (Terrestrial Habitats)[1] | PULAs 3 and 4 (Aquatic and Wetland Habitats)[1] |
| Corn | 6 | 6 | 9 | 9 |
| Cotton | 6 | 6 | 9 | 9 |
| Sorghum | 1 | 6 | 6 | 9 |
| Soybean | 6 | 6 | 9 | 9 |
| Tomato | 6 | 6 | 9 | 9 |

[1] Many of the listed wetland species that occur in PULAs 3 and 4 also occur in terrestrial habitats. EPA proposes that if mitigations are applicable for terrestrial habitats (PULAs 1 and 2), these mitigations for terrestrial habitats would also apply to areas covered by PULAs 3 and 4. The result would be that PULAs 3 and 4 would have two sets of mitigations—one set for terrestrial habitats and one for the wetland/aquatic habitats. See Section 7.2.2 in the Strategy Framework document for the full explanation of this proposal.

## 10.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 10.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of metolachlor. For major crops (corn, cotton and soybean), the crop-specific UDLs were selected. For sorghum and tomato, EPA selected the grouped UDLs represented by other grains and vegetables and ground fruit (respectively). EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential metolachlor use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 10-12**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5%

overlap with multiple UDLs. **Table 10-23** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected metolachlor UDLs[136] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For metolachlor's UDLs, fewer species (269) and CHs (43) have overlap >5%. An important consideration for the purposes of this example is that EPA did not evaluate all registered uses of metolachlor (see **Section 10.2**), so additional species could be identified in the future for metolachlor. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of metolachlor; however, the PULAs include some species and CHs that have <5% overlap with metolachlor's potential exposure area for the considered uses.

**Table 10-23. The Number of Listed Species and Designated Critical Habitats Identified where there may be Potential for Population-Level Impacts in CONUS for Metolachlor Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Corn | 469 / 142 | 150 | 30 |
| Cotton | | 71 | 13 |
| Other Grains | | 236 | 0 |
| Soybeans | | 88 | 9 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Total across all UDLs above[2] | | 269 | 43 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Corn | 534 / 316 | 317 | 148 |
| Cotton | | 186 | 83 |
| Other Grains | | 145 | 90 |
| Soybeans | | 225 | 92 |
| Vegetables and Ground Fruit | | 166 | 83 |
| Total across all UDLs above[2] | | 375 | 181 |
| Cultivated | | 460 | 225 |

[136] The selected use data layers (UDLs) do not represent every registered use of metolachlor. See **Section 10.2** for more information on the selected uses evaluated in this example.

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for metolachlor. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for metolachlor (excluding the Cultivated UDL, which is summarized below this row).

## 10.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

The ranges of $IC_{25}$ values for plant height from the seedling emergence studies are 0.0297 to 1.09 lb a.i./A (excluding non-definitive endpoints[137]) for monocots and 0.022 to 2.97 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.61 and 0.64 lb a.i./A, respectively. The ranges of $IC_{25}$ values for plant height from the vegetative vigor studies are 0.508 to 5.62 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.00549 to 13.9 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 2.8 and 2.5 lb a.i./A, respectively. For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.0223 to 3.73 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.00546 to 3.33 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.74 and 0.57 lb a.i./A, respectively. Similarly, the ranges of $IC_{25}$ values for dry weight data in the vegetative vigor studies are 0.0497 to 4.09 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.00409 to 2.73 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 1.7 and 0.85 lb a.i./A, respectively.

[137] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 1.2 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 10.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to metolachlor. EPA developed separate SSDs for height and weight.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the metolachlor data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

### Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA made comparison of the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### *Seedling Emergence Height Data*

Goodness of fit:

Results:

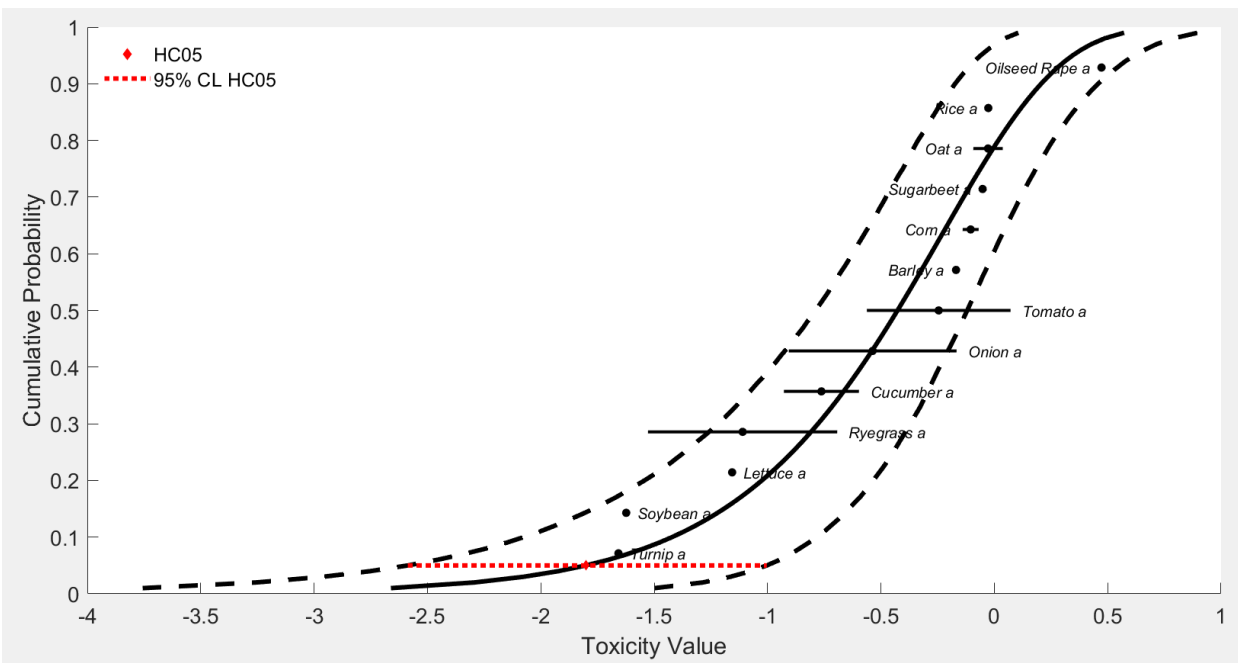
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0253 | 0.0989 |
| 2 | logistic | ML | 0.0242 | 0.0644 |
| 3 | triangular | ML | 0.0297 | 0.2459 |
| 4 | gumbel | ML | 0.0264 | 0.0604 |
| 5 | weibull | ML | 0.0158 | 0.2930 |
| 6 | burr | ML | 0.0119 | 0.2308 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.022833 |
| Model-averaged SE of HCp: | 0.016515 |
| CV of HCp: | 0.7233 |

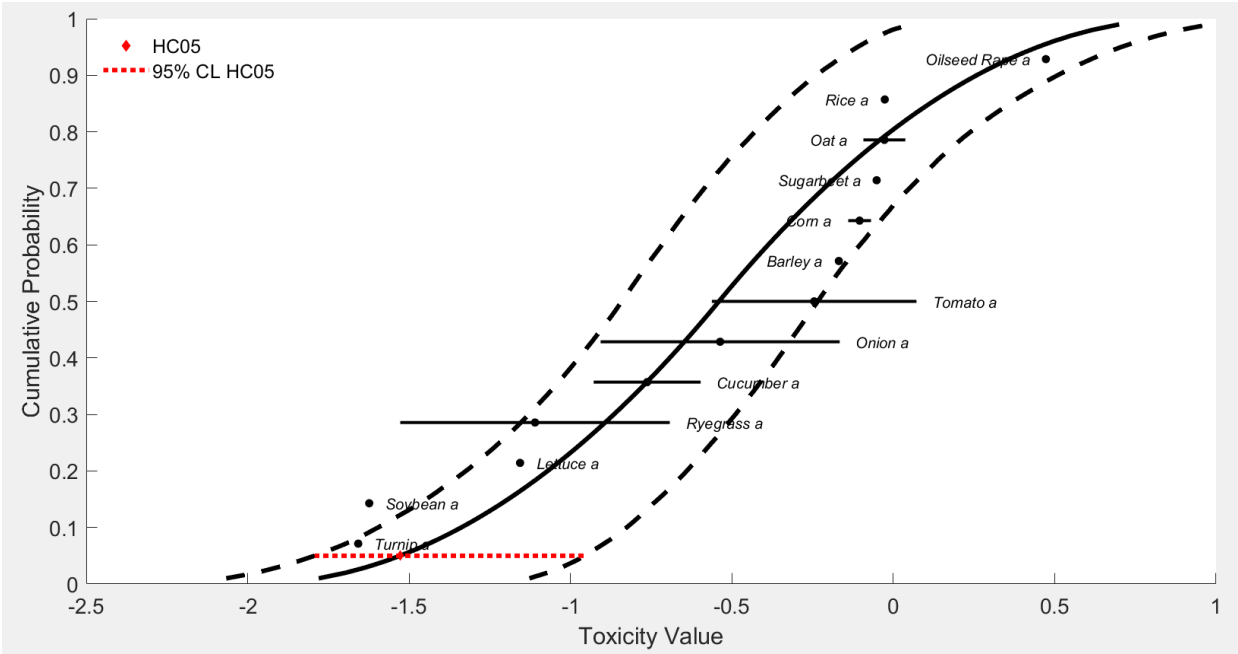
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | weibull | 19.0599 | 0 | 0.3068 | 0.0158 | 0.0153 |
| 2 | triangular | 19.1878 | 0.1280 | 0.2878 | 0.0297 | 0.0138 |
| 3 | normal | 20.0895 | 1.0296 | 0.1834 | 0.0253 | 0.0160 |
| 4 | logistic | 21.0055 | 1.9456 | 0.1160 | 0.0242 | 0.0186 |
| 5 | burr | 22.4622 | 3.4023 | 0.0560 | 0.0119 | 0.0165 |
| 6 | gumbel | 22.6886 | 3.6287 | 0.0500 | 0.0264 | 0.0119 |

Based on the goodness of fit, EPA moved forward with Weibull and triangular distributions, and ultimately selected the Weibull distribution for the height data from the seedling emergence toxicity tests.




**Weibull (selected distribution)**




Triangular

## *Seedling Emergence Dry Weight Data*

Goodness of fit:

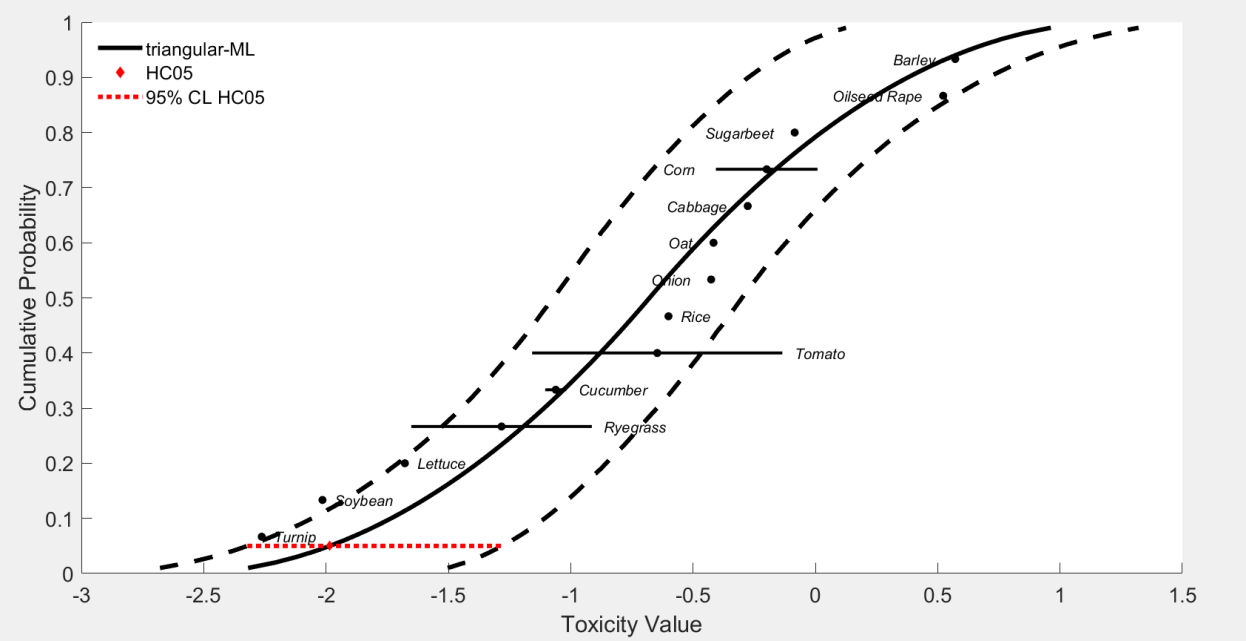
Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0085 | 0.4812 |
| 2 | logistic | ML | 0.0082 | 0.4288 |
| 3 | triangular | ML | 0.0104 | 0.7632 |
| 4 | gumbel | ML | 0.0090 | 0.1635 |
| 5 | weibull | ML | 0.0037 | 0.8316 |
| 6 | burr | ML | 0.0046 | 0.6683 |

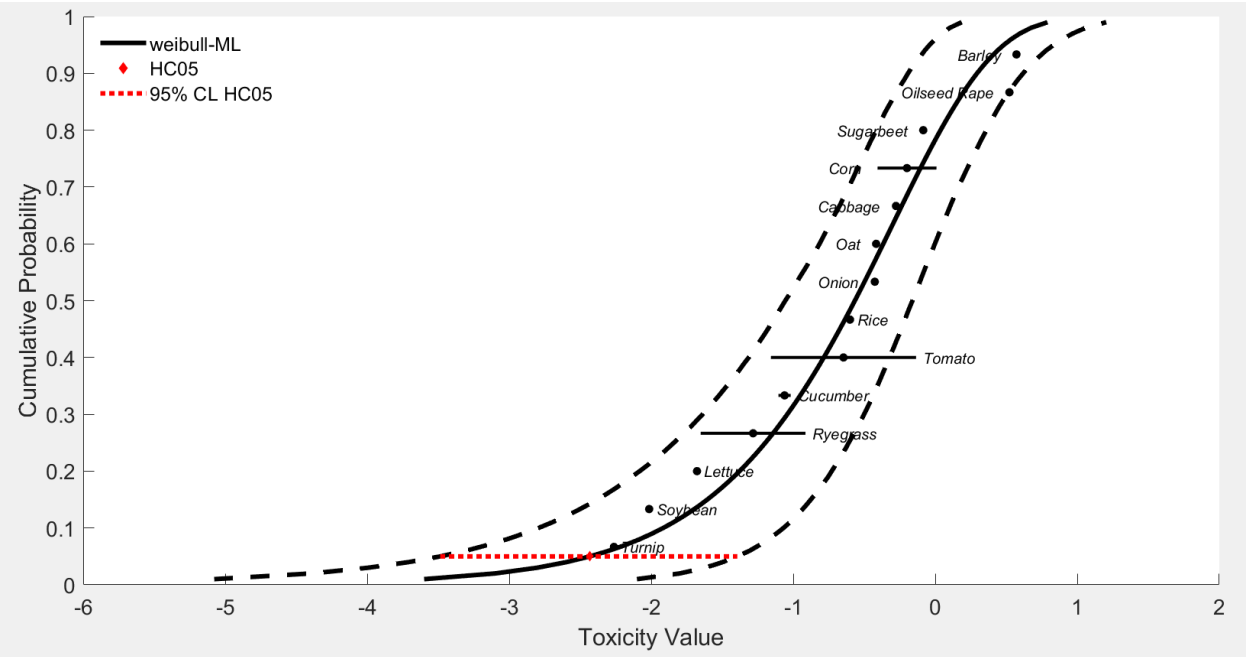
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 16.4162 | 0 | 0.3589 | 0.0104 | 0.0056 |
| 2 | weibull | 17.3674 | 0.9512 | 0.2231 | 0.0037 | 0.0046 |
| 3 | normal | 17.6379 | 1.2217 | 0.1948 | 0.0085 | 0.0067 |
| 4 | logistic | 18.3491 | 1.9328 | 0.1365 | 0.0082 | 0.0076 |
| 5 | gumbel | 20.3161 | 3.8999 | 0.0511 | 0.0090 | 0.0051 |
| 6 | burr | 21.0396 | 4.6234 | 0.0356 | 0.0046 | 0.0072 |

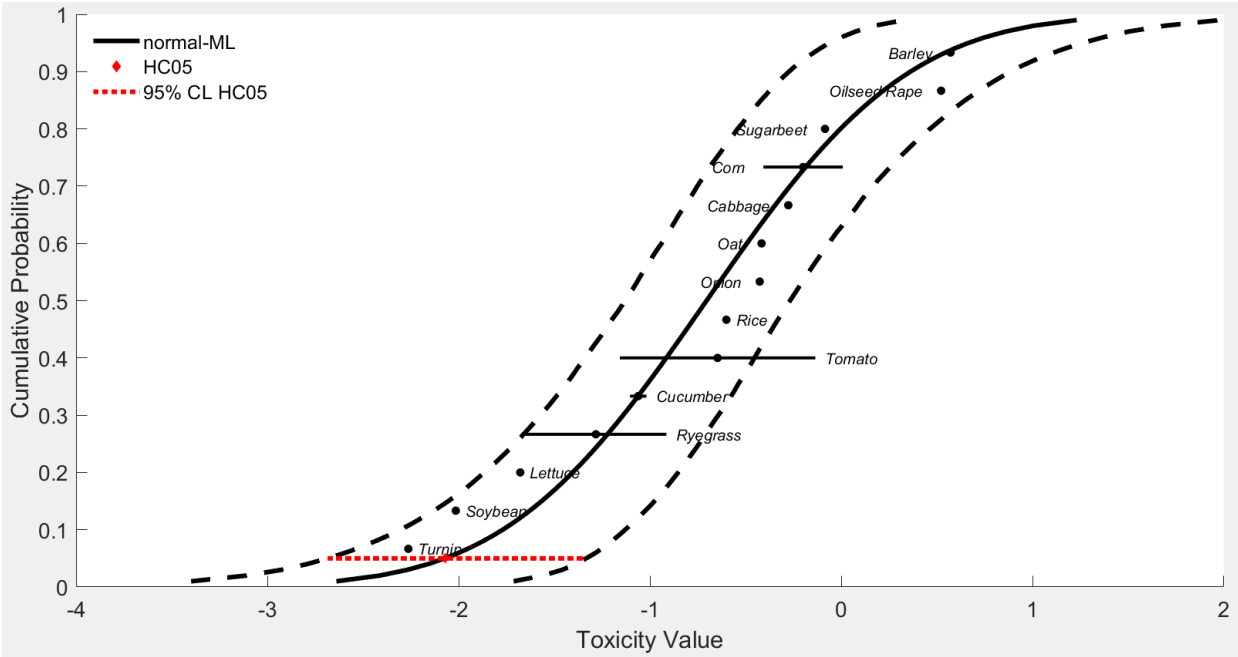
Based on the goodness of fit, EPA moved forward with triangular, Weibull, and normal distributions, and ultimately selected the Weibull distribution for the dry weight data from the seedling emergence toxicity tests.




Triangular




**Weibull (selected distribution)**




Normal

### *Vegetative Vigor Height Data*

Goodness of fit:

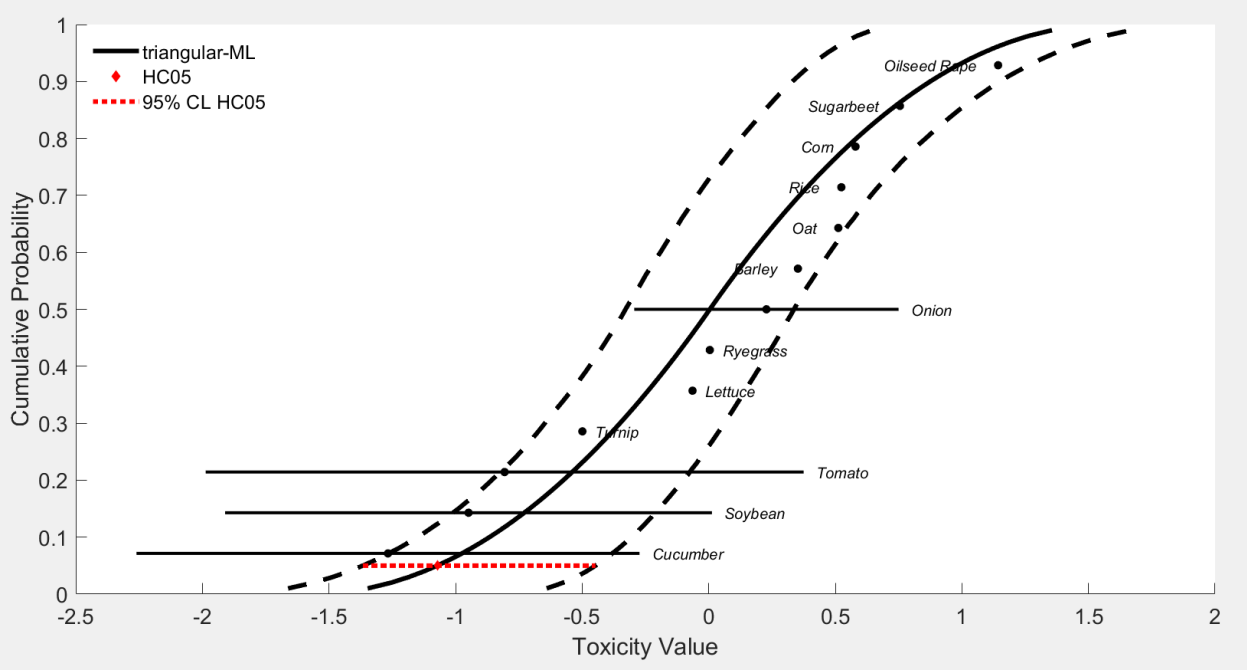
Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0782 | 0.3253 |
| 2 | logistic | ML | 0.0749 | 0.3089 |
| 3 | triangular | ML | 0.0847 | 0.4107 |
| 4 | gumbel | ML | 0.0820 | 0.1397 |
| 5 | weibull | ML | 0.0445 | 0.8283 |
| 6 | burr | ML | 0.0345 | 0.7329 |

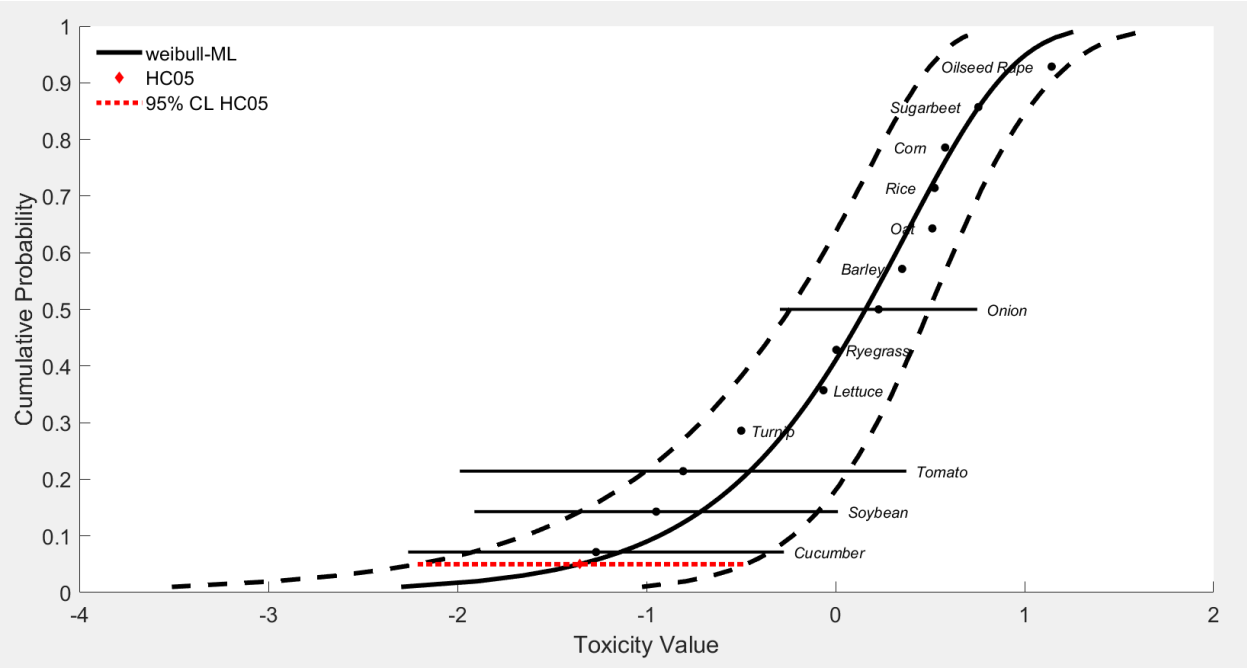
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 55.6676 | 0 | 0.3202 | 0.0847 | 0.0323 |
| 2 | weibull | 55.9538 | 0.2862 | 0.2775 | 0.0445 | 0.0470 |
| 3 | normal | 56.7496 | 1.0820 | 0.1864 | 0.0782 | 0.0531 |
| 4 | logistic | 57.5964 | 1.9288 | 0.1220 | 0.0749 | 0.0617 |
| 5 | gumbel | 59.3249 | 3.6573 | 0.0514 | 0.0820 | 0.0402 |
| 6 | burr | 59.7049 | 4.0373 | 0.0425 | 0.0345 | 0.0532 |

Based on the goodness of fit, EPA moved forward with Weibull and triangular distributions, and ultimately selected the Weibull distribution for the height data from the vegetative vigor toxicity tests.




Triangular




**Weibull (selected distribution)**

### *Vegetative Vigor Dry Weight Data*

Goodness of fit:

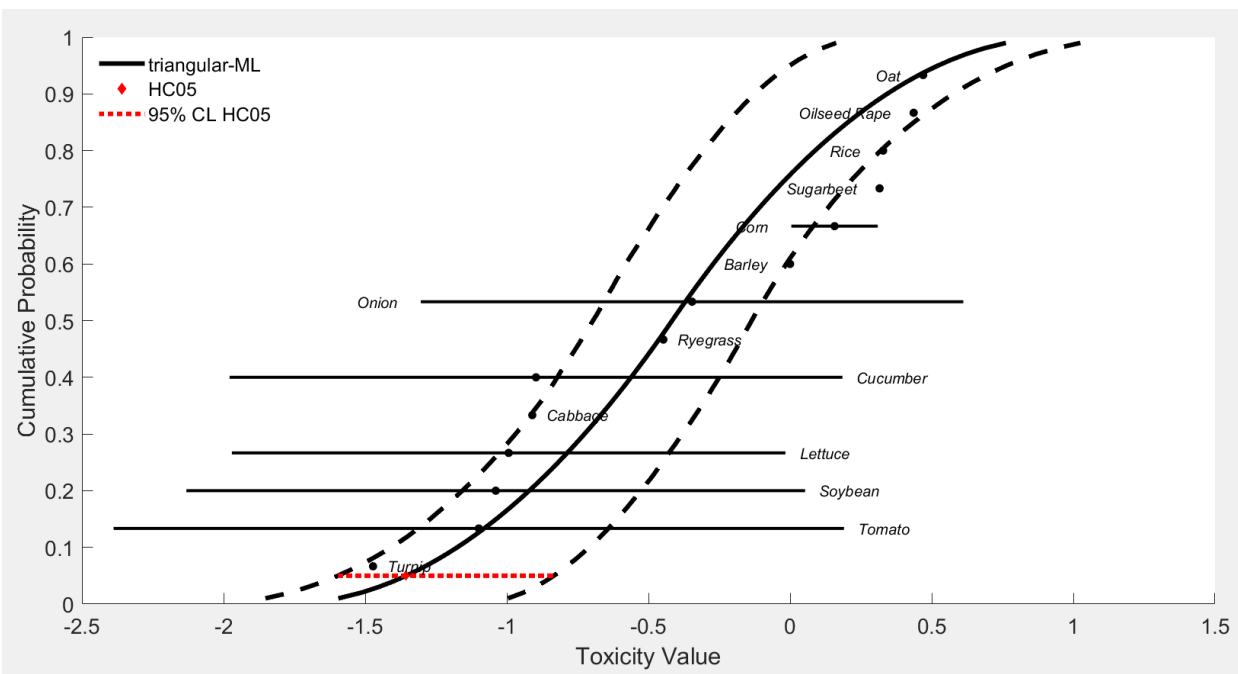
Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0348 | 0.0583 |
| 2 | logistic | ML | 0.0263 | 0.0292 |
| 3 | triangular | ML | 0.0441 | 0.0821 |
| 4 | gumbel | ML | 0.0443 | 0.1044 |
| 5 | weibull | ML | 0.0184 | 0.0457 |
| 6 | burr | ML | 0.0431 | 0.0413 |

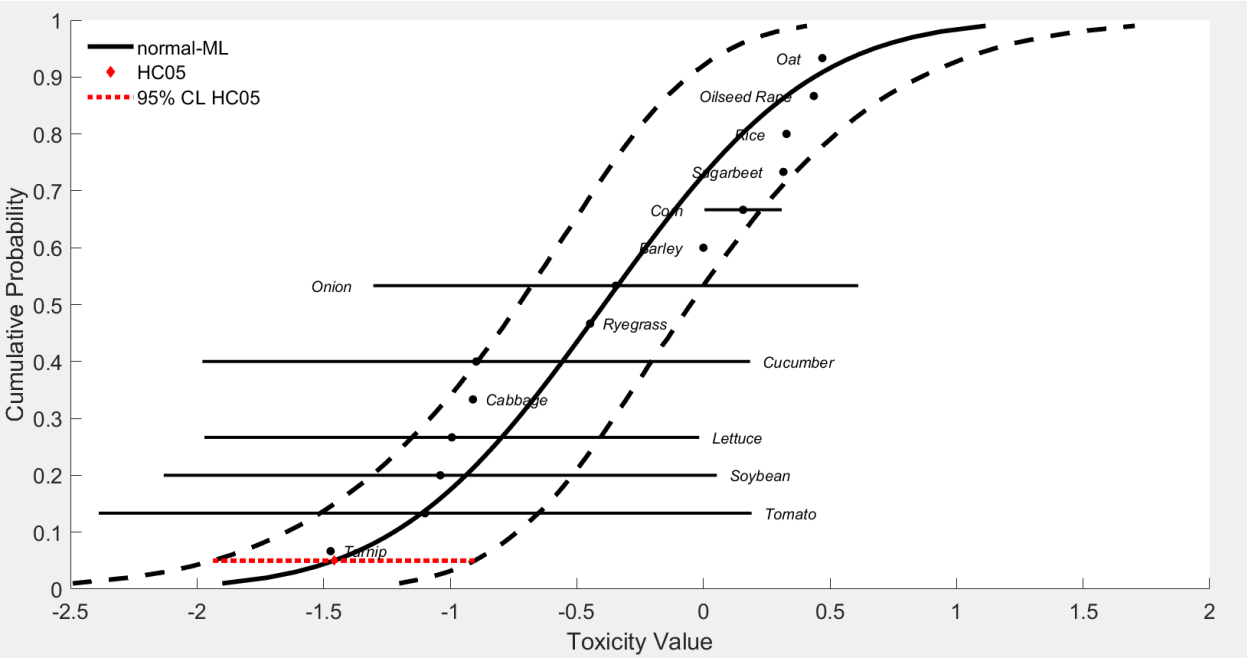
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 29.4205 | 0 | 0.3775 | 0.0441 | 0.0223 |
| 2 | normal | 30.7141 | 1.2936 | 0.1977 | 0.0348 | 0.0213 |
| 3 | weibull | 30.8972 | 1.4767 | 0.1804 | 0.0184 | 0.0184 |
| 4 | gumbel | 31.5139 | 2.0933 | 0.1325 | 0.0443 | 0.0178 |
| 5 | logistic | 32.3385 | 2.9180 | 0.0878 | 0.0263 | 0.0192 |
| 6 | burr | 34.9227 | 5.5022 | 0.0241 | 0.0431 | 0.0000 + ... |

Based on the goodness of fit, EPA moved forward with triangular and normal distributions, and ultimately selected the normal distribution for the dry weight data from the vegetative vigor toxicity tests.




Triangular




**Normal (selected distribution)**

## 10.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 10-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.67 lb a.i./A (maximum application rate for use on corn)** | | | | | | | |
| Distance to Medium MoE (ft)[2,3] | 175 | 125 | 75 | 50 | 20 | 10 | 5 |
| **Application Rate of 1.9 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE (ft)[2,3] | 125 | 100 | 50 | 50 | 10 | 5 | 5 |
| **Application Rate of 1.2 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE (ft)[2,3] | 100 | 50 | 50 | 20 | 10 | 5 | <5 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 8.0 µg a.i./L for green algae, *Selenastrum capricornutum* (MRID 43928929). None of the magnitude of difference values for aquatic plants exceed 10 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For metolachlor, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 10. This is explained further in **Section 10.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than an order of magnitude (*i.e.,* >10). When the MoE is medium or greater at the maximum buffer distance, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

**Table 10-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 2.67 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 360.8 | 360.7 | 360.7 | 761.5 | 735.6 | 730.9 | 727.3 | 343.7 |
| 10 | 242.8 | 218.1 | 200.1 | 189.4 | 67.5 | 33.5 | 20.1 | 166.3 |
| 20 | 180.4 | 144.7 | 124.0 | 95.5 | 32.0 | 18.0 | 10.9 | 93.7 |
| 25 | 154.3 | 117.4 | 97.2 | 70.3 | 23.7 | 14.3 | 8.7 | 67.7 |
| 50 | 121.1 | 78.0 | 51.5 | 34.2 | 12.1 | 8.3 | 5.1 | 24.6 |
| 75 | 85.0 | 52.7 | 34.0 | 22.7 | 8.4 | 6.1 | 3.8 | 11.8 |
| 100 | 71.8 | 42.0 | 26.6 | 18.2 | 6.9 | 5.1 | 3.2 | 7.6 |
| 125 | 53.6 | 31.0 | 19.8 | 14.3 | 5.6 | 4.2 | 2.7 | 4.7 |
| 150 | 45.0 | 24.7 | 15.5 | 11.8 | 4.8 | 3.6 | 2.4 | 3.1 |
| 175 | 37.5 | 20.6 | 12.6 | 9.9 | 4.1 | 3.2 | 2.1 | 2.2 |
| 200 | 33.4 | 18.0 | 10.9 | 8.8 | 3.7 | 2.9 | 1.9 | 1.7 |
| 225 | 30.3 | 15.4 | 9.1 | 7.6 | 3.3 | 2.6 | 1.7 | 1.3 |
| 250 | 26.5 | 13.3 | 7.9 | 6.8 | 3.0 | 2.4 | 1.6 | 1.0 |
| 275 | 24.1 | 11.7 | 7.0 | 6.0 | 2.7 | 2.2 | 1.5 | 0.8 |
| 300 | 21.9 | 10.5 | 6.3 | 5.4 | 2.5 | 2.0 | 1.4 | 0.7 |
| 325 | 20.1 | 9.5 | 5.8 | 4.9 | 2.3 | 1.8 | 1.3 | 0.5 |
| 350 | 18.9 | 8.9 | 5.4 | 4.5 | 2.2 | 1.7 | 1.2 | 0.5 |
| 375 | 17.5 | 8.2 | 5.1 | 4.1 | 2.0 | 1.6 | 1.1 | 0.4 |
| 400 | 16.4 | 7.6 | 4.7 | 3.8 | 1.9 | 1.5 | 1.1 | 0.3 |
| 500 | 13.5 | 6.3 | 3.8 | 2.1 | 0.8 | 0.6 | 0.4 | 0.2 |
| 600 | 11.7 | 5.4 | 3.2 | 1.5 | 0.6 | 0.5 | 0.4 | 0.1 |
| 700 | 10.5 | 4.8 | 2.9 | 1.2 | 0.5 | 0.4 | 0.3 | 0.1 |
| 800 | 9.6 | 4.4 | 2.6 | 0.9 | 0.5 | 0.4 | 0.3 | 0.1 |
| 900 | 9.0 | 4.1 | 2.4 | 0.8 | 0.4 | 0.3 | 0.2 | <0.1 |
| 1000 | 8.5 | 3.9 | 2.3 | 0.6 | 0.4 | 0.3 | 0.2 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0037 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 10-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 2.67 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 20.9 | 20.9 | 20.9 | 44.0 | 42.5 | 42.3 | 42.0 | 19.9 |
| 10 | 14.0 | 12.6 | 11.6 | 11.0 | 3.9 | 1.9 | 1.2 | 9.6 |
| 20 | 10.4 | 8.4 | 7.2 | 5.5 | 1.8 | 1.0 | 0.6 | 5.4 |
| 25 | 8.9 | 6.8 | 5.6 | 4.1 | 1.4 | 0.8 | 0.5 | 3.9 |
| 50 | 7.0 | 4.5 | 3.0 | 2.0 | 0.7 | 0.5 | 0.3 | 1.4 |
| 75 | 4.9 | 3.0 | 2.0 | 1.3 | 0.5 | 0.4 | 0.2 | 0.7 |
| 100 | 4.2 | 2.4 | 1.5 | 1.1 | 0.4 | 0.3 | 0.2 | 0.4 |
| 125 | 3.1 | 1.8 | 1.1 | 0.8 | 0.3 | 0.2 | 0.2 | 0.3 |
| 150 | 2.6 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.2 | 1.2 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.7 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.2 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.064 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 10-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.9 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 256.7 | 256.7 | 256.7 | 541.9 | 523.4 | 520.1 | 517.6 | 244.6 |
| 10 | 172.8 | 155.2 | 142.4 | 134.8 | 48.0 | 23.8 | 14.3 | 118.4 |
| 20 | 128.4 | 102.9 | 88.2 | 68.0 | 22.7 | 12.8 | 7.8 | 66.7 |
| 25 | 109.8 | 83.5 | 69.2 | 50.0 | 16.9 | 10.2 | 6.2 | 48.2 |
| 50 | 86.2 | 55.5 | 36.7 | 24.3 | 8.6 | 5.9 | 3.6 | 17.5 |
| 75 | 60.5 | 37.5 | 24.2 | 16.2 | 6.0 | 4.3 | 2.7 | 8.4 |
| 100 | 51.1 | 29.9 | 18.9 | 12.9 | 4.9 | 3.6 | 2.3 | 5.4 |
| 125 | 38.1 | 22.0 | 14.1 | 10.2 | 4.0 | 3.0 | 1.9 | 3.3 |
| 150 | 32.0 | 17.6 | 11.0 | 8.4 | 3.4 | 2.6 | 1.7 | 2.2 |
| 175 | 26.7 | 14.7 | 9.0 | 7.0 | 2.9 | 2.3 | 1.5 | 1.6 |
| 200 | 23.7 | 12.8 | 7.7 | 6.3 | 2.7 | 2.1 | 1.4 | 1.2 |
| 225 | 21.5 | 11.0 | 6.5 | 5.4 | 2.4 | 1.9 | 1.2 | 0.9 |
| 250 | 18.9 | 9.5 | 5.6 | 4.8 | 2.1 | 1.7 | 1.1 | 0.7 |
| 275 | 17.2 | 8.3 | 5.0 | 4.3 | 1.9 | 1.5 | 1.0 | 0.6 |
| 300 | 15.6 | 7.4 | 4.5 | 3.8 | 1.8 | 1.4 | 1.0 | 0.5 |
| 325 | 14.3 | 6.8 | 4.1 | 3.5 | 1.6 | 1.3 | 0.9 | 0.4 |
| 350 | 13.4 | 6.3 | 3.9 | 3.2 | 1.6 | 1.2 | 0.9 | 0.3 |
| 375 | 12.5 | 5.8 | 3.6 | 2.9 | 1.4 | 1.2 | 0.8 | 0.3 |
| 400 | 11.6 | 5.4 | 3.4 | 2.7 | 1.4 | 1.1 | 0.8 | 0.2 |
| 500 | 9.6 | 4.4 | 2.7 | 1.5 | 0.5 | 0.5 | 0.3 | 0.1 |
| 600 | 8.3 | 3.8 | 2.3 | 1.1 | 0.4 | 0.4 | 0.3 | 0.1 |
| 700 | 7.4 | 3.4 | 2.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 800 | 6.9 | 3.1 | 1.8 | 0.7 | 0.3 | 0.3 | 0.2 | <0.1 |
| 900 | 6.4 | 2.9 | 1.7 | 0.5 | 0.3 | 0.2 | 0.2 | <0.1 |
| 1000 | 6.1 | 2.8 | 1.6 | 0.4 | 0.3 | 0.2 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0037 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 10-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.9 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 14.8 | 14.8 | 14.8 | 31.3 | 30.3 | 30.1 | 29.9 | 14.1 |
| 10 | 10.0 | 9.0 | 8.2 | 7.8 | 2.8 | 1.4 | 0.8 | 6.8 |
| 20 | 7.4 | 6.0 | 5.1 | 3.9 | 1.3 | 0.7 | 0.4 | 3.9 |
| 25 | 6.3 | 4.8 | 4.0 | 2.9 | 1.0 | 0.6 | 0.4 | 2.8 |
| 50 | 5.0 | 3.2 | 2.1 | 1.4 | 0.5 | 0.3 | 0.2 | 1.0 |
| 75 | 3.5 | 2.2 | 1.4 | 0.9 | 0.3 | 0.2 | 0.2 | 0.5 |
| 100 | 3.0 | 1.7 | 1.1 | 0.7 | 0.3 | 0.2 | 0.1 | 0.3 |
| 125 | 2.2 | 1.3 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 150 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 |
| 175 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 200 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 250 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 |
| 275 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 |
| 300 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 |
| 325 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 |
| 350 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| 375 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| 400 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| 500 | 0.6 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 600 | 0.5 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 700 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 800 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 900 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1000 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.064 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 10-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.2 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 162.2 | 162.1 | 162.1 | 342.2 | 330.6 | 328.5 | 326.9 | 154.5 |
| 10 | 109.1 | 98.0 | 89.9 | 85.1 | 30.3 | 15.0 | 9.0 | 74.8 |
| 20 | 81.1 | 65.0 | 55.7 | 42.9 | 14.4 | 8.1 | 4.9 | 42.1 |
| 25 | 69.3 | 52.7 | 43.7 | 31.6 | 10.7 | 6.4 | 3.9 | 30.4 |
| 50 | 54.4 | 35.1 | 23.2 | 15.4 | 5.4 | 3.7 | 2.3 | 11.1 |
| 75 | 38.2 | 23.7 | 15.3 | 10.2 | 3.8 | 2.7 | 1.7 | 5.3 |
| 100 | 32.3 | 18.9 | 12.0 | 8.2 | 3.1 | 2.3 | 1.5 | 3.4 |
| 125 | 24.1 | 13.9 | 8.9 | 6.4 | 2.5 | 1.9 | 1.2 | 2.1 |
| 150 | 20.2 | 11.1 | 7.0 | 5.3 | 2.1 | 1.6 | 1.1 | 1.4 |
| 175 | 16.9 | 9.3 | 5.7 | 4.4 | 1.9 | 1.4 | 0.9 | 1.0 |
| 200 | 15.0 | 8.1 | 4.9 | 4.0 | 1.7 | 1.3 | 0.9 | 0.8 |
| 225 | 13.6 | 6.9 | 4.1 | 3.4 | 1.5 | 1.2 | 0.8 | 0.6 |
| 250 | 11.9 | 6.0 | 3.6 | 3.0 | 1.4 | 1.1 | 0.7 | 0.5 |
| 275 | 10.9 | 5.3 | 3.1 | 2.7 | 1.2 | 1.0 | 0.7 | 0.4 |
| 300 | 9.8 | 4.7 | 2.8 | 2.4 | 1.1 | 0.9 | 0.6 | 0.3 |
| 325 | 9.0 | 4.3 | 2.6 | 2.2 | 1.0 | 0.8 | 0.6 | 0.2 |
| 350 | 8.5 | 4.0 | 2.4 | 2.0 | 1.0 | 0.8 | 0.5 | 0.2 |
| 375 | 7.9 | 3.7 | 2.3 | 1.9 | 0.9 | 0.7 | 0.5 | 0.2 |
| 400 | 7.4 | 3.4 | 2.1 | 1.7 | 0.9 | 0.7 | 0.5 | 0.2 |
| 500 | 6.1 | 2.8 | 1.7 | 0.9 | 0.3 | 0.3 | 0.2 | 0.1 |
| 600 | 5.2 | 2.4 | 1.5 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 700 | 4.7 | 2.2 | 1.3 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 800 | 4.3 | 2.0 | 1.2 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 900 | 4.1 | 1.8 | 1.1 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 1000 | 3.8 | 1.7 | 1.0 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0037 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 10-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.2 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 9.4 | 9.4 | 9.4 | 19.8 | 19.1 | 19.0 | 18.9 | 8.9 |
| 10 | 6.3 | 5.7 | 5.2 | 4.9 | 1.8 | 0.9 | 0.5 | 4.3 |
| 20 | 4.7 | 3.8 | 3.2 | 2.5 | 0.8 | 0.5 | 0.3 | 2.4 |
| 25 | 4.0 | 3.0 | 2.5 | 1.8 | 0.6 | 0.4 | 0.2 | 1.8 |
| 50 | 3.1 | 2.0 | 1.3 | 0.9 | 0.3 | 0.2 | 0.1 | 0.6 |
| 75 | 2.2 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 100 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.4 | 0.8 | 0.5 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 |
| 150 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 225 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.064 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 11 Metribuzin Case Study Example (PC Code 101101)

## 11.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 11.2 Use Information

Metribuzin is a pre-emergent and post-emergent herbicide with selective activity on certain grasses and broadleaf weeds. It is a triazinone that inhibits electron transport in photosynthesis via photosystem II. Triazinones are very closely related to triazines and are thought to have very similar modes of action. Triazinones and triazines bind to D-1 proteins forming free radicals that destroy chloroplasts and associated plant tissue.

Metribuzin end-use products are formulated as emulsifiable concentrates, flowable concentrates, wettable powders, water soluble packaging, and water dispersible granules. Application methods for metribuzin include ground spray, aerial spray, and chemigation. The application rate varies with the formulation used, stage of weed growth, and application timing. Metribuzin is currently registered on crop and non-crop areas including alfalfa, asparagus, carrots, Christmas trees, corn, crops grown for oil, lentils, peas, ornamental lawns and turf, rights-of-ways, industrial and recreational areas, crops grown for seed, potatoes, soybeans,

sugarcane, tomatoes, wheat, and barley. Per the 2017 Draft Risk Assessment for Registration Review (DP432009), typical label restrictions include: applying large droplet sizes and reducing boom length.

**Table 11-1** includes the use information from the 2017 Draft Risk Assessment (DRA; DP432009) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for metribuzin, changes to the registered labels and uses since this DRA are not considered at this time but would be considered when EPA conducts assessments for metribuzin for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2020 assessment. **Table 11-1** also identifies the Use Data Layer (UDL) that EPA assigned to each for the purposes of conducting GIS analyses such as those discussed in Section 11.6. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on field corn is the Corn UDL and the UDL for use on sugarcane is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5**.

EPA estimated exposures using the selected[138] uses and application information provided in **Table 11-1**. The selected uses do not necessarily represent all registered uses of metribuzin and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where metribuzin usage is most common. These selected uses are examples to illustrate the draft Herbicide Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Herbicide Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of metribuzin as this application method represents the greatest source of potential offsite movement. Although granular formulations of metribuzin are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

**Table 11-1. Summary of the Selected Agricultural Use Patterns Labeled for Metribuzin (2017 Draft Risk Assessment for Registration Review, DP432009)[1]**

[138] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2017 Draft Risk Assessment for Registration Review (DP432009) for metribuzin. Any uses not evaluated in the 2017 assessment and any new uses since this assessment are not included in this example case study for the Herbicide Strategy.

| Use Site/Location | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d)[2] |
|---|---|---|---|---|---|---|
| **Alfalfa Use Data Layer** | | | | | | |
| Alfalfa/Sainfoin[3] | A, G | Dormant, Establish planting | 1 | 1 | 1 | N/A |
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | |
| Asparagus | G | Pre-emergence | 2 | 1 | 2 | N/A |
| Carrot | G | Post-emergence, Spring | 0.25 | NS (2) | 0.50 | 21 |
| Lentils/peas, garbanzo | A, G | Pre-emergence, Post-emergence | 0.375 | NS (2) | 0.5 | NS (7) |
| Potato | A, G | Pre-emergence, Post-emergence | 1 | 1 | 1 | N/A |
| Tomato | G | Post-emergence, Pre-plant | 1 | 1 | 1 | N/A |
| **Corn Use Data Layer** | | | | | | |
| Corn (field) | A, G | Pre-plant (Fall/Spring), Pre-emergence, Post-emergence | 0.37 | NS (2) | 0.56 | NS (7) |
| **Soybeans Use Data Layer** | | | | | | |
| Soybeans | A, G | Pre-emergence, Pre-plant, when needed | 1 | 1 | 1 | N/A |
| **Other Grains Use Data Layer** | | | | | | |
| Crops grown for oil | A, G | Dormant, Post-harvest, Post-transplant, Pre-plant | 0.56 | 1 | 0.56 | N/A |
| Sugarcane | A, G | Pre-emergence, Early post-emergence | 3 | NS (3) | 8 | NS (7) |
| Barley | A, G | Post-harvest, Post-emergence | 0.75 | 1 | 0.75 | NS (7) |
| **Wheat Use Data Layer** | | | | | | |
| Wheat | A, G | Post-harvest, Post-emergence | 0.75 | 1 | 0.75 | NS (7) |

App=application; equip=equipment; MRI = Minimum retreatment interval; A=aerial; G=ground; ai=active ingredient; d=day; N/A = not applicable; NS=not specified on the label; () Values in parenthesis were calculated based on other information provided on the label. These values are not on the label.

[1] The use information presented in this table is identical to the agricultural uses included in the 2017 Draft Risk Assessment for Registration Review (DP432009).

[2] The majority of the end-use product labels do not specify a minimum retreatment interval; thus, EPA assumed a conservative minimum retreatment interval of 7 days with the exception of carrots, for which EPA assumed a minimum retreatment interval of 21 days due to specifications provided on the label.

[3] Sainfoin is grown as a hay/forage crop, corresponding to the Pasture Use Data Layer, which is not considered an agricultural use nor included in the draft Strategy at this time.

## 11.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of metribuzin (**Section 11.3.1**), reported incidents (**Section 11.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 11.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 11.3.1 Toxicity Information

**Table 11-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for metribuzin.

**Table 11-2. Summary of the Most Sensitive Toxicity Endpoints for Metribuzin (As Summarized in the 2017 Draft Risk Assessment for Registration Review, DP432009)**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Ryegrass (*Lolium perenne*) | $EC_{05}$ = 0.002 lb a.i./A[2]<br>$EC_{25}$ = 0.011 lb a.i./A | 49006503 Supplemental | Test with Metribuzin SC 600 g/L (Sencor SC600®, 52% a.i. metribuzin); based on effects on survival. |
| | Dicot: Sugar beet (*Beta vulgaris*) | NOAEC = 0.007 lb a.i./A<br>$EC_{25}$ = 0.010 lb a.i./A | | |
| Vegetative Vigor | Monocot: Onion (*Allium cepa*) | NOAEC = 0.011 lb a.i./A<br>$IC_{25}$ = 0.017 lb a.i./A | 42447803 Acceptable | Test with TGAI; based on effects on biomass. |
| | Dicot: Sugar beet (*Beta vulgaris*) | NOAEC = 0.0001 lb a.i./A[3]<br>$IC_{25}$ = 0.002 lb a.i./A[3] | 49006502 Supplemental | Test with Metribuzin SC 600 g/L (Sencor SC600®, 52% a.i. metribuzin); based on effects on biomass. |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 0.226 µg a.i./L<br>**$IC_{50}$ = 17.8 µg a.i./L** | 49006501 Supplemental | Test with TGAI; Most sensitive endpoint based on the $IC_{50}$ was yield based on frond density with 25% reduction at the LOAEC (0.547 µg a.i./L) |
| Aquatic Nonvascular Plant | Green alga (*Pseudokirchneriella subcapitata*) | NOAEC = 2.3 µg a.i./L<br>**$IC_{50}$ = 7.9 µg a.i./L** | 43921001 Acceptable | Test with TGAI; Based on cell density, reduced 22% at the LOAEC (4.69 µg a.i./L) |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $EC_{05}$/$EC_{25}$=Concentration resulting in a 5 or 25% effect on survival; $IC_{25}$/$_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the metribuzin seedling emergence and vegetative vigor tests. See Figure 11-1 and Figure 11-2 these SSD results.

[2] The $EC_{25}$ is less than the NOAEC (0.015 lb a.i./A), so EPA used the $EC_{05}$ instead of the NOAEC in the 2017 assessment.

[3] Endpoints and/or confidence intervals are outside the tested range of concentrations and should be interpreted cautiously.

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). Additionally, EPA generated an SSD for the seedling emergence survival data. See **Section 11.7** for the data used to generate the SSDs and **Section 11.8** for the process for calculating the SSDs. Because the height data were too few from the vegetative vigor

studies, EPA did not generate an SSD for this endpoint. In total, EPA calculated four SSDs for metribuzin by combining the results for tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to metribuzin. Specifically, as summarized in **Section 11.7**, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) and survival toxicity endpoints (*i.e.,* the concentration resulting in 25% effect in plant survival ($EC_{25}$ values)) overlap for monocot and dicot survival, height, and weight data from the seedling emergence and vegetative vigor (weight data only) studies when considering all definitive values available. The mean and median $IC_{25}$ values for monocot and dicot height data are essentially equivalent based on the seedling emergence and vegetative vigor studies. For dry weight, the mean and median $IC_{25}$ values for monocots and dicots only differ by a factor of 2. Similarly, the mean and median $EC_{25}$ values for monocot and dicot survival in the seedling emergence studies are essentially equal. Therefore, EPA did not create separate SSDs for monocots and dicots as their sensitivities to metribuzin do not differ.

**Figure 11-1** shows the four SSDs that EPA generated for metribuzin. Although the SSD for weight in the vegetative vigor study generated the most sensitive 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values, EPA selected the SSD based on the seedling emergence survival data to compare to the EECs for metribuzin. As shown in **Figure 11-2,** the 5$^{th}$ and 25$^{th}$ percentile EC/$IC_{25}$ values for seedling emergence survival and vegetative vigor weight are generally within the other SSD's confidence intervals (confidence intervals shown with dashed lines in **Figure 11-2**), indicating that the 5$^{th}$ and 25$^{th}$ percentile EC/$IC_{25}$ values do not differ between these two endpoints when considering the variability in the empirical toxicity data. Additionally, EPA determined that effects on plant survival are a more severe adverse impact to individual plants and plant populations than effects on plant weight. Therefore, EPA used the 5$^{th}$ and 25$^{th}$ percentile $EC_{25}$ values from the seedling emergence survival SSD (represented as red and black dots in **Figure 11-2** respectively) to calculate the magnitude of difference between the EEC and toxicity endpoints (**Table 11-3** and **Table 11-4**; see **Section 11.3.3**). By combining the monocot and dicot data, these 5$^{th}$ and 25$^{th}$ percentile values represent the sensitivities of both types of flowering plants to metribuzin.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[139] are available to evaluate potential impacts of metribuzin on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 11-2** and **Table 11-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[140].

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[139] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[140] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

**Table 11-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Metribuzin**

| Percentile (x) | Seedling Emergence Test | | | Vegetative Vigor Test |
|---|---|---|---|---|
| | **Survival: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** |
| 5 | **0.0063** (0.0036 – 0.013) | 0.013 (0.010 – 0.020) | 0.0096 (0.0072 – 0.015) | 0.0026 (0.0011 – 0.0073) |
| 25 | **0.013** (0.0085 – 0.021) | 0.019 (0.015 – 0.028) | 0.015 (0.012 – 0.022) | 0.0085 (0.0045 – 0.019) |
| 50 | 0.021 (0.014 – 0.032) | 0.027 (0.019 – 0.039) | 0.023 (0.017 – 0.035) | 0.019 (0.010 – 0.036) |

**Bolded** values indicate the selected toxicity endpoints that EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

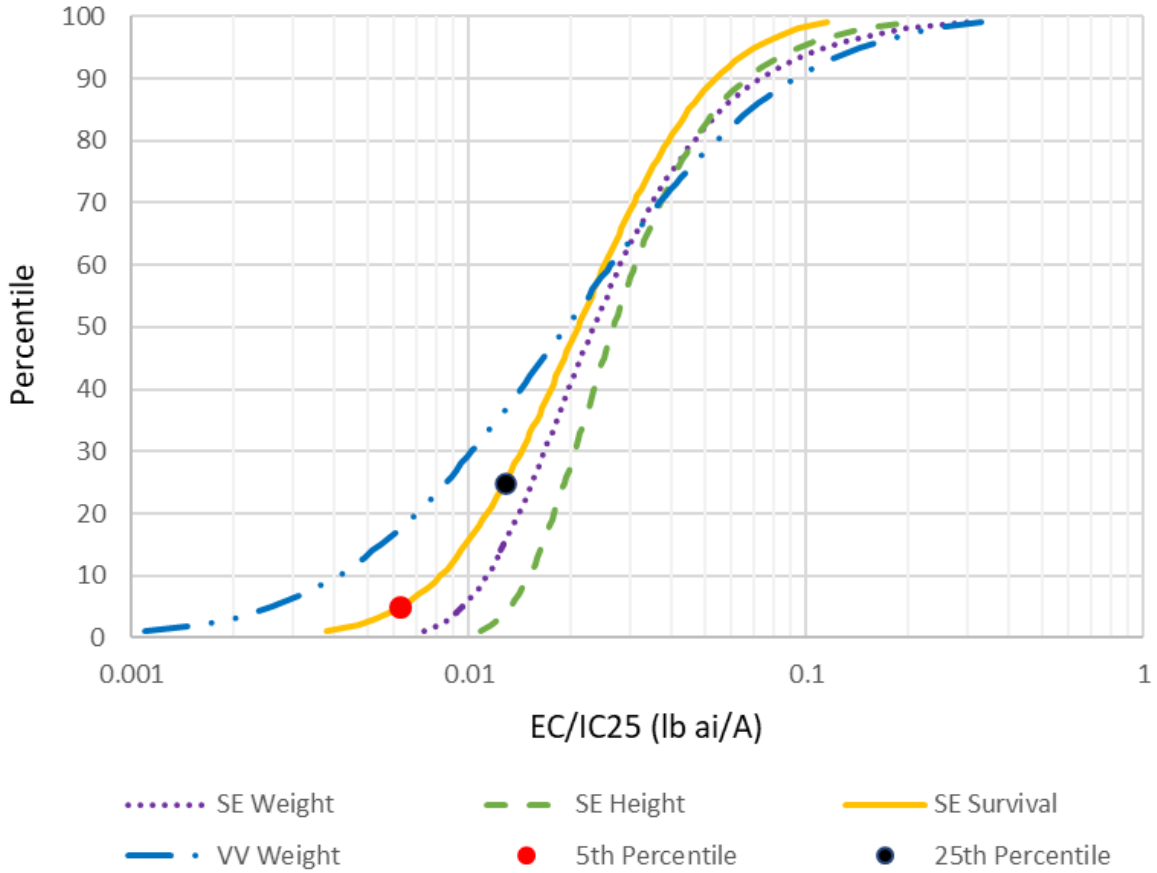


**Figure 11-1. Seedling Emergence (SE) and Vegetative Vigor (VV) Study Species Sensitivity Distributions representing the Distributions of the Plant Height and Weight IC25s and Survival EC25s for Metribuzin.**

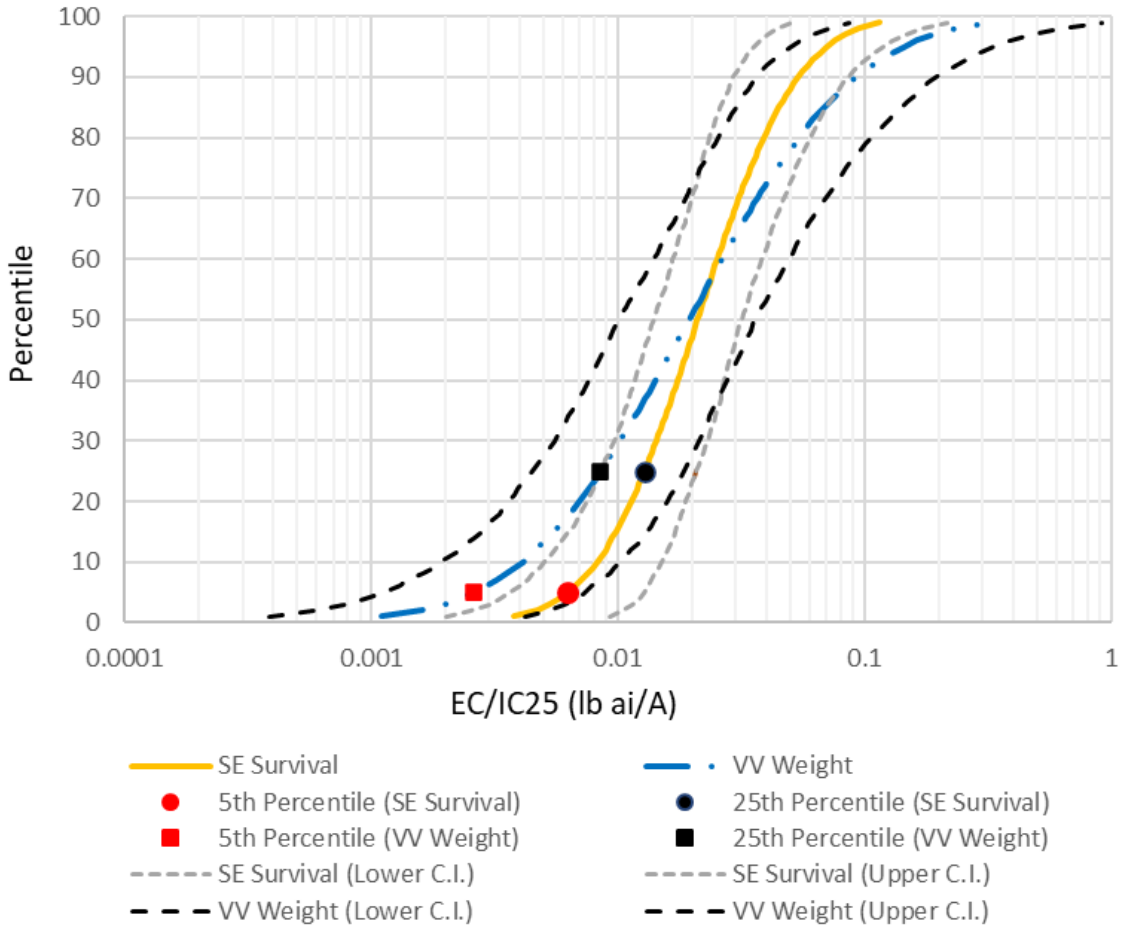


**Figure 11-2. Seedling Emergence (SE) Plant Survival and Vegetative Vigor (VV) Plant Weight Species Sensitivity Distributions (SSD) with the Upper and Lower Confidence Intervals (C.I.) for Metribuzin. Note that the 5th and 25th percentiles for the survival SSD fall within the C.I. for the VV weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 11.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on plants[141], EPA calculated the magnitude of difference as a ratio of the EEC to the 5th percentile of the seedling emergence survival SSD (**Table 11-4**). For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[142] and for critical habitats of

[141] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[142] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25th percentile of the survival SSD (**Table 11-4**). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Table 11-4**).

**Table 11-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Metribuzin[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[1] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.0063 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.0063 lb a.i./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.0063 lb a.i./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.0063 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.0063 lb a.i./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.013 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on the terrestrial plant endpoint: 0.013 lb a.i./A |
| | | Based on aquatic plant endpoints: 17.8 µg a.i./L (Vascular) 7.9 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 17.8 µg a.i./L Nonvascular: 7.9 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Strategy. In this case study for metribuzin, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 11.3.2 Incidents

The incident information from the 2017 Draft Risk Assessment for Registration Review (DP432009) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[143] (as discussed in **Section 11.3.3**), which informs the potential population-level impacts (**Section 11.6**), and to identify the proposed level of mitigation (see **Section 11.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 11.3.3**).[144] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents. In addition, pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. A review of the IDS indicated a total of 58 reported ecological incidents associated with the use of metribuzin, two aquatic and 56 terrestrial species. Forty-one aggregated incidents have been reported to the Agency associated with metribuzin.

The terrestrial incidents reported are for adverse effects to crops, trees, and ornamental plants. Effects include mortality, plant damage, and discoloration. The incidents occurred both from direct application and from spray drift. All aggregated incidents are for minor plant damage.

Because the plant incidents are relatively few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for metribuzin. In other words, the metribuzin incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 11.3.3**) are unaltered by the available metribuzin incident data.

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[143] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[144] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

### 11.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *11.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 11-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of metribuzin ($5^{th}$ percentile of SSD = 0.0063 lb a.i./A). **Table 11-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of metribuzin ($25^{th}$ percentile of SSD = 0.013 lb a.i./A). Within **Table 11-5** and **Table 11-6**, the modeled application rates are representative of the maximum single application rate currently registered for metribuzin (3.0 lb a.i./A for use on sugarcane) and reduced rates (2.0 and 1.0) representative of maximum single application rates for other uses (**Table 11-1**). **Table 11-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 11-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 11.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 11.9**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland

plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 11-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 3.0 lb a.i./A (maximum application rate for use on sugarcane)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | >1000 | 600 | 450 | 400 | 275 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **14.5** [300] | **6.9** [300] | **7.2** [200] | **5.8** [200] | **4.6** [100] | **3.4** [100] | **2.1** [100] |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on asparagus[4] and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | 1000 | 500 | 325 | 250 | 150 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **9.6** [300] | **4.6** [300] | **4.8** [200] | **3.9** [200] | **3.1** [100] | **2.2** [100] | **1.4** [100] |
| **Application Rate of 1.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 800 | 400 | 350 | 150 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **4.8** [300] | **2.3** [300] | **2.4** [200] | **1.9** [200] | **1.5** [100] | **1.1** [100] | 0.7 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For metribuzin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 11.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 11.9** contains the full output of results.

[4] Aerial applications are not permitted for use on asparagus; however, 2 lb a.i./A could be a reduced application rate applied aerially for sugarcane. Therefore, the aerial spray drift results are presented in this table.

**Table 11-6. Spray Drift Distances to the Population-Level Effects Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | **F-M** | **M-C** | **C-VC** | **VF-F High Boom** | **VF-F Low Boom** | **F-MC High Boom** | **F-MC Low Boom** |
| **Application Rate of 3.0 lb a.i./A (maximum application rate for use on sugarcane)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | 700 | 500 | 275 | 200 | 125 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **7.0** [300] | **3.3** [300] | **3.5** [200] | **2.8** [200] | **2.2** [100] | **1.6** [100] | **1.0** [100] |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on asparagus[4] and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 800 | 500 | 375 | 175 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **4.7** [300] | **2.2** [300] | **2.3** [200] | **1.9** [200] | **1.5** [100] | **1.1** [100] | 0.7 [100] |
| **Application Rate of 1.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 1000 | 350 | 250 | 200 | 75 | 50 | 25 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.3** [300] | **1.1** [300] | **1.2** [200] | **0.9** [200] | **0.7** [100] | **0.5** [100] | 0.3 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For metribuzin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 11.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation procedures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 11.9** contains the full output of results.

[4] Aerial applications are not permitted for use on asparagus; however, 2 lb a.i./A could be a reduced application rate applied aerially for sugarcane. Therefore, the aerial spray drift results are presented in this table.

#### *11.3.3.2 Runoff/Erosion and based EECs Approach*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.**

**Table 11-7** through **Table 11-11** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 11-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Alfalfa/sainfoin | 4.4 – 23 | 0.25 – 1.3 | 0.56 – 3.0 |
| Asparagus | 9.0 – 94 | 0.50 – 5.3 | 1.1 – 12 |
| Carrot | 2.6 – 26 | 0.14 – 1.5 | 0.32 – 3.3 |
| Corn, Field | 2.9 – 16 | 0.16 – 0.88 | 0.36 – 2.0 |
| Oil Crops | 3.8 – 17 | 0.21 – 0.97 | 0.48 – 2.2 |
| Lentils, Peas, Garbanzos | 2.4 – 22 | 0.14 – 1.2 | 0.31 – 2.7 |
| Potatoes | 4.8 – 50 | 0.27 – 2.8 | 0.60 – 6.4 |
| Soybeans | 7.3 – 31 | 0.41 – 1.7 | 0.92 – 3.9 |
| Sugarcane | 33 – 130 | 1.8 – 7.3 | 4.1 – 16 |
| Tomato | 4.5 – 47 | 0.25 – 2.7 | 0.57 – 6.0 |
| Wheat | 3.9 – 23 | 0.22 – 1.3 | 0.49 – 3.0 |
| Barley | 5.1 – 23 | 0.29 – 1.3 | 0.65 – 2.9 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for metribuzin, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 11-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Alfalfa/sainfoin | 0.07 – 0.23 | 11 – 37 | 54 - 1700 | 3.1 – 93 | 6.9 – 210 |
| Asparagus | 0.16 – 0.58 | 26 – 92 | 180 – 890 | 10 – 50 | 23 – 110 |
| Carrot | 0.04 – 0.17 | 6.2 – 27 | 39 – 220 | 2.2 – 13 | 4.9 – 28 |
| Corn, Field | 0.04 – 0.11 | 5.8 – 18 | 46 – 540 | 2.6 – 30 | 5.8 – 69 |
| Oil Crops | 0.05 – 0.16 | 7.5 – 25 | 43 – 710 | 2.4 – 40 | 5.4 – 90 |
| Lentils, Peas, Garbanzos | 0.05 – 0.14 | 7.3 – 22 | 38 – 440 | 2.1 – 25 | 4.7 – 56 |
| Potatoes | 0.11 – 0.36 | 17 – 58 | 97 – 950 | 5.5 – 54 | 12 – 120 |
| Soybeans | 0.08 – 0.26 | 13 – 42 | 89 – 800 | 5.0 – 45 | 11 – 100 |
| Sugarcane | 0.40 – 0.89 | 63 – 140 | 400 – 4900 | 22 – 280 | 50 – 620 |
| Tomato | 0.08 – 0.29 | 13 – 46 | 91 – 450 | 5.1 – 25 | 12 – 57 |
| Wheat | 0.05 – 0.19 | 8.2 – 30 | 61 – 860 | 3.4 – 49 | 7.8 – 110 |
| Barley | 0.06 – 0.21 | 10 – 34 | 57 – 950 | 3.2 – 54 | 7.3 – 120 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 11-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Alfalfa/sainfoin | 0.07 – 0.23 | 5.1 – 18 |
| Asparagus | 0.16 – 0.58 | 12 – 44 |
| Carrot | 0.04 – 0.17 | 3.0 – 13 |
| Corn, Field | 0.04 – 0.11 | 2.8 – 8.5 |
| Oil Crops | 0.05 – 0.16 | 3.6 – 12 |
| Lentils, Peas, Garbanzos | 0.05 – 0.14 | 3.5 – 11 |
| Potatoes | 0.11 – 0.36 | 8.2 – 28 |
| Soybeans | 0.08 – 0.26 | 6.4 – 20 |
| Sugarcane | 0.40 – 0.89 | 30 – 69 |
| Tomato | 0.08 – 0.29 | 6.2 – 22 |
| Wheat | 0.05 – 0.19 | 4.0 – 15 |
| Barley | 0.06 – 0.21 | 4.8 – 16 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 11-8**.
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 11-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Alfalfa/sainfoin | 0.09 – 0.31 | 14 – 50 |
| Asparagus | 0.19 – 0.32 | 30 – 51 |
| Carrot | 0.05 – 0.08 | 7.3 – 12 |
| Corn, Field | 0.06 – 0.15 | 9.4 – 24 |
| Oil Crops | 0.05 – 0.08 | 8.7 – 13 |
| Lentils, Peas, Garbanzos | 0.05 – 0.16 | 7.8 – 25 |
| Potatoes | 0.10 – 0.32 | 16 – 51 |
| Soybeans | 0.09 – 0.23 | 14 – 37 |
| Sugarcane | 0.65 – 1.5 | 100 – 240 |
| Tomato | 0.09 – 0.16 | 15 – 26 |
| Wheat | 0.07 – 0.26 | 11 – 42 |
| Barley | 0.07 – 0.17 | 12 – 28 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 11-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Alfalfa/sainfoin | 0.09 – 0.31 | 6.7 – 24 |
| Asparagus | 0.19 – 0.32 | 14 – 25 |
| Carrot | 0.05 – 0.08 | 3.5 – 6.1 |
| Corn, Field | 0.06 – 0.15 | 4.5 – 12 |
| Oil Crops | 0.05 – 0.08 | 4.2 – 6.2 |
| Lentils, Peas, Garbanzos | 0.05 – 0.16 | 3.8 – 12 |
| Potatoes | 0.10 – 0.32 | 7.8 – 25 |
| Soybeans | 0.09 – 0.23 | 7.0 – 18 |
| Sugarcane | 0.65 – 1.5 | 50 – 120 |
| Tomato | 0.09 – 0.16 | 7.1 – 13 |
| Wheat | 0.07 – 0.26 | 5.4 – 20 |
| Barley | 0.07 – 0.17 | 5.7 – 13 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *11.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 11-12**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented in **Sections 11.3.3.1** and **11.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 11.4**) and conducting a population-level impact analysis (**Section 11.6**).

For metribuzin, given the toxicity profile (including only about a 2X difference between the 5$^{th}$ and 25$^{th}$ percentiles of the survival SSD with steep slopes of the SSDs (**Figure 11-1**)[145], EPA assigned a low magnitude of effect in **Table 11-12** on a use basis to groups of listed species and critical habitats (CHs)[146] when the magnitude of difference is less than 1. For low magnitude of

[145] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[146] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

effect, population-level impacts are not expected. EPA assigned medium magnitude of effect in **Table 11-12**Table 11-12 when the magnitude of difference is from 1 up to 10. EPA assigned a magnitude of effect of high or very high based on a magnitude of difference of 10 up to 100 or greater than 100, respectively.

**Table 11-12. Use-Based Magnitude of Effect for Metribuzin.[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Alfalfa/sainfoin | High | High | High | High | Medium | Medium |
| Asparagus | High | High | High | High | Medium | Medium |
| Carrot | High | Medium | High | High | Medium | Medium |
| Corn, Field | High | High | High | High | Medium | Medium |
| Oil Crops | High | Medium | High | High | Medium | Medium |
| Lentils, Peas, Garbanzos | High | Medium | High | High | Medium | Medium |
| Potatoes | High | High | High | High | Medium | Medium |
| Soybeans | High | High | High | High | Medium | Medium |
| Sugarcane | Very High | Very High | Very High | Very High | High | High |
| Tomato | High | High | High | High | Medium | Medium |
| Wheat | High | High | High | High | Medium | Medium |
| Barley | High | High | High | High | Medium | Medium |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 11.4**) and to conduct the population-level impacts analysis (**Section 11.6**). If the magnitude of effect is medium or higher for metribuzin, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 11.4 Framework Step 2: Identify Mitigation Measures

**Section 11.4** outlines the mitigation measures identified for metribuzin for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 11.4.1**) and runoff/erosion (**Section 11.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 11.4.1 Spray Drift Mitigation Measures Identified

**Table 11-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 11-14** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 11-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 3.0 | 300 + windbreak[3] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 2.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g] |
| 1.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 75[e,f,g] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70% | | | [d] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[e] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half | | | |

| | | |
|---|---|---|
| | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 11-1.**
[3] Additional mitigation measures (*e.g.,* windbreak) would apply for aerial applications at this rate using this droplet size because the magnitude of difference exceeds 10 at the maximum buffer distance. Use of these additional mitigation measures do not result in reduced buffer distances.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 11-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 3.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 100[d,e,f,g,] |
| 2.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 100[d,f,g] | 100[d,f,g] | 75[e,f,g] |
| 1.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[d,f,g] | 75[f,g] | 50[f,g] | 25[h] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[3] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70% | | | [d] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[e] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 11-1.**
[3] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 11.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts and minimize the potential for future take differs across uses and, as

shown in **Figure 11-3,** the level of mitigation is dependent upon the toxicity endpoint and representative species (*e.g.,* listed plants (5th percentile endpoint), generalists (25th percentile endpoint)). **Figure 11-3** visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for metribuzin.

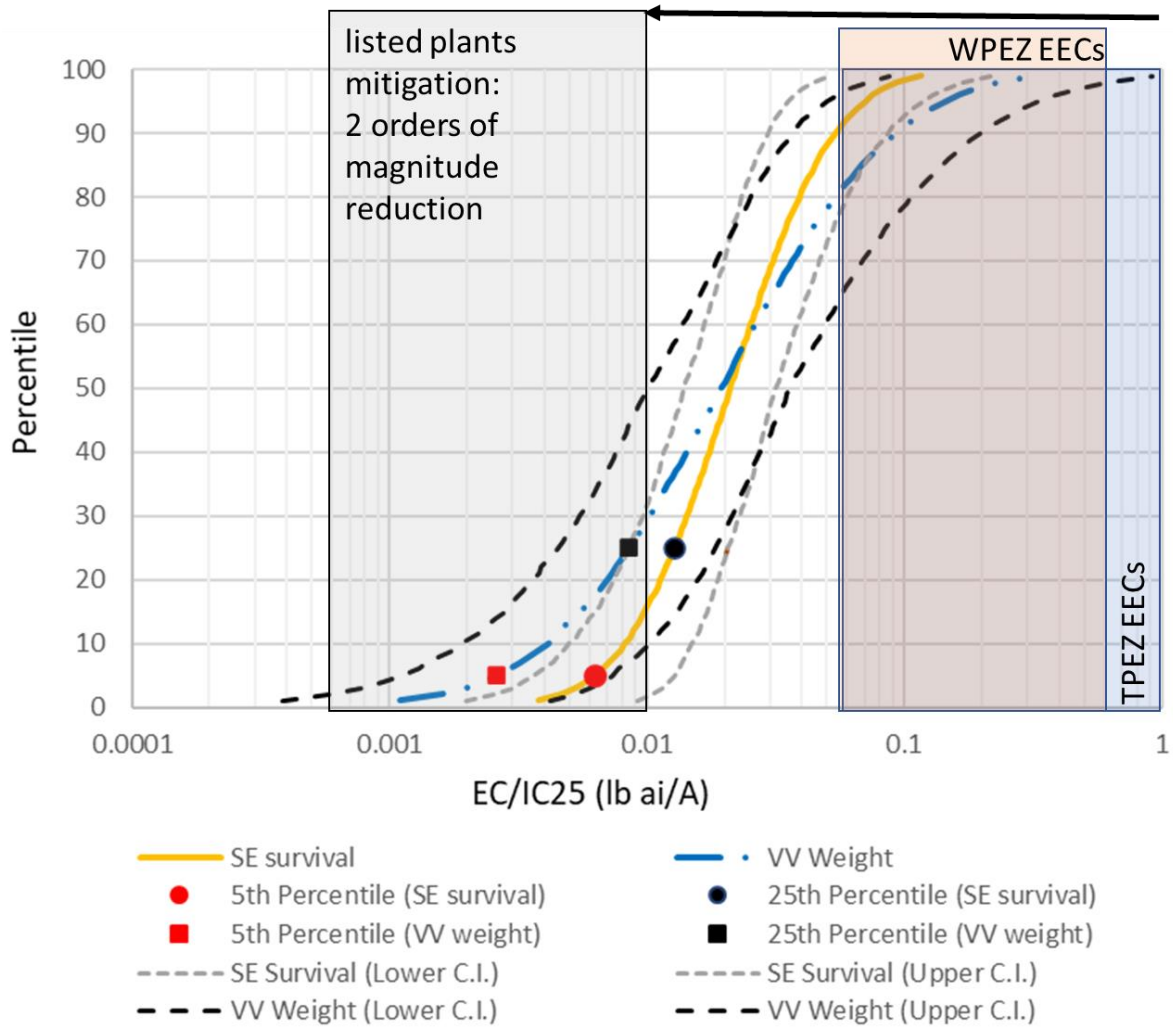


**Figure 11-3. Metribuzin Seedling Emergence (SE) Survival and Vegetative Vigor (VV) Weight Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5th percentile (represents listed plants and animals with obligate relationships to plants) and the 25th percentile (represents generalists and CH) from the SE survival SSD. Upper and lower confidence intervals (C.I.) are provided for the SE survival and VV weight SSDs to illustrate the similarity in the endpoints.**

For metribuzin, see **Section 11.3.3.2** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as

discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of metribuzin is <1,000 L/kg-o.c. (mean $K_{OC}$ = 20 L/kg-o.c. for the parent), higher mitigation points are identified for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework**, EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would be applicable and if it is between 100 and 1,000, high mitigation would be applicable. If the magnitude of difference exceeds 1,000, then very high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high/very high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For metribuzin, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for metribuzin, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses that are considered in this document.

- For listed aquatic plants and animals that depend on these plants[147] in waterbodies similar in size to the EPA farm pond or larger[148], the mitigation category[149] is low for all uses except use on sugarcane, for which it is medium (based on the more sensitive results for nonvascular plants; **Table 11-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies (**Table 11-15**).
- For all uses except use on sugarcane, the mitigation category is medium for listed semi-aquatic/wetland monocots and dicots and animals that obligately depend on wetland monocots or dicots[150] (**Table 11-16**). EPA identified high mitigation for use on sugarcane.
- For aquatic plants in wetlands or small waterbodies[151] and for animals that depend on these plants (both obligately[150] and generally[152]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic

[147] None of the listed aquatic animals have obligate relationships to plants.
[148] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[149] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios ≥1000), High (ratios ≥100 but <1000), Medium (ratios ≥10 but <100), Low (ratios ≥1 but <10), No Mitigation (ratios <1).
[150] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[151] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[152] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

vascular and nonvascular plants. The resulting mitigation category is medium for all uses except for use on sugarcane, for which the mitigation category is high (**Table 11-16**).

- For animals that generally rely on wetland monocots or dicots[152], EPA identified medium mitigation for all uses except for use on carrot, corn, crops grown for oil, lentils, peas, and garbanzos, for which the mitigation category is low (**Table 11-17**).
- For listed terrestrial plants and animals that obligately depend on terrestrial plants[150], the mitigation category is medium for all uses except use on sugarcane, for which EPA identified high mitigation (**Table 11-18**)
- For listed animals that generally depend on terrestrial plants[152], the mitigation category is low for use on carrot, crops grown for oil, lentils, peas, and garbanzos, high for use on sugarcane, and medium for all other uses (**Table 11-11**).

**Table 11-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Alfalfa/sainfoin | 4.4 – 23 | 0.25 – 1.3 | Low | 0.56 – 3.0 | Low |
| Asparagus | 9.0 – 94 | 0.50 – 5.3 | Low | 1.1 – 12 | Low[5] |
| Carrot | 2.6 – 26 | 0.14 – 1.5 | No mitigation[5] | 0.32 – 3.3 | Low |
| Corn, Field | 2.9 – 16 | 0.16 – 0.88 | No mitigation | 0.36 – 2.0 | Low |
| Oil Crops | 3.8 – 17 | 0.21 – 0.97 | No mitigation | 0.48 – 2.2 | Low |
| Lentils, Peas, Garbanzos | 2.4 – 22 | 0.14 – 1.2 | No mitigation[5] | 0.31 – 2.7 | Low |
| Potatoes | 4.8 – 50 | 0.27 – 2.8 | Low | 0.60 – 6.4 | Low |
| Soybeans | 7.3 – 31 | 0.41 – 1.7 | Low | 0.92 – 3.9 | Low |
| Sugarcane | 33 – 130 | 1.8 – 7.3 | Low | 4.1 – 16 | Medium |
| Tomato | 4.5 – 47 | 0.25 – 2.7 | Low | 0.57 – 6.0 | Low |
| Wheat | 3.9 – 23 | 0.22 – 1.3 | No mitigation[5] | 0.49 – 3.0 | Low |
| Barley | 5.1 – 23 | 0.29 – 1.3 | No mitigation[5] | 0.65 – 2.9 | Low |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for metribuzin, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.
[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 11-15** outlines the proposed mitigation categories for listed aquatic plants, animals that rely on those plants, and designated critical habitats in waterbodies equivalent to the EPA pond or larger[153]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[154]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For metribuzin, EPA determined the proposed mitigation categories presented in **Table 11-15** based on the weight of evidence discussed below, which is specifically relevant for use on asparagus, carrot, lentils/peas/garbanzos, wheat, and barley as discussed below.

For use on asparagus, although the highest magnitude of difference value for nonvascular plants exceeds 10 (indicating medium mitigation), this only occurred in 1 out of 21 modeled application scenarios. Given that 95% of the scenarios indicate low mitigation with only 5% indicating medium mitigation, EPA set the mitigation category as low for use on asparagus when considering aquatic nonvascular plants and animals that depend on these plants.

For use on carrot, the magnitude of difference ranges from 0.14 to 1.5 for aquatic vascular plants. Only two out of the 42 modeled scenarios resulted in a magnitude of difference exceeding 1. Given that 95% of the scenarios indicate no mitigation with 5% of scenarios indicating low mitigation, EPA set the mitigation category as no mitigation for use on carrot when considering aquatic vascular plants and animals that depend on these plants.

For use on lentils/peas/garbanzos, the magnitude of difference ranges from 0.14 to 1.2 for aquatic vascular plants. Only one out of the 21 modeled scenarios resulted in a magnitude of difference exceeding 1. Given that 95% of the scenarios indicate no mitigation with 5% indicating low mitigation, EPA set the mitigation category as no mitigation for use on lentils/peas/garbanzos when considering aquatic vascular plants and animals that depend on these plants.

For use on wheat, the magnitude of difference ranges from 0.22 to 1.3 for aquatic vascular plants. Seven out of the 70 modeled scenarios resulted in a magnitude of difference exceeding 1. Given that 90% of the scenarios indicate no mitigation with only 10% indicating low mitigation, EPA set the mitigation category as no mitigation for use on wheat when considering aquatic vascular plants and animals that depend on these plants.

For use on barley, the magnitude of difference ranges from 0.29 to 1.3 for aquatic vascular plants. Six out of the 42 modeled scenarios resulted in a magnitude of difference exceeding 1.

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[153] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger. This correlates to aquatic bins 3, 4, 6, 7, 9, and 10 (as discussed in **Section 3.1**).

[154] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2**.

Given that 86% indicate no mitigation with the rest indicating low mitigation, EPA set the mitigation category as no mitigation for use on barley when considering aquatic vascular plants and animals that depend on these plants.

**Table 11-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category | | Range of Magnitude of Difference[3] | Mitigation Category | Range of Magnitude of Difference[3] | Mitigation Category |
| Alfalfa/sainfoin | 0.07 – 0.23 | 11 – 37 | Medium | 54 - 1700 | 3.1 – 93 | Medium | 6.9 – 210 | Medium[5] |
| Asparagus | 0.16 – 0.58 | 26 – 92 | Medium | 180 – 890 | 10 – 50 | Medium | 23 – 110 | Medium[5] |
| Carrot | 0.04 – 0.17 | 6.2 – 27 | Medium | 39 – 220 | 2.2 – 13 | Low[5] | 4.9 – 28 | Medium |
| Corn, Field | 0.04 – 0.11 | 5.8 – 18 | Medium | 46 – 540 | 2.6 – 30 | Medium | 5.8 – 69 | Medium |
| Oil Crops | 0.05 – 0.16 | 7.5 – 25 | Medium | 43 – 710 | 2.4 – 40 | Medium | 5.4 – 90 | Medium |
| Lentils, Peas, Garbanzos | 0.05 – 0.14 | 7.3 – 22 | Medium | 38 – 440 | 2.1 – 25 | Medium | 4.7 – 56 | Medium |
| Potatoes | 0.11 – 0.36 | 17 – 58 | Medium | 97 – 950 | 5.5 – 54 | Medium | 12 – 120 | Medium[5] |
| Soybeans | 0.08 – 0.26 | 13 – 42 | Medium | 89 – 800 | 5.0 – 45 | Medium | 11 – 100 | Medium[5] |
| Sugarcane | 0.40 – 0.89 | 63 – 140 | High | 400 – 4900 | 22 – 280 | High | 50 – 620 | High |
| Tomato | 0.08 – 0.29 | 13 – 46 | Medium | 91 – 450 | 5.1 – 25 | Medium | 12 – 57 | Medium |
| Wheat | 0.05 – 0.19 | 8.2 – 30 | Medium | 61 – 860 | 3.4 – 49 | Medium | 7.8 – 110 | Medium[5] |
| Barley | 0.06 – 0.21 | 10 – 34 | Medium | 57 – 950 | 3.2 – 54 | Medium | 7.3 – 120 | Medium[5] |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies are all have equivalent magnitudes of difference and equivalent mitigation categories.

[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 11-16** outlines the proposed mitigation categories for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[155]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 11.4**. For metribuzin, EPA determined the proposed mitigation categories presented in **Table 11-16** based on the weight of evidence discussed below, which is specifically relevant for use on alfalfa/sainfoin, asparagus, carrot, potatoes, soybeans, wheat, and barley as discussed below.

For use on alfalfa/sainfoin, the magnitude of difference ranges from 6.9 to 210 for aquatic nonvascular plants. Only three out of the 42 modeled scenarios resulted in a magnitude of difference exceeding 100. Given that for 93% of modeled scenarios EPA identified low or medium mitigation, EPA set the mitigation category as medium for use on alfalfa/sainfoin when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on asparagus, the magnitude of difference ranges from 23 to 110 for aquatic nonvascular plants. Only two out of the 21 modeled scenarios resulted in a magnitude of difference exceeding 100. Given that for 90% of scenarios EPA identified medium mitigation, EPA set the mitigation category as medium for use on asparagus when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on carrot, the magnitude of difference ranges from 2.2 to 13 for aquatic vascular plants. Only two out of the 21 modeled scenarios resulted in a magnitude of difference exceeding 10. Given that 90% of the scenarios indicate low mitigation with 10% indicating medium mitigation, EPA set the mitigation category as low for use on carrot when considering aquatic vascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on potatoes, the magnitude of difference ranges from 12 to 120 for aquatic nonvascular plants. Only three out of the 42 modeled scenarios resulted in a magnitude of difference exceeding 100. Given that 93% of the scenarios indicate medium mitigation with only 7% indicating high mitigation, EPA identified medium mitigation for use on potatoes when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on soybeans, the magnitude of difference ranges from 11 to 100 for aquatic nonvascular plants. Only one modeled scenario resulted in a magnitude of difference that

[155] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

marginally exceeds 100. Therefore, EPA set the mitigation category as medium for use on soybeans when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on wheat, the magnitude of difference ranges from 7.8 to 110 for aquatic nonvascular plants. Only two modeled scenarios out of 70 resulted in a magnitude of difference that exceeds 100. Given that 97% of the modeled scenarios indicate medium mitigation, EPA set the mitigation category as medium for use on wheat when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

For use on barley, the magnitude of difference ranges from 7.3 to 120 for aquatic nonvascular plants. Only one modeled scenario out of 42 resulted in a magnitude of difference that exceeds 100. Given that 98% of modeled scenarios indicate low or medium mitigation, EPA set the mitigation category as medium for use on barley when considering aquatic nonvascular plants and animals that depend on these plants in wetlands or small waterbodies.

**Table 11-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |
| Alfalfa/sainfoin | 0.07 – 0.23 | 5.1 – 18 | Medium |
| Asparagus | 0.16 – 0.58 | 12 – 44 | Medium |
| Carrot | 0.04 – 0.17 | 3.0 – 13 | Low[5] |
| Corn, Field | 0.04 – 0.11 | 2.8 – 8.5 | Low |
| Oil Crops | 0.05 – 0.16 | 3.6 – 12 | Low[5] |
| Lentils, Peas, Garbanzos | 0.05 – 0.14 | 3.5 – 11 | Low[5] |
| Potatoes | 0.11 – 0.36 | 8.2 – 28 | Medium |
| Soybeans | 0.08 – 0.26 | 6.4 – 20 | Medium |
| Sugarcane | 0.40 – 0.89 | 30 – 69 | Medium |
| Tomato | 0.08 – 0.29 | 6.2 – 22 | Medium |
| Wheat | 0.05 – 0.19 | 4.0 – 15 | Medium |
| Barley | 0.06 – 0.21 | 4.8 – 16 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 11-16**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 11-17** outlines the proposed mitigation categories for listed animals that generally rely on monocots or dicots in wetlands or small waterbodies[156]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 11.4**. For metribuzin, EPA determined the proposed mitigation categories presented in **Table 11-17** based on the weight of evidence discussed below, which is specifically relevant for use on carrot, oil crops, and lentils/peas/garbanzos.

For use on carrot, the magnitude of difference ranges from 3.0 to 13 for animals generally relying on monocots or dicots in wetlands. Only one out of 21 modeled scenarios resulted in a magnitude of difference that exceeds 10. Given that 95% of scenarios indicated low mitigation, EPA set the mitigation category as low for use on carrot to protect animals that generally depend on monocots or dicots in wetlands or small waterbodies.

For use on oil crops, the magnitude of difference ranges from 3.6 to 12 for animals generally relying on monocots or dicots in wetlands. Only four out of 42 modeled scenarios resulted in a magnitude of difference that exceeds 10. Given that 90% of the modeled scenarios indicated low mitigation and only 10% indicated medium mitigation, EPA identified low mitigation for use on oil crops to protect animals that generally depend on monocots or dicots in wetlands or small waterbodies.

For use on lentils/peas/garbanzos, the magnitude of difference ranges from 3.5 to 11 for animals generally relying on monocots or dicots in wetlands. Only three out of 42 modeled scenarios resulted in a magnitude of difference that exceeds 10. Given that 93% of scenarios indicated only low mitigation with 7% indicating medium mitigation, EPA set the mitigation category as low mitigation for use on lentils/peas/garbanzos to protect animals that generally depend on monocots or dicots in wetlands or small waterbodies.

[156] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

**Table 11-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Alfalfa/sainfoin | 0.09 – 0.31 | 14 – 50 | Medium |
| Asparagus | 0.19 – 0.32 | 30 – 51 | Medium |
| Carrot | 0.05 – 0.08 | 7.3 – 12 | Medium |
| Corn, Field | 0.06 – 0.15 | 9.4 – 24 | Medium |
| Oil Crops | 0.05 – 0.08 | 8.7 – 13 | Medium |
| Lentils, Peas, Garbanzos | 0.05 – 0.16 | 7.8 – 25 | Medium |
| Potatoes | 0.10 – 0.32 | 16 – 51 | Medium |
| Soybeans | 0.09 – 0.23 | 14 – 37 | Medium |
| Sugarcane | 0.65 – 1.5 | 100 – 240 | High |
| Tomato | 0.09 – 0.16 | 15 – 26 | Medium |
| Wheat | 0.07 – 0.26 | 11 – 42 | Medium |
| Barley | 0.07 – 0.17 | 12 – 28 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 11-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Alfalfa/sainfoin | 0.09 – 0.31 | 6.7 – 24 | Medium |
| Asparagus | 0.19 – 0.32 | 14 – 25 | Medium |
| Carrot | 0.05 – 0.08 | 3.5 – 6.1 | Low |
| Corn, Field | 0.06 – 0.15 | 4.5 – 12 | Medium |
| Oil Crops | 0.05 – 0.08 | 4.2 – 6.2 | Low |
| Lentils, Peas, Garbanzos | 0.05 – 0.16 | 3.8 – 12 | Low[3] |
| Potatoes | 0.10 – 0.32 | 7.8 – 25 | Medium |
| Soybeans | 0.09 – 0.23 | 7.0 – 18 | Medium |
| Sugarcane | 0.65 – 1.5 | 50 – 120 | High |
| Tomato | 0.09 – 0.16 | 7.1 – 13 | Medium |
| Wheat | 0.07 – 0.26 | 5.4 – 20 | Medium |
| Barley | 0.07 – 0.17 | 5.7 – 13 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 11-19** identifies the proposed mitigation category for listed animals that generally rely on terrestrial plants. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For metribuzin, EPA determined the proposed mitigation categories presented in

**Table 11-19** based on the weight of evidence discussed below, which is specifically relevant for use on lentils/peas/garbanzos. For use on lentils/peas/garbanzos, the magnitude of difference ranges from 3.8 to 12 for animals generally relying on monocots or dicots in terrestrial environments. Only one out of 42 modeled scenarios resulted in a magnitude of difference that exceeds 10. Given that 98% of modeled scenarios indicated low mitigation, EPA set the mitigation category as low for use on lentils/peas/garbanzos to protect animals that generally depend on terrestrial monocots or dicots.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 11-15** and **Table 11-16**) and wetland plants (**Table 11-16** and **Table 11-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether it is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will typically be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 11-18**) and for generalist animals (**Table 11-19**). **Table 11-20** and **Table 11-21** provide the runoff/erosion mitigation points identified for each evaluated use of metribuzin.

**Table 11-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Alfalfa/sainfoin | Medium (6 pts) | Medium (6 pts) |
| Asparagus | Medium (6 pts) | Medium (6 pts) |
| Carrot | Medium (6 pts) | Medium (6 pts) |
| Corn, Field | Medium (6 pts) | Medium (6 pts) |
| Oil Crops | Medium (6 pts) | Medium (6 pts) |
| Lentils, Peas, Garbanzos | Medium (6 pts) | Medium (6 pts) |
| Potatoes | Medium (6 pts) | Medium (6 pts) |

| | | |
|---|---|---|
| Soybeans | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | High (9 pts) |
| Tomato | Medium (6 pts) | Medium (6 pts) |
| Wheat | Medium (6 pts) | Medium (6 pts) |
| Barley | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat
[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.
[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 11-15** and **Table 11-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 11-15** and **Table 11-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 11-15**, **Table 11-16**, and **Table 11-17**).

**Table 11-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | **Plants and Obligate Animals (Mitigation Points)** | **Generalist Animals and CHs (Mitigation Points)** |
| Alfalfa/sainfoin | Medium (6 pts) | Medium (6 pts) |
| Asparagus | Medium (6 pts) | Medium (6 pts) |
| Carrot | Medium (6 pts) | Low (3 pts) |
| Corn, Field | Medium (6 pts) | Medium (6 pts) |
| Oil Crops | Medium (6 pts) | Low (3 pts) |
| Lentils, Peas, Garbanzos | Medium (6 pts) | Low (3 pts) |
| Potatoes | Medium (6 pts) | Medium (6 pts) |
| Soybeans | Medium (6 pts) | Medium (6 pts) |
| Sugarcane | High (9 pts) | High (9 pts) |
| Tomato | Medium (6 pts) | Medium (6 pts) |
| Wheat | Medium (6 pts) | Medium (6 pts) |
| Barley | Medium (6 pts) | Medium (6 pts) |

CH=designated critical habitat
[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.
[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 11-18**), listed animals that obligately depend on terrestrial plants (**Table 11-18**), and listed animals that generally depend on terrestrial plants (**Table 11-19).**

## 11.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA

proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for metribuzin are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 11-13**) and one for generalist animals that depend on plants (**Table 11-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are slightly different for these two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For metribuzin, the less restrictive mitigations relevant to generalist animals that are depicted in **Table 11-14** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 11-13** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For aquatic/wetland habitats, the level of mitigations identified are equivalent for listed plants, animals with obligate relationships to plants, and generalist animals (see **Table 11-20**). This is driven by the lack of an SSD for aquatic nonvascular plants, resulting in equivalent mitigation levels for listed plants, listed obligate animals, and listed generalist animals—whereas if an SSD was available for the aquatic plant data, it is possible that less mitigation could be identified for generalist animals. Because the mitigation levels are equivalent for all three groups of species, all mitigations for aquatic/wetland habitats would go on the general label since generalist animals are distributed widely across the United States.

For terrestrial habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 11-21**). Therefore, for terrestrial habitats, mitigations for generalist animals would go on the general label with higher mitigations for listed plants and obligate animals in Bulletins. This would be particularly impactful for use on carrot, oil crops, and lentils/peas/garbanzos where less mitigation has been identified for listed animals that generally rely on terrestrial plants.

**Table 11-22** summarizes the runoff/erosion mitigation points identified for the different metribuzin uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas included in the PULAs. PULAs 1 and 2, and PULAs 3 and 4 are grouped because the same mitigations would be applied to monocots and dicots in these habitats; this is supported by metribuzin's similar toxicity to both monocots and dicots (see **Section 11.3.1**).

**Table 11-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | | Geographically Specific Mitigation Points | |
|---|---|---|---|---|
| | Terrestrial Habitats | Aquatic and Wetland Habitats | PULAs 1 and 2 (Terrestrial Habitats) | PULAs 3 and 4 (Aquatic and Wetland Habitats) |
| Alfalfa/sainfoin | 6 | 6 | 6 | 6 |
| Asparagus | 6 | 6 | 6 | 6 |
| Carrot | 3 | 6 | 6 | 6 |
| Corn, Field | 6 | 6 | 6 | 6 |
| Oil Crops | 3 | 6 | 6 | 6 |
| Lentils, Peas, Garbanzos | 3 | 6 | 6 | 6 |
| Potatoes | 6 | 6 | 6 | 6 |
| Soybeans | 6 | 6 | 6 | 6 |
| Sugarcane | 9 | 9 | 9 | 9 |
| Tomato | 6 | 6 | 6 | 6 |
| Wheat | 6 | 6 | 6 | 6 |
| Barley | 6 | 6 | 6 | 6 |

## 11.6 Summary of EPA's Predictions for Potential Likelihood of Population Level Impacts Summary for Metribuzin Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 11.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of metribuzin. For major crops (*e.g.,* corn, soybean, wheat), the crop-specific UDLs were selected. For other uses such as on asparagus and barley, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential metribuzin use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or

high (**Table 11-12**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 11-23** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected metribuzin UDLs[157] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For metribuzin's UDLs, fewer species (356) and CHs (76) have 5% overlap. An important consideration for the purposes of this example is that EPA did not necessarily evaluate all registered uses of metribuzin (see **Section 11.2**), so additional species could be identified in the future for metribuzin. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of metribuzin; however, the PULAs include some species and CHs that have <5% overlap with metribuzin's potential exposure area for the considered uses.

**Table 11-23. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Metribuzin Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Other Crops | 469 / 142 | 324 | 63 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Corn | | 150 | 30 |
| Other Grains | | 236 | 51 |
| Soybeans | | 88 | 9 |
| Wheat | | 182 | 41 |
| Alfalfa | | 141 | 42 |
| Total across all UDLs above[2] | | 356 | 76 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Other Crops | 534 / 316 | 413 | 197 |
| Vegetables and Ground Fruit | | 166 | 83 |
| Corn | | 317 | 148 |

[157] The selected use data layers (UDLs) do not necessarily represent every registered use of metribuzin. See **Section 11.2** for more information on the uses evaluated in this example.

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| Other Grains | | 284 | 137 |
| Soybeans | | 225 | 92 |
| Wheat | | 304 | 136 |
| Alfalfa | | 152 | 82 |
| Total across all UDLs above[2] | | 438 | 219 |
| Cultivated | | 460 | 225 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for metribuzin. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for metribuzin (excluding the Cultivated UDL, which is summarized below this row).

## 11.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

The ranges of $IC_{25}$ values for plant height from the seedling emergence studies are 0.00649 to 0.106 lb a.i./A (excluding non-definitive endpoints[158]) for monocots and 0.0181 to 0.0635 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.044 and 0.035 lb a.i./A, respectively. There are only three monocot test species with definitive $IC_{25}$ values for height from the vegetative vigor studies, and the range of the $IC_{25}$ values is 0.019 to 0.063 lb a.i./A (excluding non-definitive endpoints). Similarly, only one definitive $IC_{25}$ value (0.023 lb a.i./A) is available for dicots from the vegetative vigor studies.

For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.0044 to 0.059 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.008 to 0.193 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.028 and 0.049 lb a.i./A, respectively. The ranges of $IC_{25}$ values for dry weight data in the vegetative vigor studies are 0.012 to 0.103 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.002 to 0.15 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.053 and 0.027 lb a.i./A, respectively.

The ranges of $EC_{25}$ values for survival from the seedling emergence studies are 0.000974 to 0.132 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.0057 to 0.0717 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $EC_{25}$ values of 0.038 and 0.029 lb a.i./A, respectively.

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[158] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 0.214 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 11.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to metribuzin. EPA developed separate SSDs for height and weight.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the metribuzin data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the $5^{th}$ percentile of the $IC_{25}$ values from the SSD.

Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

## Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA made comparisons of the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### *Seedling Emergence Height Data*

Goodness of fit:

Results:

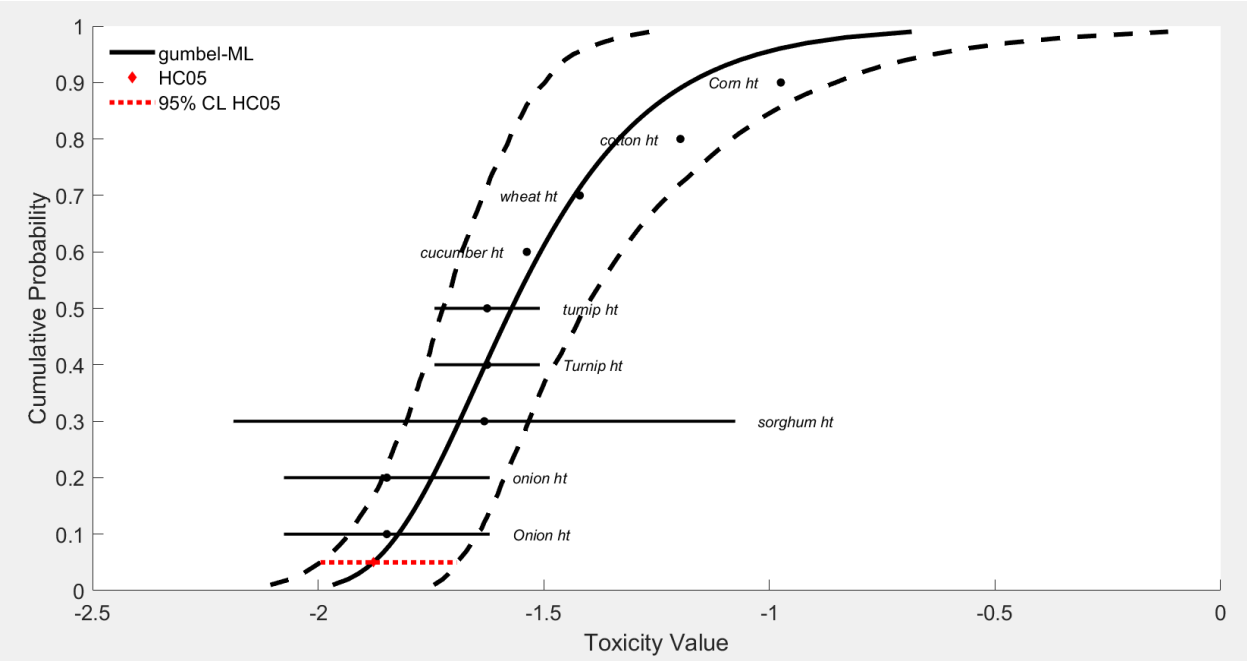
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0107 | 0.3477 |
| 2 | logistic | ML | 0.0099 | 0.3536 |
| 3 | triangular | ML | 0.0113 | 0.4755 |
| 4 | gumbel | ML | 0.0133 | 0.5415 |
| 5 | weibull | ML | 0.0057 | 0.1768 |
| 6 | burr | ML | 0.0133 | 0.4855 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.011496 |
| Model-averaged SE of HCp: | 0.0038085 |
| CV of HCp: | 0.3313 |

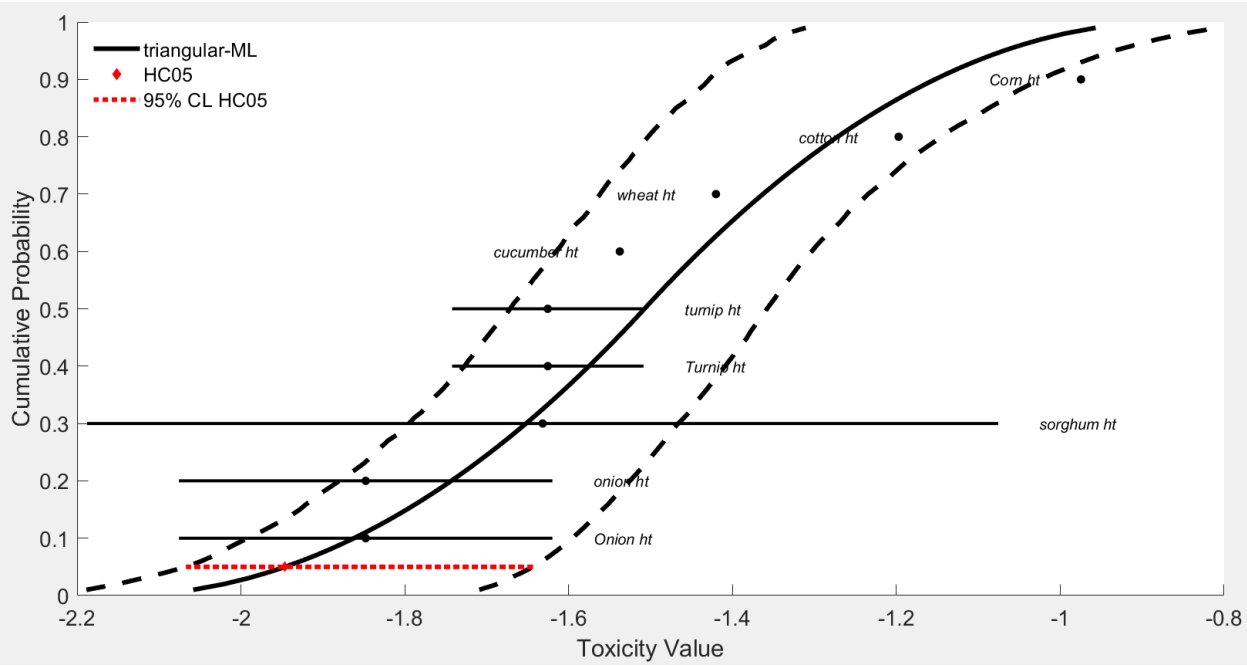
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -41.5287 | 0 | 0.3630 | 0.0133 | 0.0024 |
| 2 | triangular | -40.5777 | 0.9510 | 0.2256 | 0.0113 | 0.0044 |
| 3 | normal | -40.0708 | 1.4578 | 0.1751 | 0.0107 | 0.0034 |
| 4 | logistic | -39.8537 | 1.6749 | 0.1571 | 0.0099 | 0.0034 |
| 5 | weibull | -37.4128 | 4.1159 | 0.0464 | 0.0057 | 0.0034 |
| 6 | burr | -36.7270 | 4.8016 | 0.0329 | 0.0133 | 0.0023 |

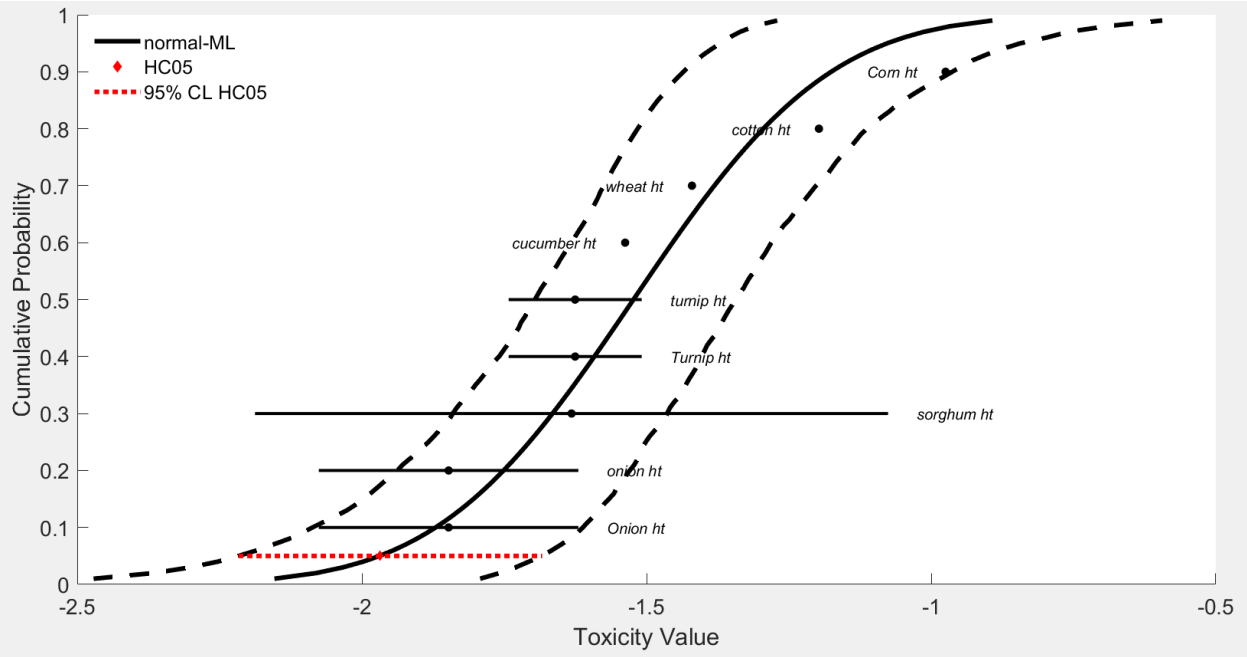
Based on the goodness of fit, EPA moved forward with Gumbel, triangular, and normal distributions, and ultimately selected the Gumbel distribution for the height data from the seedling emergence toxicity tests.




**Gumbel (selected distribution)**




Triangular


normal-ML
HC05
95% CL HC05
Cumulative Probability
Toxicity Value
Corn ht
cotton ht
wheat ht
cucumber ht
turnip ht
Turnip ht
sorghum ht
onion ht
Onion ht
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2.5
-2
-1.5
-1
-0.5

Normal

*Seedling Emergence Weight Data*

Goodness of fit:

Results:

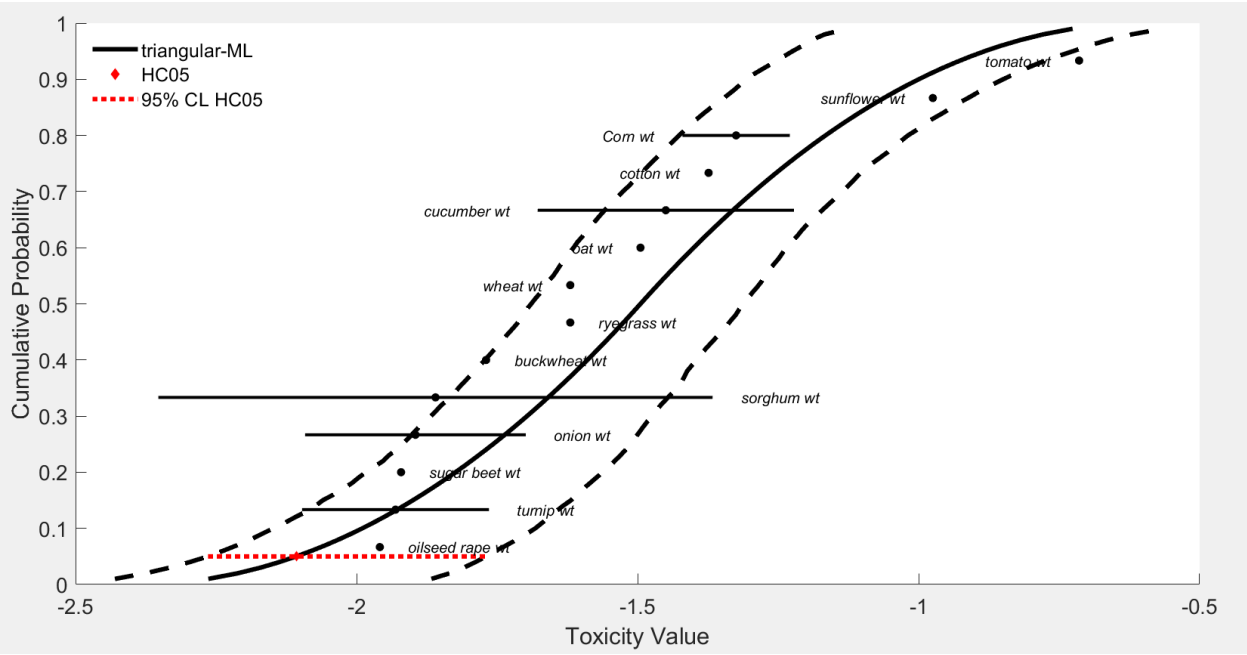
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0069 | 0.2907 |
| 2 | logistic | ML | 0.0062 | 0.3846 |
| 3 | triangular | ML | 0.0078 | 0.0669 |
| 4 | gumbel | ML | 0.0096 | 0.3327 |
| 5 | weibull | ML | 0.0026 | 0.0599 |
| 6 | burr | ML | 0.0096 | 0.2607 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0087319 |
| Model-averaged SE of HCp: | 0.0023507 |
| CV of HCp: | 0.26921 |

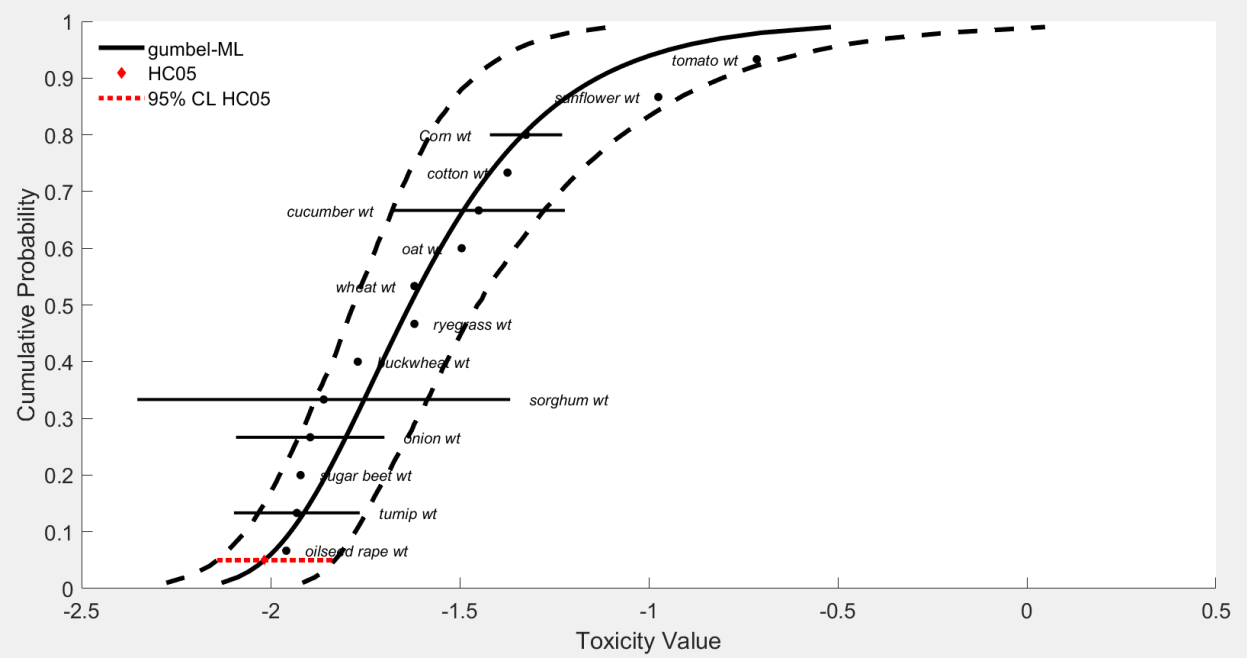
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -64.4646 | 0 | 0.5656 | 0.0096 | 0.0018 |
| 2 | triangular | -61.2212 | 3.2434 | 0.1117 | 0.0078 | 0.0014 |
| 3 | burr | -61.1513 | 3.3133 | 0.1079 | 0.0096 | 0.0018 |
| 4 | normal | -61.0919 | 3.3727 | 0.1047 | 0.0069 | 0.0024 |
| 5 | logistic | -61.0320 | 3.4326 | 0.1017 | 0.0062 | 0.0023 |
| 6 | weibull | -56.0281 | 8.4365 | 0.0083 | 0.0026 | 0.0017 |

Based on the goodness of fit, EPA moved forward with triangular and Gumbel distributions, and ultimately selected the Gumbel distribution for the dry weight data from the seedling emergence toxicity tests.




Triangular




**Gumbel (selected distribution)**

### *Seedling Emergence Survival Data*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0063 | 0.1608 |
| 2 | logistic | ML | 0.0054 | 0.0969 |
| 3 | triangular | ML | 0.0073 | 0.2048 |
| 4 | gumbel | ML | 0.0075 | 0.1898 |
| 5 | weibull | ML | 0.0040 | 0.2148 |
| 6 | burr | ML | 0.0075 | 0.1349 |

Percentile of interest: 5

Model-averaged HCp: 0.0066172

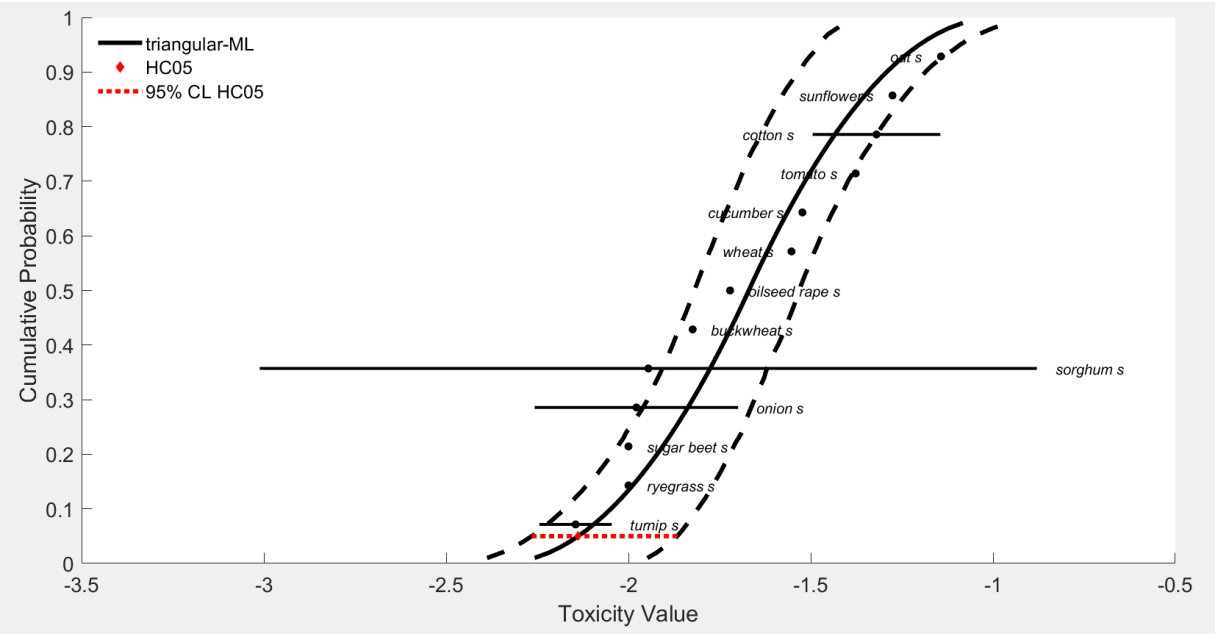
Model-averaged SE of HCp: 0.002212

CV of HCp: 0.33428

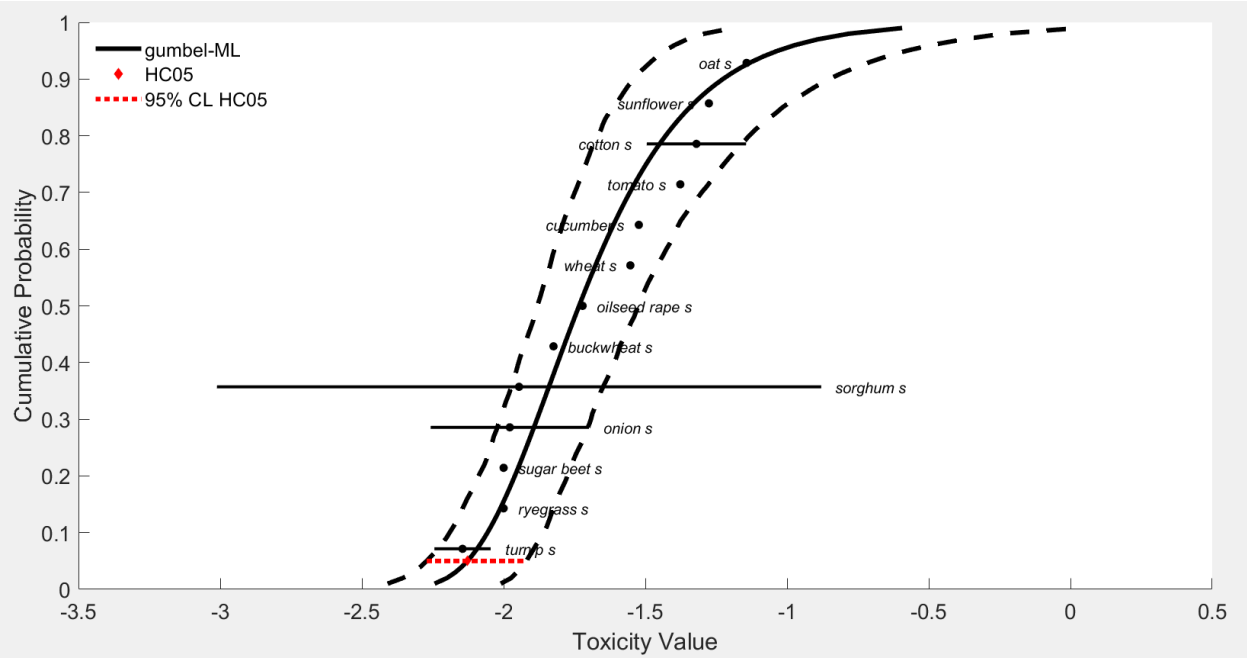
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -67.4217 | 0 | 0.3324 | 0.0073 | 0.0021 |
| 2 | gumbel | -66.6646 | 0.7571 | 0.2277 | 0.0075 | 0.0015 |
| 3 | normal | -66.3951 | 1.0266 | 0.1990 | 0.0063 | 0.0020 |
| 4 | weibull | -65.0353 | 2.3864 | 0.1008 | 0.0040 | 0.0021 |
| 5 | logistic | -65.0173 | 2.4044 | 0.0999 | 0.0054 | 0.0020 |
| 6 | burr | -63.1960 | 4.2257 | 0.0402 | 0.0075 | 0.0015 |

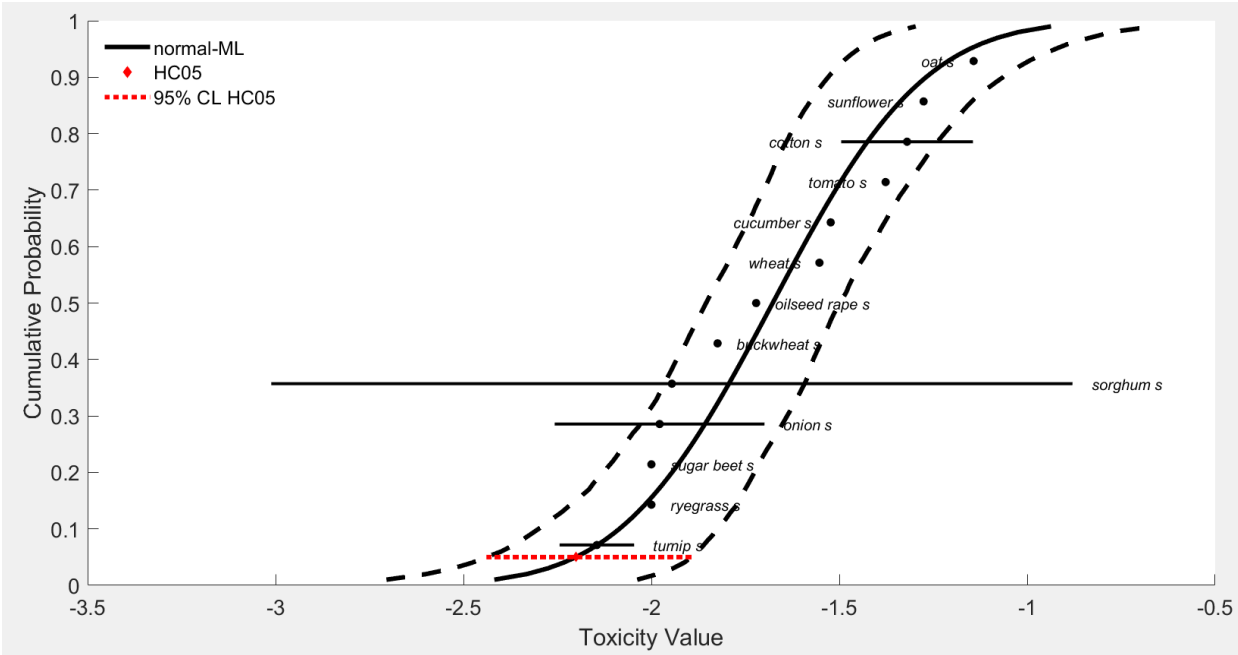
Based on the goodness of fit, EPA moved forward with triangular, Gumbel, and normal distributions, and ultimately selected the normal distribution for the survival data from the seedling emergence toxicity tests.




Triangular




Gumbel




**Normal (selected distribution)**

### *Vegetative Vigor Weight Data*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0026 | 0.7792 |
| 2 | logistic | ML | 0.0024 | 0.6563 |
| 3 | triangular | ML | 0.0029 | 0.8721 |
| 4 | gumbel | ML | 0.0029 | 0.4715 |
| 5 | weibull | ML | 0.0013 | 0.4116 |
| 6 | burr | ML | 0.0024 | 0.6134 |

Percentile of interest: 5

Model-averaged HCp: 0.002575

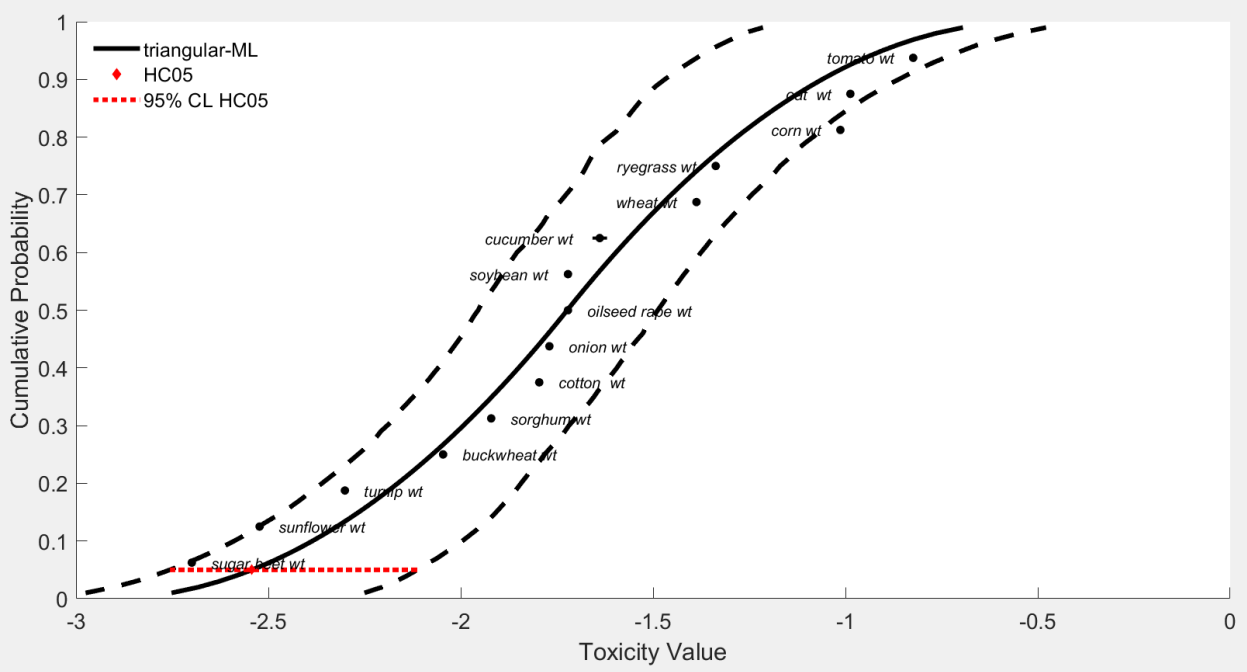
Model-averaged SE of HCp: 0.0012502

CV of HCp: 0.48549

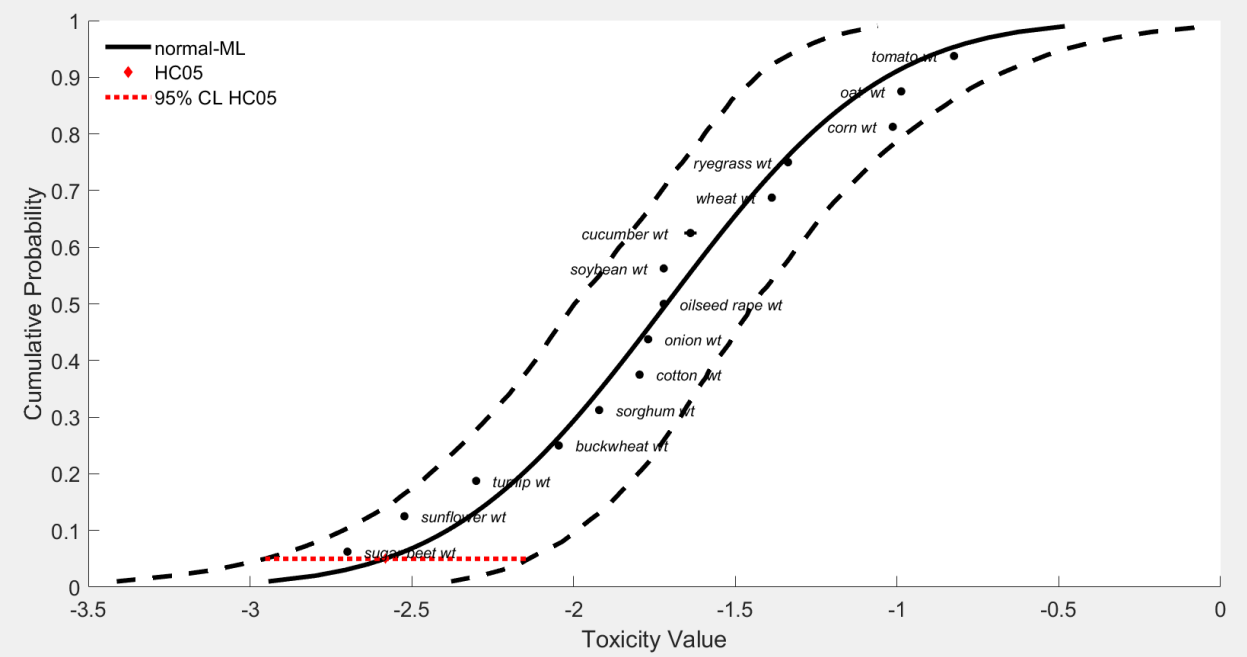
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -66.6932 | 0 | 0.4779 | 0.0029 | 0.0011 |
| 2 | normal | -64.7962 | 1.8970 | 0.1851 | 0.0026 | 0.0013 |
| 3 | logistic | -64.0663 | 2.6269 | 0.1285 | 0.0024 | 0.0013 |
| 4 | weibull | -63.8397 | 2.8536 | 0.1147 | 0.0013 | 0.0010 |
| 5 | gumbel | -62.7828 | 3.9105 | 0.0676 | 0.0029 | 9.6563e-04 |
| 6 | burr | -60.8849 | 5.8084 | 0.0262 | 0.0024 | 0.0017 |

Based on the goodness of fit, EPA moved forward with triangular and normal distributions, and ultimately selected the normal distribution for the weight data from the vegetative vigor toxicity tests.




Triangular




**Normal (selected distribution)**

## 11.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 11-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1] and the Magnitude of Difference at the Maximum Spray Buffer Distance**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 3.0 lb a.i./A (maximum application rate for use on sugarcane)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 450 | 300 | 250 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **3.1** [300] | **1.5** [300] | **1.5** [200] | **1.2** [200] | **1.0** [100] | 0.7 [100] | 0.5 [100] |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on asparagus[4] and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 700 | 325 | 225 | 175 | 75 | 50 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.1** [300] | **1.0** [300] | **1.0** [200] | 0.8 [200] | 0.6 [100] | 0.5 [100] | 0.3 [100] |
| **Application Rate of 1.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 325 | 200 | 125 | 100 | 50 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.0** [300] | 0.5 [300] | 0.5 [200] | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.2 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 7.9 µg a.i./L for freshwater green algae, *Pseudokirchneriella subcapitata* (MRID 43921001).

[2] For metribuzin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 11.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

[4] Aerial applications are not permitted for use on asparagus; however, 2 lb a.i./A could be a reduced application rate applied aerially for sugarcane. Therefore, the aerial spray drift results are presented in this table.

**Table 11-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 3.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 238.1 | 238.0 | 238.0 | 502.5 | 485.4 | 482.3 | 479.9 | 226.8 |
| 10 | 160.2 | 143.9 | 132.0 | 125.0 | 44.5 | 22.1 | 13.2 | 109.8 |
| 20 | 119.1 | 95.5 | 81.8 | 63.0 | 21.1 | 11.9 | 7.2 | 61.8 |
| 25 | 101.8 | 77.4 | 64.1 | 46.4 | 15.7 | 9.4 | 5.7 | 44.7 |
| 50 | 79.9 | 51.5 | 34.0 | 22.6 | 8.0 | 5.5 | 3.4 | 16.2 |
| 75 | 56.1 | 34.7 | 22.4 | 15.0 | 5.6 | 4.0 | 2.5 | 7.8 |
| 100 | 47.4 | 27.7 | 17.5 | 12.0 | 4.6 | 3.4 | 2.1 | 5.0 |
| 125 | 35.4 | 20.4 | 13.1 | 9.4 | 3.7 | 2.8 | 1.8 | 3.1 |
| 150 | 29.7 | 16.3 | 10.2 | 7.8 | 3.1 | 2.4 | 1.6 | 2.1 |
| 175 | 24.7 | 13.6 | 8.3 | 6.5 | 2.7 | 2.1 | 1.4 | 1.4 |
| 200 | 22.0 | 11.9 | 7.2 | 5.8 | 2.5 | 1.9 | 1.3 | 1.1 |
| 225 | 20.0 | 10.2 | 6.0 | 5.0 | 2.2 | 1.7 | 1.2 | 0.9 |
| 250 | 17.5 | 8.8 | 5.2 | 4.5 | 2.0 | 1.6 | 1.1 | 0.7 |
| 275 | 15.9 | 7.7 | 4.6 | 4.0 | 1.8 | 1.4 | 1.0 | 0.5 |
| 300 | 14.5 | 6.9 | 4.2 | 3.6 | 1.7 | 1.3 | 0.9 | 0.4 |
| 325 | 13.2 | 6.3 | 3.8 | 3.2 | 1.5 | 1.2 | 0.8 | 0.4 |
| 350 | 12.4 | 5.9 | 3.6 | 3.0 | 1.4 | 1.2 | 0.8 | 0.3 |
| 375 | 11.6 | 5.4 | 3.3 | 2.7 | 1.3 | 1.1 | 0.7 | 0.3 |
| 400 | 10.8 | 5.0 | 3.1 | 2.5 | 1.3 | 1.0 | 0.7 | 0.2 |
| 500 | 8.9 | 4.1 | 2.5 | 1.4 | 0.5 | 0.4 | 0.3 | 0.1 |
| 600 | 7.7 | 3.6 | 2.1 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 700 | 6.9 | 3.2 | 1.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 800 | 6.4 | 2.9 | 1.7 | 0.6 | 0.3 | 0.2 | 0.2 | <0.1 |
| 900 | 6.0 | 2.7 | 1.6 | 0.5 | 0.3 | 0.2 | 0.2 | <0.1 |
| 1000 | 5.6 | 2.6 | 1.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0063 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 11-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 3.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 115.4 | 115.4 | 115.4 | 243.5 | 235.2 | 233.7 | 232.6 | 109.9 |
| 10 | 77.7 | 69.7 | 64.0 | 60.6 | 21.6 | 10.7 | 6.4 | 53.2 |
| 20 | 57.7 | 46.3 | 39.7 | 30.5 | 10.2 | 5.8 | 3.5 | 30.0 |
| 25 | 49.3 | 37.5 | 31.1 | 22.5 | 7.6 | 4.6 | 2.8 | 21.6 |
| 50 | 38.7 | 24.9 | 16.5 | 10.9 | 3.9 | 2.7 | 1.6 | 7.9 |
| 75 | 27.2 | 16.8 | 10.9 | 7.3 | 2.7 | 1.9 | 1.2 | 3.8 |
| 100 | 23.0 | 13.4 | 8.5 | 5.8 | 2.2 | 1.6 | 1.0 | 2.4 |
| 125 | 17.1 | 9.9 | 6.3 | 4.6 | 1.8 | 1.4 | 0.9 | 1.5 |
| 150 | 14.4 | 7.9 | 4.9 | 3.8 | 1.5 | 1.2 | 0.8 | 1.0 |
| 175 | 12.0 | 6.6 | 4.0 | 3.2 | 1.3 | 1.0 | 0.7 | 0.7 |
| 200 | 10.7 | 5.8 | 3.5 | 2.8 | 1.2 | 0.9 | 0.6 | 0.6 |
| 225 | 9.7 | 4.9 | 2.9 | 2.4 | 1.1 | 0.8 | 0.6 | 0.4 |
| 250 | 8.5 | 4.3 | 2.5 | 2.2 | 1.0 | 0.8 | 0.5 | 0.3 |
| 275 | 7.7 | 3.8 | 2.2 | 1.9 | 0.9 | 0.7 | 0.5 | 0.3 |
| 300 | 7.0 | 3.3 | 2.0 | 1.7 | 0.8 | 0.6 | 0.4 | 0.2 |
| 325 | 6.4 | 3.0 | 1.8 | 1.6 | 0.7 | 0.6 | 0.4 | 0.2 |
| 350 | 6.0 | 2.8 | 1.7 | 1.4 | 0.7 | 0.6 | 0.4 | 0.2 |
| 375 | 5.6 | 2.6 | 1.6 | 1.3 | 0.7 | 0.5 | 0.4 | 0.1 |
| 400 | 5.2 | 2.4 | 1.5 | 1.2 | 0.6 | 0.5 | 0.3 | 0.1 |
| 500 | 4.3 | 2.0 | 1.2 | 0.7 | 0.2 | 0.2 | 0.1 | 0.1 |
| 600 | 3.7 | 1.7 | 1.0 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 700 | 3.3 | 1.5 | 0.9 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 800 | 3.1 | 1.4 | 0.8 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.9 | 1.3 | 0.8 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 2.7 | 1.2 | 0.7 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 11-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 158.7 | 158.7 | 158.7 | 335.0 | 323.6 | 321.5 | 320.0 | 151.2 |
| 10 | 106.8 | 95.9 | 88.0 | 83.3 | 29.7 | 14.7 | 8.8 | 73.2 |
| 20 | 79.4 | 63.6 | 54.5 | 42.0 | 14.1 | 7.9 | 4.8 | 41.2 |
| 25 | 67.9 | 51.6 | 42.8 | 30.9 | 10.4 | 6.3 | 3.8 | 29.8 |
| 50 | 53.3 | 34.3 | 22.7 | 15.0 | 5.3 | 3.7 | 2.3 | 10.8 |
| 75 | 37.4 | 23.2 | 14.9 | 10.0 | 3.7 | 2.7 | 1.7 | 5.2 |
| 100 | 31.6 | 18.5 | 11.7 | 8.0 | 3.1 | 2.2 | 1.4 | 3.4 |
| 125 | 23.6 | 13.6 | 8.7 | 6.3 | 2.5 | 1.9 | 1.2 | 2.1 |
| 150 | 19.8 | 10.9 | 6.8 | 5.2 | 2.1 | 1.6 | 1.0 | 1.4 |
| 175 | 16.5 | 9.1 | 5.5 | 4.3 | 1.8 | 1.4 | 0.9 | 1.0 |
| 200 | 14.7 | 7.9 | 4.8 | 3.9 | 1.6 | 1.3 | 0.8 | 0.8 |
| 225 | 13.3 | 6.8 | 4.0 | 3.4 | 1.5 | 1.2 | 0.8 | 0.6 |
| 250 | 11.7 | 5.9 | 3.5 | 3.0 | 1.3 | 1.0 | 0.7 | 0.4 |
| 275 | 10.6 | 5.2 | 3.1 | 2.6 | 1.2 | 1.0 | 0.6 | 0.4 |
| 300 | 9.6 | 4.6 | 2.8 | 2.4 | 1.1 | 0.9 | 0.6 | 0.3 |
| 325 | 8.8 | 4.2 | 2.5 | 2.1 | 1.0 | 0.8 | 0.6 | 0.2 |
| 350 | 8.3 | 3.9 | 2.4 | 2.0 | 1.0 | 0.8 | 0.5 | 0.2 |
| 375 | 7.7 | 3.6 | 2.2 | 1.8 | 0.9 | 0.7 | 0.5 | 0.2 |
| 400 | 7.2 | 3.4 | 2.1 | 1.7 | 0.8 | 0.7 | 0.5 | 0.1 |
| 500 | 5.9 | 2.7 | 1.7 | 0.9 | 0.3 | 0.3 | 0.2 | 0.1 |
| 600 | 5.1 | 2.4 | 1.4 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 700 | 4.6 | 2.1 | 1.3 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 800 | 4.2 | 1.9 | 1.1 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 900 | 4.0 | 1.8 | 1.1 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 1000 | 3.8 | 1.7 | 1.0 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0063 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 11-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 76.9 | 76.9 | 76.9 | 162.3 | 156.8 | 155.8 | 155.1 | 73.3 |
| 10 | 51.8 | 46.5 | 42.7 | 40.4 | 14.4 | 7.1 | 4.3 | 35.5 |
| 20 | 38.5 | 30.8 | 26.4 | 20.4 | 6.8 | 3.8 | 2.3 | 20.0 |
| 25 | 32.9 | 25.0 | 20.7 | 15.0 | 5.1 | 3.0 | 1.8 | 14.4 |
| 50 | 25.8 | 16.6 | 11.0 | 7.3 | 2.6 | 1.8 | 1.1 | 5.2 |
| 75 | 18.1 | 11.2 | 7.2 | 4.8 | 1.8 | 1.3 | 0.8 | 2.5 |
| 100 | 15.3 | 8.9 | 5.7 | 3.9 | 1.5 | 1.1 | 0.7 | 1.6 |
| 125 | 11.4 | 6.6 | 4.2 | 3.0 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.6 | 5.3 | 3.3 | 2.5 | 1.0 | 0.8 | 0.5 | 0.7 |
| 175 | 8.0 | 4.4 | 2.7 | 2.1 | 0.9 | 0.7 | 0.4 | 0.5 |
| 200 | 7.1 | 3.8 | 2.3 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.5 | 3.3 | 1.9 | 1.6 | 0.7 | 0.6 | 0.4 | 0.3 |
| 250 | 5.7 | 2.8 | 1.7 | 1.4 | 0.6 | 0.5 | 0.3 | 0.2 |
| 275 | 5.1 | 2.5 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.7 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 4.0 | 1.9 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.7 | 1.7 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.5 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.9 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.2 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.1 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.8 | 0.8 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 11-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 79.4 | 79.3 | 79.3 | 167.5 | 161.8 | 160.8 | 160.0 | 75.6 |
| 10 | 53.4 | 48.0 | 44.0 | 41.7 | 14.8 | 7.4 | 4.4 | 36.6 |
| 20 | 39.7 | 31.8 | 27.3 | 21.0 | 7.0 | 4.0 | 2.4 | 20.6 |
| 25 | 33.9 | 25.8 | 21.4 | 15.5 | 5.2 | 3.1 | 1.9 | 14.9 |
| 50 | 26.6 | 17.2 | 11.3 | 7.5 | 2.7 | 1.8 | 1.1 | 5.4 |
| 75 | 18.7 | 11.6 | 7.5 | 5.0 | 1.9 | 1.3 | 0.8 | 2.6 |
| 100 | 15.8 | 9.2 | 5.8 | 4.0 | 1.5 | 1.1 | 0.7 | 1.7 |
| 125 | 11.8 | 6.8 | 4.4 | 3.1 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.9 | 5.4 | 3.4 | 2.6 | 1.0 | 0.8 | 0.5 | 0.7 |
| 175 | 8.2 | 4.5 | 2.8 | 2.2 | 0.9 | 0.7 | 0.5 | 0.5 |
| 200 | 7.3 | 4.0 | 2.4 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.7 | 3.4 | 2.0 | 1.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| 250 | 5.8 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.4 | 0.2 |
| 275 | 5.3 | 2.6 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.8 | 2.3 | 1.4 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 |
| 325 | 4.4 | 2.1 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 4.1 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.9 | 1.8 | 1.1 | 0.9 | 0.4 | 0.4 | 0.2 | 0.1 |
| 400 | 3.6 | 1.7 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 3.0 | 1.4 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.6 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.3 | 1.1 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.0 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 1000 | 1.9 | 0.9 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0063 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 11-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | F-M | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 38.5 | 38.5 | 38.5 | 81.2 | 78.4 | 77.9 | 77.5 | 36.6 |
| 10 | 25.9 | 23.2 | 21.3 | 20.2 | 7.2 | 3.6 | 2.1 | 17.7 |
| 20 | 19.2 | 15.4 | 13.2 | 10.2 | 3.4 | 1.9 | 1.2 | 10.0 |
| 25 | 16.4 | 12.5 | 10.4 | 7.5 | 2.5 | 1.5 | 0.9 | 7.2 |
| 50 | 12.9 | 8.3 | 5.5 | 3.6 | 1.3 | 0.9 | 0.5 | 2.6 |
| 75 | 9.1 | 5.6 | 3.6 | 2.4 | 0.9 | 0.6 | 0.4 | 1.3 |
| 100 | 7.7 | 4.5 | 2.8 | 1.9 | 0.7 | 0.5 | 0.3 | 0.8 |
| 125 | 5.7 | 3.3 | 2.1 | 1.5 | 0.6 | 0.5 | 0.3 | 0.5 |
| 150 | 4.8 | 2.6 | 1.6 | 1.3 | 0.5 | 0.4 | 0.3 | 0.3 |
| 175 | 4.0 | 2.2 | 1.3 | 1.1 | 0.4 | 0.3 | 0.2 | 0.2 |
| 200 | 3.6 | 1.9 | 1.2 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 225 | 3.2 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 250 | 2.8 | 1.4 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 275 | 2.6 | 1.3 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 300 | 2.3 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 325 | 2.1 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 350 | 2.0 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 375 | 1.9 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 400 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.4 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 1.2 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.1 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 1.0 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 1.0 | 0.4 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 12 Oxyfluorfen Case Study Example (PC Code 111601)

## 12.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 12.2 Use Information

Oxyfluorfen is a light-dependent peroxidizing herbicide (LDPH) in the diphenyl ether chemical class used for control of monocotyledonous (monocot) and broadleaf weeds at pre- and post-emergence of crops. Oxyfluorfen must contact plant foliage to cause effects and is not translocated in plants, thus damage is normally limited to the areas it contacts. Oxyfluorfen is generally applied as foliar spray or soil treatment using ground or aerial methods (for use on fallow fields and garlic only), banded treatment, or chemigation applications; ground spray is the primary application method.

**Table 12-1** includes the use information from the 2019 Draft Risk Assessment for Registration Review (DRA; DP445743). EPA only included the agricultural uses which were evaluated in this DRA in the draft Strategy. As this is an illustrative example of how the draft Strategy would be implemented for oxyfluorofen, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Proposed Interim Decision in July 2021) are not considered at this time

but would be considered when EPA conducts assessments for oxyfluorfen for regulatory decisions using the final Herbicide Strategy. **Table 12-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 12.6** of this document. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on corn is the Corn UDL and the UDL for use on artichoke is the Vegetables and Ground Fruit UDL. Information about the UDL assignments can be found in **Section 5**.

EPA estimated exposures using the selected[159] uses and application information provided in **Table 12-1**. The selected uses do not necessarily represent all registered uses of oxyfluorfen and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where oxyfluorfen usage is most common. Note that coffee is a labeled use of oxyfluorfen; however, coffee is not grown in the conterminous United States (CONUS), and therefore EPA did not evaluate this use further as part of the draft Strategy. The selected uses are examples to illustrate the draft Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of oxyfluorfen as this application method represents the greatest source of potential offsite movement. Although granular formulations of oxyfluorfen are registered for non-agricultural use sites (*e.g.,* nurseries), spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

**Table 12-1. Summary of the Selected Agricultural Use Patterns Labeled for Oxyfluorfen (2019 Draft Risk Assessment for Registration Review, DP445743)[1]**

| Use Site/ Location | App Target | App Type[2] | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d)[3] |
|---|---|---|---|---|---|---|---|---|
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | | | |
| Artichoke | Foliage/Plant | Broad | G | Pre/Post | 1.5 | 1 | 1.5 | NA |
| Beans | Foliage/Plant | Broad | G | Pre | 0.25 | 6 | 1.5 | 14 |
| Berry | Foliage/Plant | Broad, BT | G | Pre/Post | 1 | 2 | 0.013 | 14 |
| Broccoli | Foliage/Plant | Broad | G | Pre | 0.25 | 1 | 0.25 | NA |
| Cabbage | Foliage/Plant | Broad | G | Pre/Post | 0.5 | 1 | 0.5 | NA |
| Fruiting Vegetables | Foliage/Plant | Broad | G | Pre/Post | 0.25 | 1 | 0.25 | NA |
| Garlic | Foliage/Plant | Broad | A[4], G | Pre/Post | 0.5 | 1 | 0.5 | NA |

[159] The uses evaluated as part of the proposed Herbicide Strategy were consistent with the agricultural uses that were evaluated in the 2019 Draft Risk Assessment for Registration Review (DP445743) for oxyfluorfen. Any uses not evaluated in the 2019 assessment and any new uses since this assessment are not included in this example case study for the Herbicide Strategy.

| Use Site/ Location | App Target | App Type[2] | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d)[3] |
|---|---|---|---|---|---|---|---|---|
| Onion | Foliage/Plant | Broad, BT, C | G | Pre/Post | 0.5 | 1 | 0.5 | NA |
| **Citrus Use Data Layer** | | | | | | | | |
| Citrus | Foliage/Plant | Broad | G | Pre/Post | 1.5 | 1 | 1.5 | NA |
| **Other Orchards Use Data Layer** | | | | | | | | |
| Coffee[5] | Foliage/Plant | Broad | G | Pre/Post | 2 | 3 | 6 | 14 |
| Pome Fruit | Foliage/Plant | Broad, BT, C | G | Pre/Post | 1.5 | 1 | 1.5 | NA |
| Stone Fruit | Foliage/Plant | Broad, BT, C | G | Pre/Post | 1.5 | 1 | 1.5 | NA |
| Tree Nut | Foliage/Plant | Broad, BT, C | G | Pre/Post | 1.5 | 1 | 1.5 | NA |
| **Corn Use Data Layer** | | | | | | | | |
| Corn | Foliage/Plant | Broad | G | Post | 0.5 | 3 | 1.5 | 14 |
| Corn | Foliage/Plant | Broad | G | Pre | 0.75 | 2 | 1.5 | 14 |
| **Cotton Use Data Layer** | | | | | | | | |
| Cotton | Foliage/Plant | Broad, BT | G | Post | 0.5 | 2 | 1 | 14 |
| **Grapes Use Data Layer** | | | | | | | | |
| Grape | Foliage/Plant | Broad, BT, C | G | Pre/Post | 2 | 1 | 2 | NA |
| **Soybeans Use Data Layer** | | | | | | | | |
| Soybean | Foliage/Plant | Broad | G | Pre/Post | 0.5 | 3 | 1.5 | 14 |

App=application; equip=equipment; MRI = Minimum retreatment interval; BT=banded treatment; Broad = broadcast; G=ground; A=aerial; ai=active ingredient; NA=not applicable; d=day.

[1] The use information presented in this table is identical to the agricultural uses included in the 2019 Draft Risk Assessment for Registration Review (DP445743).

[2] EPA modeled broadcast ground spray applications in the PRA (USEPA, 2019; DP445743). Crops such as berries, cotton, forestry, grape, onion, pome fruit, stone fruit and tree nut also have banded treatment or chemigation applications, but exposure concentrations are not expected to exceed those modeled from ground spray scenarios.

[3] Not specified; assumed to be 14 days.

[4] The only agricultural crops with aerial applications are use on fallow fields at 0.5 lb a.i./A (not assessed in the 2019 Draft Risk Assessment, DP445743), use on fallow fields prior to planting corn at 0.5 lb a.i./A (not assessed in the 2019 Draft Risk Assessment, DP445743), and use on garlic in California at 0.25 lb a.i./A.

[5] Coffee is not grown within CONUS (the conterminous United States), so although it is presented as a use in this table, mitigations for use on coffee will not be identified as part of the draft Strategy.

## 12.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of oxyfluorfen (**Section 12.3.1**), reported incidents (**Section 12.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 12.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 12.3.1 Toxicity Information

**Table 12-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for oxyfluorfen.

**Table 12-2. Summary of the Most Sensitive Toxicity Endpoints for Oxyfluorfen (As Summarized in the 2019 Draft Risk Assessment for Registration Review (DP445743) and Response to Comments (DP456510))**

| Toxicity Test | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence[1] | Monocot: Ryegrass (*Lolium perenne*) | NOAEC = 0.030 lb a.i./A<br>$IC_{25}$ = 0.063 lb a.i./A | 45861101 Acceptable | Effect based on decreased dry weight; 42-85% reduction. |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.0080 lb a.i./A<br>$IC_{25}$ = 0.0072 lb a.i./A | | Effect based on decreased dry weight; 47-83% reduction |
| Vegetative Vigor[1] | Monocot: Oat (*Avena sativa*) | NOAEC = 0.22 lb a.i./A<br>$IC_{25}$ = 0.27 lb a.i./A | 45861102 Acceptable | Effect based on decreased dry weight, 53% reduction |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.000035 lb a.i./A<br>$IC_{25}$ = 0.0078 lb a.i./A | | Effect based on decreased dry weight, 24-41% reduction |
| Aquatic Vascular Plant | **Duckweed (*Lemna gibba*)** | NOAEC < 0.1 µg a.i./L<br>**$IC_{50}$ = 0.33 µg a.i./L** | 45861103 Supplemental | $IC_{50}$ based on decreased frond number<br><br>Supplemental due to low recovery, resulting in uncertain exposure concentrations |
| Aquatic Nonvascular Plant | **Marine diatom (*Skeletonema costatum*)** | NOAEC = 0.65 µg a.i./L<br>**$IC_{50}$ = 1.1 µg a.i./L** | 45861106 Supplemental | $IC_{50}$ based on decreased biomass (area under the curve)<br><br>Supplemental due to uncertain exposure concentrations due to low recovery |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}$/$IC_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the oxyfluorfen seedling emergence and vegetative vigor tests. See **Figure 12-1** and **Table 12-3** for the SSD results.

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). See Appendix 1: Species Sensitivity Distribution Data (SSD) and Results for

the data used to generate the SSDs and Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints for the process for calculating the SSDs. In total, EPA calculated four SSDs for oxyfluorfen by combining the results for the tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to oxyfluorfen. Specifically, as summarized in Appendix 1: Species Sensitivity Distribution Data (SSD) and Results, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the seedling emergence and vegetative vigor (height data only) studies typically overlap when considering all definitive values available. Additionally, the mean and median $IC_{25}$ values for monocot and dicot height data only differ by factors of 4 and 9, respectively, when EPA compared the data within the same test design (seedling emergence or vegetative vigor). Similarly, the mean and median $IC_{25}$ values for monocot and dicot dry weight only differ by factors of 3.5 and 2, respectively, based on the seedling emergence study. The most dissimilar toxicity data for monocots and dicots are for the dry weights measured in the vegetative vigor study where the mean and median $IC_{25}$ values differ by factors of 10 and 22 without overlapping ranges of $IC_{25}$ values. However, because the dry weight data from the vegetative vigor study did not provide the most sensitive 25$^{th}$ percentile of the SSD, EPA determined that it was still appropriate to combine monocots and dicots to generate the four SSDs.

**Figure 12-1** the four SSDs that EPA generated. The SSD based on the seedling emergence weight data resulted in the most sensitive 25$^{th}$ percentile $IC_{25}$ values (represented as red and black dots **Figure 12-1** respectively). EPA used the resulting most sensitive 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values from the SSD to calculate the ratio of EEC to toxicity endpoint (**Table 12-3** and **Table 12-4**; see **Section 12.3.3**)[160]. By combining the monocot and dicot data, these 5$^{th}$ and 25$^{th}$ percentile values represent the sensitivities of both types of flowering plants to oxyfluorfen.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[161] are available to evaluate potential impacts of oxyfluorfen on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 12-2**and **Table 12-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[162].

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[160] Although the 5$^{th}$ percentile of the SSD is more sensitive for vegetative vigor weight data, EPA selected the SSD for this case study example based on the most sensitive 25$^{th}$ percentile of the SSD.
[161] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158
[162] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1** in the **Case Study Summary and Process** document.

**Table 12-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Oxyfluorfen**

| Percentile | Seedling Emergence Test | | Vegetative Vigor Test | |
|---|---|---|---|---|
| | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A |
| 5 | **0.0048** (0.022 – 0.017) | 0.0058 (0.0015 – 0.029) | 0.0035 (0.00083 – 0.022) | 0.027 (0.0030 – 0.24) |
| 25 | **0.013** (0.0064 – 0.038) | 0.024 (0.0087 – 0.077) | 0.017 (0.0056 – 0.064) | 0.166 (0.0.045 – 0.58) |
| 50 | 0.033 (0.014 – 0.11) | 0.066 (0.024 – 0.17) | 0.053 (0.018 – 0.16) | 0.421 (0.15 – 0.98) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

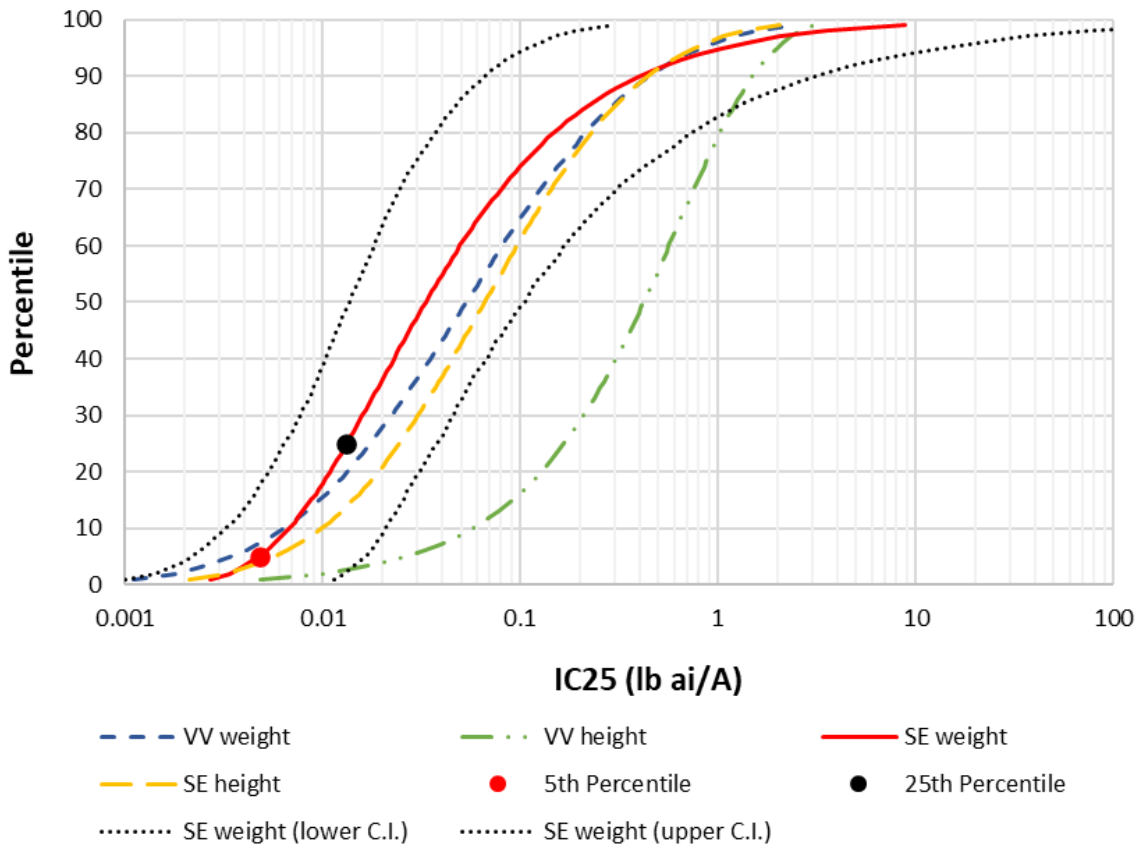


**Figure 12-1. Vegetative Vigor (VV) and Seedling Emergence (SE) Study Species Sensitivity Distributions (SSD) representing the Distributions of the Plant Height and Weight IC25s for Oxyfluorfen. The Upper and Lower Confidence Intervals (C.I.) are plotted for the SE plant weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 12.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on these plants[163], EPA calculated the magnitude of difference as a ratio of the EEC to the 5$^{th}$ percentile of the seedling emergence plant weight SSD (**Table 12-4)**. For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[164] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25$^{th}$ percentile of the SSD (**Table 12-4)**. For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Table 12-4**).

**Table 12-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Oxyfluorfen**[1]

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.0048 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.0048 lb a.i./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.0048 lb a.i./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.0048 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.0048 lb a.i./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.013 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 0.013 lb a.i./A |
| | | Based on aquatic plant endpoints: 0.33 µg a.i./L (Vascular) 1.1 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 0.33 µg a.i./L Nonvascular: 1.1 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Strategy. In this case study for oxyfluorfen, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.

[163] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.

[164] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 12.3.2 Incidents

The incident information from the 2019 Draft Risk Assessment for Registration Review (DP445743) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[165] (as discussed in **Section 12.3.3.3**), which informs the potential population-level impacts (**Section 12.6**), and to identify the proposed level of mitigation (see **Section 12.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 9.3.3.36.3.3.3)**.[166] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the reported ecological incidents associated with pesticides, including those that have been aggregately reported to the EPA. EPA searched the IDS in August 2018 for inclusion in the 2019 Draft Risk Assessment for Registration

[165] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.
[166] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

Review (DP445743). This search excluded incidents classified as 'unlikely' or 'unrelated' and only includes those incidents with certainty categories of 'possible', 'probable', and 'highly probable'. Also excluded were incidents due to misuse. Between 1996 and 2016, 15 incidents involving oxyfluorfen were reported to EPA. All incident reports involved effects to plants. The certainty categories regarding the likelihood that the use of oxyfluorfen caused the 15 incidents range from 'possible' (12 incidents) to 'probable' (3 incidents). Ten of the incidents were considered registered uses at the time of the incident, and the legality of use is undetermined in 5 incidents. Four of the incident reports involve additional chemicals besides oxyfluorfen, one for a registered use. In The 2019 assessment included the 15 incident reports.

In addition to the incidents recorded in IDS, additional incidents are reported to the Agency in aggregate form. Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. Ecological incidents reported in aggregate reports include those categorized as 'minor fish and wildlife', 'minor plant', and 'other non-target' incidents. For oxyfluorfen, registrants have reported 56 minor plant incidents. Forty-six of these incidents involved at least one other chemical other than oxyfluorfen. These incidents are assumed to be representative of registered uses of oxyfluorfen.

Because the incidents of oxyfluorfen damage to non-target plants are not numerous, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for oxyfluorfen. In other words, the oxyfluorfen incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 12.3.3.3**) are unaltered by the available oxyfluorfen incident data.

### 12.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *12.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 12-5** demonstrates the impact of each of these variables on drift

exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of oxyfluorfen ($5^{th}$ percentile of SSD = 0.0048 lb a.i./A). **Table 12-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of oxyfluorfen ($25^{th}$ percentile of SSD = 0.013 lb a.i./A). Within **Table 12-5** and **Table 12-6** the modeled application rates are representative of the maximum single application rate currently registered for oxyfluorfen use on grape (2.0 lb a.i./A) and reduced rates (1.5, 0.75, 0.50, and 0.25 lb a.i./A)[167] representative of maximum single application rates for other uses (**Table 12-1**) . **Table 12-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 12-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 12.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 12.9**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

[167] Aerial applications of oxyfluorfen are permitted only for use on fallow fields at 0.5 lb a.i./A, fallow fields prior to planting corn at 0.5 lb a.i./A, and garlic in California at 0.25 lb a.i./A.

**Table 12-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on grape)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 575 | 425 | 350 | 225 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **5.1** [200] | **4.0** [100] | **2.9** [100] | **1.9** [100] |
| **Application Rate of 1.5 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 500 | 325 | 250 | 150 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **3.8** [200] | **3.0** [100] | **2.2** [100] | **1.4** [100] |
| **Application Rate of 0.75 lb a.i./A (maximum application rate for use on corn and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 350 | 150 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **1.9** [200] | **1.5** [100] | **1.1** [100] | 0.7 [100] |
| **Application Rate of 0.50 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 450 | 275 | 250 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **3.2** [300] | **1.5** [300] | **1.6** [200] | **1.3** [200] | **1.0** [100] | 0.7 [100] | 0.5 [100] |
| **Application Rate of 0.25 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 500 | 250 | 175 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.6** [300] | 0.8 [300] | 0.8 [200] | 0.6 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation is should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For oxyfluorfen, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 12.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25 ft, the distance in this table is rounded to the nearest 25 ft. **Section 12.9** contains the full output of results.

**Table 12-6. Spray Drift Distances to the Population-Level Effects Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on grape)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 375 | 175 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **1.9** [200] | **1.5** [100] | **1.1** [100] | 0.7 [100] |
| **Application Rate of 1.5 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 300 | 125 | 100 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **1.4** [200] | **1.1** [100] | 0.8 [100] | 0.5 [100] |
| **Application Rate of 0.75 lb a.i./A (maximum application rate for use on corn and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 150 | 75 | 50 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | 0.7 [200] | 0.6 [100] | 0.4 [100] | 0.3 [100] |
| **Application Rate of 0.50 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 375 | 225 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.2** [300] | 0.6 [300] | 0.6 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 0.25 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | **F-M** | **M-C** | **C-VC** | **VF-F High Boom** | **VF-F Low Boom** | **F-MC High Boom** | **F-MC Low Boom** |
| Distance to Medium MoE[2,3] (ft) | 200 | 125 | 75 | 50 | 20 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For oxyfluorfen, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 12.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance in this table is rounded to the nearest 25 ft for summarization purposes. **Section 12.9** contains the full output of results.

#### *12.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 12-7** through **Table 12-11** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 12-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 6.2 – 18 | 19 – 55 | 5.6 – 16 |
| Beans | 10 – 11 | 31 – 33 | 9.4 – 10 |
| Berry | 8.0 – 13 | 24 – 41 | 7.3 – 12 |
| Broccoli | 2.4 | 7.3 | 2.2 |
| Cabbage | 2.9 – 3.5 | 8.8 – 11 | 2.6 – 3.2 |
| Citrus | 5.2 – 13 | 16 – 39 | 4.7 – 12 |
| Corn | 10 – 18 | 31 – 53 | 9.4 – 16 |
| Cotton | 2.8 – 8.6 | 8.5 – 26 | 2.5 – 7.8 |
| Fruiting Vegetables | 0.9 – 2.3 | 2.7 – 7.0 | 0.8 – 2.1 |
| Garlic | 1.8 – 2.0 | 5.5 – 6.1 | 1.6 – 1.8 |
| Grape | 7.3 – 20 | 22 – 60 | 6.6 – 18 |
| Onion | 1.8 – 4.9 | 5.5 – 15 | 1.6 – 4.5 |
| Pome Fruit | 7.3 – 11 | 22 – 32 | 6.6 – 9.7 |
| Soybean | 5.1 – 5.6 | 16 – 17 | 4.6 – 5.1 |
| Stone Fruit | 9.1 – 12 | 28 – 37 | 8.3 – 11 |
| Tree Nuts | 6.5 – 13 | 20 – 40 | 5.9 – 12 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for oxyfluorfen, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 12-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 1.7 – 3.8 | 350 – 790 | 81 – 96 | 250 – 290 | 74 – 88 |
| Beans | 1.4 – 1.7 | 290 – 350 | 23 – 23 | 69 – 70 | 21 – 21 |
| Berry | 1.3 – 1.8 | 270 – 380 | 44 – 61 | 130 – 190 | 40 – 56 |
| Broccoli | 0.4 | 83 | 14 | 42 | 13 |
| Cabbage | 0.4 | 83 | 22 – 30 | 67 – 91 | 20 – 27 |
| Citrus | 0.8 – 1.3 | 170 – 270 | 92 – 93 | 280 – 280 | 84 – 85 |
| Corn | 1.6 – 6.1 | 330 – 1300 | 42 – 57 | 130 – 170 | 38 – 51 |
| Cotton | 0.7 – 3.2 | 150 – 670 | 31 – 38 | 93 – 110 | 28 – 34 |
| Fruiting Vegetables | 0.1 – 0.4 | 21 – 83 | 11 – 15 | 34 – 46 | 10 – 14 |
| Garlic | 0.3 – 0.4 | 63 – 83 | 19 – 31 | 56 – 95 | 17 – 28 |
| Grape | 1.3 – 5.1 | 270 – 1100 | 80 – 130 | 240 – 390 | 73 – 120 |
| Onion | 0.3 – 0.6 | 63 – 130 | 19 – 31 | 59 – 92 | 18 – 28 |
| Pome Fruit | 0.9 – 2.7 | 190 – 560 | 56 – 87 | 170 – 260 | 51 – 79 |
| Soybean | 0.8 – 1.0 | 170 – 210 | 23 – 27 | 69 – 83 | 21 – 25 |
| Stone Fruit | 1.2 – 3.4 | 250 – 710 | 64 – 90 | 190 – 270 | 58 – 82 |
| Tree Nuts | 1.0 – 1.6 | 210 – 330 | 55 – 91 | 170 – 280 | 50 – 83 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 12-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Artichoke | 1.7 – 3.8 | 130 – 290 |
| Beans | 1.4 – 1.7 | 110 – 130 |
| Berry | 1.3 – 1.8 | 100 – 140 |
| Broccoli | 0.4 | 31 |
| Cabbage | 0.4 | 31 |
| Citrus | 0.8 – 1.3 | 62 – 100 |
| Corn | 1.6 – 6.1 | 120 – 470 |
| Cotton | 0.7 – 3.2 | 54 – 250 |
| Fruiting Vegetables | 0.1 – 0.4 | 7.7 – 31 |
| Garlic | 0.3 – 0.4 | 23 – 31 |
| Grape | 1.3 – 5.1 | 100 – 390 |
| Onion | 0.3 – 0.6 | 23 – 46 |
| Pome Fruit | 0.9 – 2.7 | 69 – 210 |
| Soybean | 0.8 – 1.0 | 62 – 77 |
| Stone Fruit | 1.2 – 3.4 | 92 – 260 |
| Tree Nuts | 1.0 – 1.6 | 77 – 120 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 12-8**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

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**Table 12-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 0.7 – 1.8 | 150 – 380 |
| Beans | 1.1 | 230 |
| Berry | 1.0 – 1.4 | 210 – 290 |
| Broccoli | 0.2 | 42 |
| Cabbage | 0.4 | 83 |
| Citrus | 0.6 – 1.2 | 130 – 250 |
| Corn | 1.1 – 2.2 | 230 – 460 |
| Cotton | 0.5 – 1.3 | 100 – 270 |
| Fruiting Vegetables | 0.1 – 0.2 | 21 – 42 |
| Garlic | 0.2 – 0.3 | 42 – 63 |
| Grape | 0.8 – 2.2 | 170 – 460 |
| Onion | 0.2 – 0.4 | 42 – 83 |
| Pome Fruit | 0.7 – 1.2 | 150 – 250 |
| Soybean | 0.5 | 100 |
| Stone Fruit | 0.9 – 1.3 | 190 – 270 |
| Tree Nuts | 0.7 – 1.1 | 150 – 230 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 12-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 0.7 – 1.8 | 54 – 140 |
| Beans | 1.1 | 85 |
| Berry | 1.0 – 1.4 | 77 – 110 |
| Broccoli | 0.2 | 15 |
| Cabbage | 0.4 | 31 |
| Citrus | 0.6 – 1.2 | 46 – 92 |
| Corn | 1.1 – 2.2 | 85 – 170 |
| Cotton | 0.5 – 1.3 | 39 – 100 |
| Fruiting Vegetables | 0.1 – 0.2 | 7.7 – 15 |
| Garlic | 0.2 – 0.3 | 15 – 23 |
| Grape | 0.8 – 2.2 | 62 – 170 |
| Onion | 0.2 – 0.4 | 15 – 31 |
| Pome Fruit | 0.7 – 1.2 | 54 – 92 |
| Soybean | 0.5 | 39 |
| Stone Fruit | 0.9 – 1.3 | 69 – 100 |
| Tree Nuts | 0.7 – 1.1 | 54 – 85 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *12.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 12-12.** These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 12.3.3.1** and **12.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 12.4**) and conducting a population-level impact analysis (**Section 12.6**).

For oxyfluorfen, given the toxicity profile (including only about a 3X difference between the 5$^{th}$ and 25$^{th}$ percentiles of the most sensitive SSD with relatively steep slopes of the SSDs (**Figure 12-1**))[168], EPA assigned a low magnitude of effect in **Table 12-12** on a use basis to groups of listed species and critical habitats (CHs)[169] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned medium magnitude of effect in **Table 12-12** when the magnitude of difference is from 1 up to 10. EPA assigned a magnitude of effect of high or very high based on a magnitude of difference of 10 up to 100 or greater than 100, respectively.

**Table 12-12. Use-Based Magnitude of Effect for Oxyfluorfen[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Artichoke | Very High | Very High | Very High | Very High | High | High |
| Beans | Very High | High | Very High | Very High | High | High |
| Berry | Very High | Very High | Very High | Very High | High | High |
| Broccoli | High | High | High | High | Medium | Medium |
| Cabbage | High | High | High | High | High | High |
| Citrus | Very High | High | Very High | Very High | High | High |
| Corn | Very High | Very High | Very High | Very High | High | High |
| Cotton | Very High | High | Very High | Very High | High | High |
| Fruiting Vegetables | High | High | High | High | Medium | Medium |
| Garlic | High | High | High | High | Medium | Medium |

[168] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[169] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Grape | Very High | Very High | Very High | Very High | High | High |
| Onion | High | High | Very High | High | High | High |
| Pome Fruit | Very High | High | Very High | Very High | High | High |
| Soybean | High | High | Very High | High | High | High |
| Stone Fruit | Very High | High | Very High | Very High | High | High |
| Tree Nuts | Very High | High | Very High | Very High | High | High |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 12.4**) and to conduct the population-level impacts analysis (**Section 12.6**). If the magnitude of effect is medium or higher for oxyfluorfen, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 12.4 Framework Step 2: Identify Mitigation Measures

**Section 12.4** outlines the mitigation measures identified for oxyfluorfen for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 12.4.1**) and runoff/erosion (**Section 12.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 12.4.1 Spray Drift Mitigation Measures Identified

**Table 12-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 12-14** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift

buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds**.**

**Table 12-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.0 | Not permitted on labels | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 100[e,f,g,h] |
| 1.5 | | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 100[e,f,g,h] |
| 0.75 | | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 75[f,g,h] |
| 0.50 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 75[g,h] | 50[g,h] |
| 0.25 | 300[a,b,c] | 250[a,b,c] | 175[a,b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[3] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 12-1**Error! Reference source not found..
[3] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

**Table 12-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.0 | Not permitted on labels | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 75[f,g,h] |
| 1.5 | | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 50[g,h] |
| 0.75 | | | | 150[e,g,h] | 75[g,h] | 50[g,h] | 20[i] |
| 0.50 | 300[a,b,c] | 225[a,b] | 150[b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| 0.25 | 200[a,b] | 125[b,d] | 75[b,d] | 50[g,h] | 20[i] | 10[i] | None[3] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 12-1**.
[3] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is ≤0.5 at 10 ft off the treated field.
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 12.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts and minimize the potential for future take differs across uses and, as shown in **Figure 12-2**, the level of mitigation is dependent upon the toxicity endpoint and representative species (*e.g.,* listed plants (5$^{th}$ percentile endpoint), generalists (25$^{th}$ percentile endpoint)). **Figure 12-2** visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for oxyfluorfen.

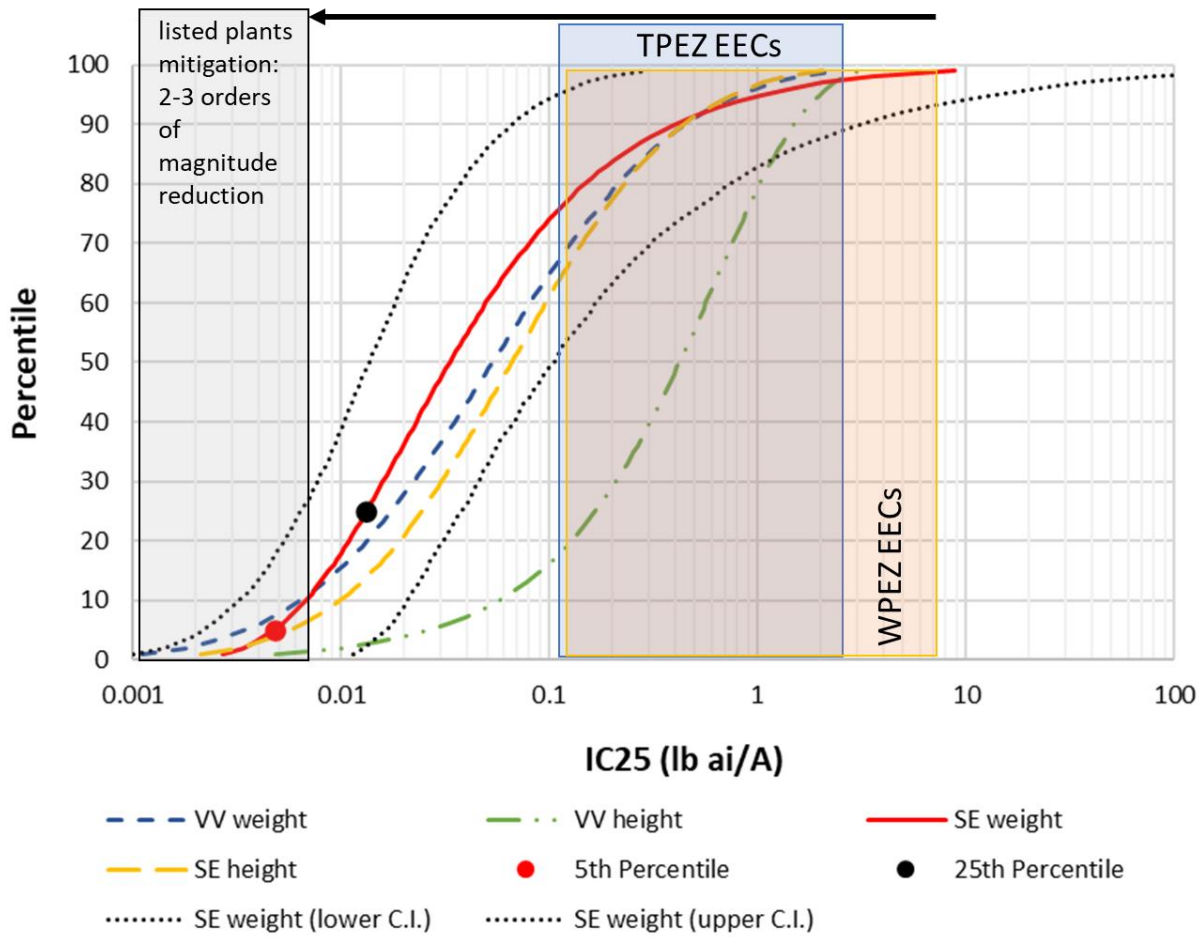


**Figure 12-2. Oxyfluorfen Vegetative Vigor (VV) and Seedling Emergence (SE) Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5$^{th}$ percentile (represents listed plants and animals with obligate relationships to plants) and the 25$^{th}$ percentile (represents generalists and designated critical habitat) from the SE weight SSD. Upper and lower confidence intervals (C.I.) are provided for the SE weight SSD.**

For oxyfluorfen, see **Section 12.3.3.2** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of oxyfluorfen is >1,000 L/kg-o.c. (mean $K_{OC}$ = 12,233 L/kg-o.c.), lower mitigation points are identified for this erosion-prone herbicide (as compared to a different runoff-prone herbicide).

As described the **Strategy Framework**, EPA identified mitigation measures for runoff/erosion that would apply whenever the magnitude of difference between the EEC and toxicity endpoint

is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would be applicable and if it is between 100 and 1,000, high mitigation would be applicable. If the magnitude of difference exceeds 1,000, then very high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (*i.e.,* low/medium/high/very high) if the weight of evidence indicates that more or less mitigation would apply to a specified use. For oxyfluorfen, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for oxyfluorfen, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed species in waterbodies similar in size to the EPA farm pond or larger[170], the mitigation category[171] is medium for all evaluated uses except for use on broccoli, fruiting vegetables and garlic for listed aquatic plants and animals that depend on aquatic plants[172] (**Table 12-15**). For use on broccoli, fruiting vegetables, and garlic, the mitigation category is low (**Table 12-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies.
- With the exception of oxyfluorfen use on broccoli, cabbage, fruiting vegetables, and garlic, the mitigation category is high for listed wetland plants and animals that obligately depend on these plants[173] (**Table 12-16**). For use on broccoli, cabbage, fruiting vegetables, and garlic, the mitigation category is medium for listed wetland plants and animals that obligately depend on these plants (**Table 12-16**).
- For aquatic plants in wetlands or small waterbodies[174] and for animals that depend on these plants (both obligately[173] and generally[175]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. The resulting mitigation category is medium or high depending on the use (**Table 12-16**).
- For listed terrestrial plants and animals that obligately rely on terrestrial plants[173], the mitigation category is high with the exception of oxyfluorfen use on broccoli, cabbage, fruiting vegetables, garlic, and onion, for which it is medium (**Table 12-18**).

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[170] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[171] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).
[172] None of the listed aquatic animals have obligate relationships to plants.
[173] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[174] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[175] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

- For animals that have a generalist relationship to wetland or terrestrial plants[175], the mitigation category is medium or high depending on the specific use (**Table 12-17** and **Table 12-19**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland and terrestrial plants and for animals that depend on wetland and/or terrestrial plants.

**Table 12-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Artichoke | 6.2 – 18 | 19 – 55 | Medium | 5.6 – 16 | Medium |
| Beans | 10 – 11 | 31 – 33 | Medium | 9.4 – 10 | Low[5] |
| Berry | 8.0 – 13 | 24 – 41 | Medium | 7.3 – 12 | Medium |
| Broccoli | 2.4 | 7.3 | Low | 2.2 | Low |
| Cabbage | 2.9 – 3.5 | 8.8 – 11 | Medium | 2.6 – 3.2 | Low |
| Citrus | 5.2 – 13 | 16 – 39 | Medium | 4.7 – 12 | Medium |
| Corn | 10 – 18 | 31 – 53 | Medium | 9.4 – 16 | Medium |
| Cotton | 2.8 – 8.6 | 8.5 – 26 | Medium | 2.5 – 7.8 | Low |
| Fruiting Vegetables | 0.9 – 2.3 | 2.7 – 7.0 | Low | 0.8 – 2.1 | Low |
| Garlic | 1.8 – 2.0 | 5.5 – 6.1 | Low | 1.6 – 1.8 | Low |
| Grape | 7.3 – 20 | 22 – 60 | Medium | 6.6 – 18 | Medium |
| Onion | 1.8 – 4.9 | 5.5 – 15 | Medium | 1.6 – 4.5 | Low |
| Pome Fruit | 7.3 – 11 | 22 – 32 | Medium | 6.6 – 9.7 | Low |
| Soybean | 5.1 – 5.6 | 16 – 17 | Medium | 4.6 – 5.1 | Low |
| Stone Fruit | 9.1 – 12 | 28 – 37 | Medium | 8.3 – 11 | Medium |
| Tree Nuts | 6.5 – 13 | 20 – 40 | Medium | 5.9 – 12 | Medium |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for oxyfluorfen, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.
[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 12-15** outlines the proposed mitigation categories for listed aquatic plants and animals that rely on those plants in larger waterbodies[176]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* pre-emergence vs. post-emergence applications) are modeled and when considering the different, relevant PWC scenarios available[177]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For oxyfluorfen, EPA determined the proposed mitigation categories presented in **Table 12-15** based on the weight of evidence discussed below, which is specifically relevant for use on beans.

For use on beans, the range of the magnitude of difference values for aquatic nonvascular plants is from 9.4 to 10. Because the maximum ratio is equivalent to (but does not exceed) the threshold for the medium mitigation category (*i.e.,* 10), EPA set the mitigation category as low for use on beans.

[176] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger. This correlates to aquatic bins 3, 4, 6, 7, 9, and 10 (as discussed in **Section 3.1**).
[177] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2** in the **Case Study Summary and Process** document.

**Table 12-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category | | Range of Magnitude of Difference[3] | Mitigation Category | Range of Magnitude of Difference[3] | Mitigation Category |
| Artichoke | 1.7 – 3.8 | 350 – 790 | High | 81 – 96 | 250 – 290 | High | 74 – 88 | Medium |
| Beans | 1.4 – 1.7 | 290 – 350 | High | 23 – 23 | 69 – 70 | Medium | 21 – 21 | Medium |
| Berry | 1.3 – 1.8 | 270 – 380 | High | 44 – 61 | 130 – 190 | High | 40 – 56 | Medium |
| Broccoli | 0.4 | 83 | Medium | 14 | 42 | Medium | 13 | Medium |
| Cabbage | 0.4 | 83 | Medium | 22 – 30 | 67 – 91 | Medium | 20 – 27 | Medium |
| Citrus | 0.8 – 1.3 | 170 – 270 | High | 92 – 93 | 280 – 280 | High | 84 – 85 | Medium |
| Corn | 1.6 – 6.1 | 330 – 1300 | High[5] | 42 – 57 | 130 – 170 | High | 38 – 51 | Medium |
| Cotton | 0.7 – 3.2 | 150 – 670 | High | 31 – 38 | 93 – 110 | High | 28 – 34 | Medium |
| Fruiting Vegetables | 0.1 – 0.4 | 21 – 83 | Medium | 11 – 15 | 34 – 46 | Medium | 10 – 14 | Medium |
| Garlic | 0.3 – 0.4 | 63 – 83 | Medium | 19 – 31 | 56 – 95 | Medium | 17 – 28 | Medium |
| Grape | 1.3 – 5.1 | 270 – 1100 | High[5] | 80 – 130 | 240 – 390 | High | 73 – 120 | High |
| Onion | 0.3 – 0.6 | 63 – 130 | High | 19 – 31 | 59 – 92 | Medium | 18 – 28 | Medium |
| Pome Fruit | 0.9 – 2.7 | 190 – 560 | High | 56 – 87 | 170 – 260 | High | 51 – 79 | Medium |
| Soybean | 0.8 – 1.0 | 170 – 210 | High | 23 – 27 | 69 – 83 | Medium | 21 – 25 | Medium |
| Stone Fruit | 1.2 – 3.4 | 250 – 710 | High | 64 – 90 | 190 – 270 | High | 58 – 82 | Medium |
| Tree Nuts | 1.0 – 1.6 | 210 – 330 | High | 55 – 91 | 170 – 280 | High | 50 – 83 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 12-16** outlines the proposed mitigation categories for listed wetland and aquatic plants and animals that obligately rely on those plants in wetlands or small waterbodies[178]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* pre-emergence vs. post-emergence applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For oxyfluorfen, EPA determined the proposed mitigation categories presented in **Table 12-16** based on the weight of evidence discussed below, which is specifically relevant for use of oxyfluorfen on corn and grape.

For use on corn, although the highest magnitude of difference for wetland monocots and dicots exceeds 1,000 (indicating very high mitigation), this only occurred in two out of the 20 modeled application scenarios with a maximum ratio of 1,300. Magnitude of difference values 1,000 only resulted from the MScornSTD PWC scenario with the next highest value at 900. The MScornSTD PWC scenario is a conservative scenario for screening-level assessments that is known to result in substantially higher runoff EECs than all other corn scenarios. Therefore, given that this scenario (MScornSTD) provides upper bound EECs, EPA set the mitigation category as high for use on corn.

For use on grape, EPA modeled three PWC scenarios with two different application timings (pre-emergence and post-emergence). The two highest magnitude of difference values for wetland monocots and dicots exceed 1,000 (both for the NYGrapeSTD PWC scenario). For the other two scenarios, the magnitude of difference values range from 270 to 350. Because the magnitude of difference values are <500 for four of the six application scenarios modeled, EPA set the mitigation category as high.

**Table 12-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |
| Artichoke | 1.7 – 3.8 | 130 – 290 | High |
| Beans | 1.4 – 1.7 | 110 – 130 | High |
| Berry | 1.3 – 1.8 | 100 – 140 | High |
| Broccoli | 0.4 | 31 | Medium |
| Cabbage | 0.4 | 31 | Medium |
| Citrus | 0.8 – 1.3 | 62 – 100 | Medium[5] |
| Corn | 1.6 – 6.1 | 120 – 470 | High |

[178] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category |
| Cotton | 0.7 – 3.2 | 54 – 250 | High |
| Fruiting Vegetables | 0.1 – 0.4 | 7.7 – 31 | Medium |
| Garlic | 0.3 – 0.4 | 23 – 31 | Medium |
| Grape | 1.3 – 5.1 | 100 – 390 | High |
| Onion | 0.3 – 0.6 | 23 – 46 | Medium |
| Pome Fruit | 0.9 – 2.7 | 69 – 210 | High |
| Soybean | 0.8 – 1.0 | 62 – 77 | Medium |
| Stone Fruit | 1.2 – 3.4 | 92 – 260 | High |
| Tree Nuts | 1.0 – 1.6 | 77 – 120 | High |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 12-16**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).

[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 12-17** outlines the proposed mitigation categories for listed animals that generally rely on monocots or dicots in wetlands or small waterbodies[179]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* pre-emergence vs. post-emergence applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For oxyfluorfen, EPA determined the proposed mitigation categories presented in **Table 12-17** based on the weight of evidence discussed below, which is specifically relevant for use of oxyfluorfen on citrus.

For use on citrus, the range of the magnitude of difference for animals generally relying on wetland monocots and dicots is from 62 to 100. Because the maximum ratio is equivalent to (but does not exceed) the threshold for the high mitigation category (*i.e.,* 100), EPA set the mitigation category as medium for animals generally relying on wetland plants.

**Table 12-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 0.7 – 1.8 | 150 – 380 | High |
| Beans | 1.1 | 230 | High |
| Berry | 1.0 – 1.4 | 210 – 290 | High |
| Broccoli | 0.2 | 42 | Medium |
| Cabbage | 0.4 | 83 | Medium |
| Citrus | 0.6 – 1.2 | 130 – 250 | High |
| Corn | 1.1 – 2.2 | 230 – 460 | High |
| Cotton | 0.5 – 1.3 | 100 – 270 | High |
| Fruiting Vegetables | 0.1 – 0.2 | 21 – 42 | Medium |
| Garlic | 0.2 – 0.3 | 42 – 63 | Medium |
| Grape | 0.8 – 2.2 | 170 – 460 | High |
| Onion | 0.2 – 0.4 | 42 – 83 | Medium |
| Pome Fruit | 0.7 – 1.2 | 150 – 250 | High |
| Soybean | 0.5 | 100 | Medium[3] |
| Stone Fruit | 0.9 – 1.3 | 190 – 270 | High |
| Tree Nuts | 0.7 – 1.1 | 150 – 230 | High |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

[179] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

**Table 12-18** outlines the proposed mitigation categories for listed terrestrial monocots or dicots and animals that obligately rely on those plants. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* pre-emergence vs. post-emergence applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For oxyfluorfen, EPA determined the proposed mitigation categories presented in **Table 12-18** based on the weight of evidence discussed below, which is specifically relevant for use of oxyfluorfen on soybean.

For use on soybean, the magnitude of difference for listed terrestrial monocots and dicots is 100. Because the maximum ratio is equivalent to (but does not exceed) the threshold for the high mitigation category (*i.e.,* 100), EPA set the mitigation category as medium for listed terrestrial flowering plants and listed animals that obligately rely on those plants.

**Table 12-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 0.7 – 1.8 | 54 – 140 | High |
| Beans | 1.1 | 85 | Medium |
| Berry | 1.0 – 1.4 | 77 – 110 | High |
| Broccoli | 0.2 | 15 | Medium |
| Cabbage | 0.4 | 31 | Medium |
| Citrus | 0.6 – 1.2 | 46 – 92 | Medium |
| Corn | 1.1 – 2.2 | 85 – 170 | High |
| Cotton | 0.5 – 1.3 | 39 – 100 | Medium[3] |
| Fruiting Vegetables | 0.1 – 0.2 | 7.7 – 15 | Medium |
| Garlic | 0.2 – 0.3 | 15 – 23 | Medium |
| Grape | 0.8 – 2.2 | 62 – 170 | High |
| Onion | 0.2 – 0.4 | 15 – 31 | Medium |
| Pome Fruit | 0.7 – 1.2 | 54 – 92 | Medium |
| Soybean | 0.5 | 39 | Medium |
| Stone Fruit | 0.9 – 1.3 | 69 – 100 | Medium[3] |
| Tree Nuts | 0.7 – 1.1 | 54 – 85 | Medium |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* pre-emergence vs. post-emergence applications, different number of applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 12-19** outlines the proposed mitigation category for listed animals that generally rely on terrestrial plants. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* pre-emergence vs. post-emergence applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3.** For oxyfluorfen, EPA determined the proposed mitigation categories presented in **Table 12-19** based on the weight of evidence discussed below, which is specifically relevant for use of oxyfluorfen on cotton and stone fruit.

For use on cotton and stone fruit, the ranges of the magnitude of difference values are from 39 to 100 and 69 to 100, respectively. Because the maximum ratio for both uses is equivalent to (but does not exceed) the threshold for the high mitigation category (*i.e.,* 100), EPA set the overall mitigation category as medium for listed animals generally relying on terrestrial plants.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 12-15** and **Table 12-16**) and wetland plants (**Table 12-16** and **Table 12-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether protection is for listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 12-18**) and for generalist animals (**Table 12-19). Table 12-20** and **Table 12-21** provide the runoff/erosion mitigation points identified for each evaluated use of oxyfluorfen.

**Table 12-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Artichoke | High (7 pts) | High (7 pts) |
| Beans | High (7 pts) | High (7 pts) |
| Berry | High (7 pts) | High (7 pts) |
| Broccoli | Medium (5 pts) | Medium (5 pts) |
| Cabbage | Medium (5 pts) | Medium (5 pts) |
| Citrus | High (7 pts) | High (7 pts) |
| Corn | High (7 pts) | High (7 pts) |
| Cotton | High (7 pts) | High (7 pts) |
| Fruiting Vegetables | Medium (5 pts) | Medium (5 pts) |
| Garlic | Medium (5 pts) | Medium (5 pts) |
| Grape | High (7 pts) | High (7 pts) |
| Onion | High (7 pts) | Medium (5 pts) |
| Pome Fruit | High (7 pts) | High (7 pts) |
| Soybean | High (7 pts) | Medium (5 pts) |
| Stone Fruit | High (7 pts) | High (7 pts) |
| Tree Nuts | High (7 pts) | High (7 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 12-15** and **Table 12-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 12-15** and **Table 12-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 12-15**, **Table 12-16**, and **Table 12-17**).

**Table 12-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Artichoke | High (7 pts) | High (7 pts) |
| Beans | High (7 pts) | Medium (5 pts) |
| Berry | High (7 pts) | High (7 pts) |
| Broccoli | Medium (5 pts) | Medium (5 pts) |
| Cabbage | Medium (5 pts) | Medium (5 pts) |
| Citrus | High (7 pts) | Medium (5 pts) |
| Corn | High (7 pts) | High (7 pts) |
| Cotton | High (7 pts) | Medium (5 pts) |
| Fruiting Vegetables | Medium (5 pts) | Medium (5 pts) |
| Garlic | Medium (5 pts) | Medium (5 pts) |
| Grape | High (7 pts) | High (7 pts) |
| Onion | Medium (5 pts) | Medium (5 pts) |
| Pome Fruit | High (7 pts) | Medium (5 pts) |
| Soybean | Medium (5 pts) | Medium (5 pts) |
| Stone Fruit | High (7 pts) | Medium (5 pts) |
| Tree Nuts | High (7 pts) | Medium (5 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 12-18**), listed animals that obligately depend on terrestrial plants (**Table 12-18**), and listed animals that generally depend on terrestrial plants (**Table 12-19**).

## 12.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for oxyfluorfen are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants **Table 12-13** and one for generalist animals that depend on plants (**Table 12-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are different for these

two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For oxyfluorfen, the less restrictive mitigations relevant to generalists animals that are depicted in Error! Reference source not found. would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 12-13** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For both sets of habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 12-20** and **Table 12-21**). **Table 12-22** summarizes the points identified for the different oxyfluorfen uses in this example; these points would be included in the general label for terrestrial and wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by the four PULAs. PULAs 1 and 2 are grouped because the same mitigations would be applied to monocots and dicots in terrestrial habitats; this is supported by oxyfluorfen's similar toxicity to both monocots and dicots (see **Section 12.3.1**). The same grouping and rational applies for PULAs 3 and 4, which represent monocots and dicots in wetland and aquatic habitats.

**Table 12-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | | Geographically Specific Mitigation Points | |
|---|---|---|---|---|
| | Terrestrial Habitats | Aquatic and Wetland Habitats | PULAs 1,2, 3 and 4 (Terrestrial Habitats)[1] | PULAs 3 and 4 (Aquatic and Wetland Habitats)[1] |
| Artichoke | 7 | 7 | 7 | 7 |
| Beans | 5 | 7 | 7 | 7 |
| Berry | 7 | 7 | 7 | 7 |
| Broccoli | 5 | 5 | 5 | 5 |
| Cabbage | 5 | 5 | 5 | 5 |
| Citrus | 5 | 7 | 7 | 7 |
| Corn | 7 | 7 | 7 | 7 |
| Cotton | 5 | 7 | 7 | 7 |
| Fruiting Vegetables | 5 | 5 | 5 | 5 |
| Garlic | 5 | 5 | 5 | 5 |
| Grape | 7 | 7 | 7 | 7 |
| Onion | 5 | 5 | 5 | 7 |
| Pome Fruit | 5 | 7 | 7 | 7 |
| Soybean | 5 | 5 | 5 | 7 |
| Stone Fruit | 5 | 7 | 7 | 7 |

| | | | | |
|---|---|---|---|---|
| Tree Nuts | 5 | 7 | 7 | 7 |

[1] Many of the listed wetland species that occur in PULAs 3 and 4 also occur in terrestrial habitats. EPA proposes that if mitigations are applicable for terrestrial habitats (PULAs 1 and 2), these mitigations for terrestrial habitats would also apply to areas covered by PULAs 3 and 4. The result would be that PULAs 3 and 4 would have two sets of mitigations—one set for terrestrial habitats and one for the wetland/aquatic habitats. See **Section 7.2.2 in the Strategy Framework document for the full explanation of this proposal**.

## 12.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 12.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of oxyfluorfen. For major crops (*e.g.,* corn, cotton, soybean), the crop-specific UDLs were selected. For other uses such as on artichoke, EPA selected the grouped UDLs represented by vegetables and ground fruit. EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential oxyfluorfen use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 12-12**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 12-23** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected oxyfluorfen UDLs[180] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For oxyfluorfen's UDLs, fewer species (281) and CHs (57) have overlap >5%. An important consideration for the purposes of this example is that EPA did not necessarily evaluate all

[180] The selected use data layers (UDLs) do not necessarily represent every registered use of oxyfluorfen. See **Section 12.2** for more information on the selected uses evaluated in this example.

registered uses of oxyfluorfen (see **Section 12.2**), so additional species could be identified in the future for oxyfluorfen. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of oxyfluorfen; however, the PULAs include some species and CHs that have <5% overlap with oxyfluorfen's potential exposure area for the considered uses.

**Table 12-23. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Oxyfluorfen Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Vegetables and Ground Fruit | 469 / 142 | 147 | 28 |
| Citrus | | 50 | 10 |
| Other Orchards | | 131 | 36 |
| Corn | | 150 | 30 |
| Grapes | | 117 | 31 |
| Soybeans | | 88 | 9 |
| Cotton | | 71 | 13 |
| Total across all UDLs above[2] | | 281 | 57 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Vegetables and Ground Fruit | 534 / 316 | 166 | 83 |
| Citrus | | 33 | 5 |
| Other Orchards | | 132 | 80 |
| Corn | | 317 | 148 |
| Grapes | | 54 | 30 |
| Soybeans | | 225 | 92 |
| Cotton | | 186 | 83 |
| Total across all UDLs above[2] | | 382 | 184 |
| Cultivated | | 460 | 225 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for oxyfluorfen. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for oxyfluorfen (excluding the Cultivated UDL, which is summarized below this row).

## 12.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

The ranges of $IC_{25}$ values for plant height from the seedling emergence studies are 0.006 to 1.055 lb a.i./A (excluding non-definitive endpoints[181]) for monocots and 0.015 to 0.247 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.33 and 0.083 lb a.i./A, respectively. The ranges of $IC_{25}$ values for plant height from the vegetative vigor studies are 0.513 to 1.351 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.029 to 1.204 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.832 and 0.433 lb a.i./A, respectively.

For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.006 to 0.324 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.007 to 2.047 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.108 and 0.380 lb a.i./A, respectively. The ranges of $IC_{25}$ values for dry weight data in the vegetative vigor studies are 0.267 to 0.576 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.006 to 0.112 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.382 and 0.039 lb a.i./A, respectively. Although the dry weight data from the vegetative vigor studies shows a potential difference between monocots and dicots, these data did not provide the most sensitive 25$^{th}$ percentile of the SSD. Therefore, EPA determined that it was still appropriate to combine monocots and dicots to generate the four SSDs.

[181] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 2.17 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 12.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to oxyfluorfen. EPA developed separate SSDs for height and weight.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr)to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the oxyfluorfen data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the $5^{th}$ percentile of the $IC_{25}$ values from the SSD.

Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions

## Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA compared the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

### *Seedling Emergence Height Data*

Goodness of fit:

Results:

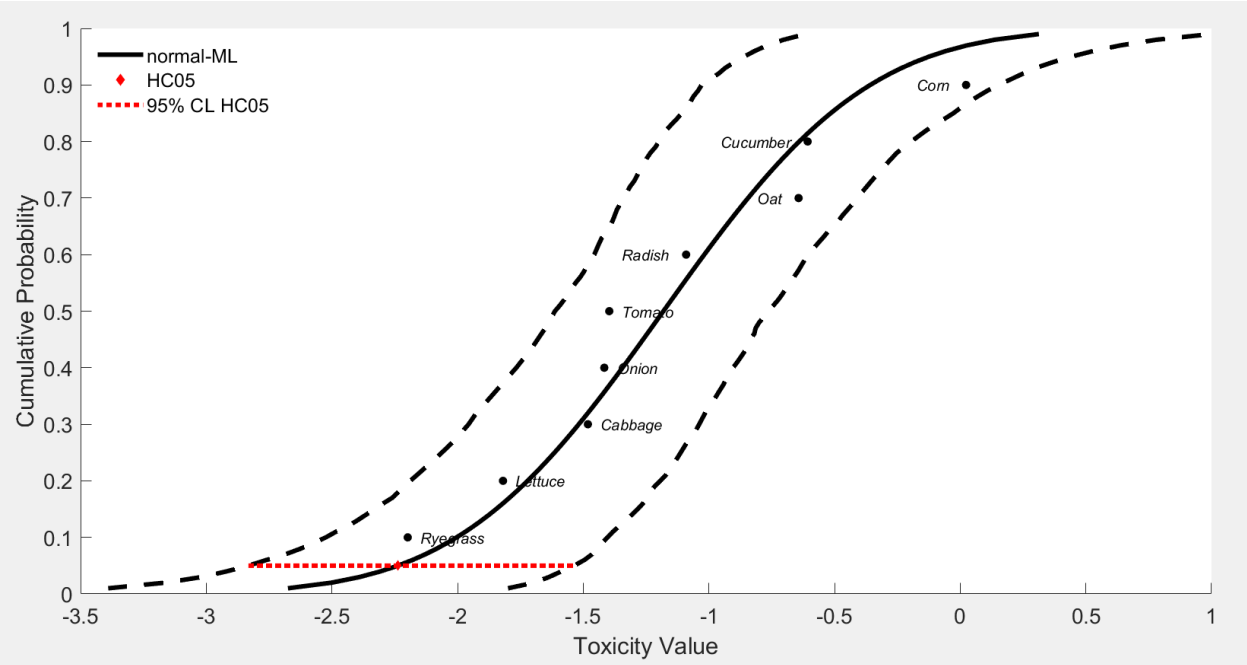
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0058 | 0.7043 |
| 2 | logistic | ML | 0.0048 | 0.5714 |
| 3 | triangular | ML | 0.0069 | 0.7902 |
| 4 | gumbel | ML | 0.0078 | 0.8581 |
| 5 | weibull | ML | 0.0017 | 0.5614 |
| 6 | burr | ML | 0.0076 | 0.7962 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0060559 |
| Model-averaged SE of HCp: | 0.0046625 |
| CV of HCp: | 0.76991 |

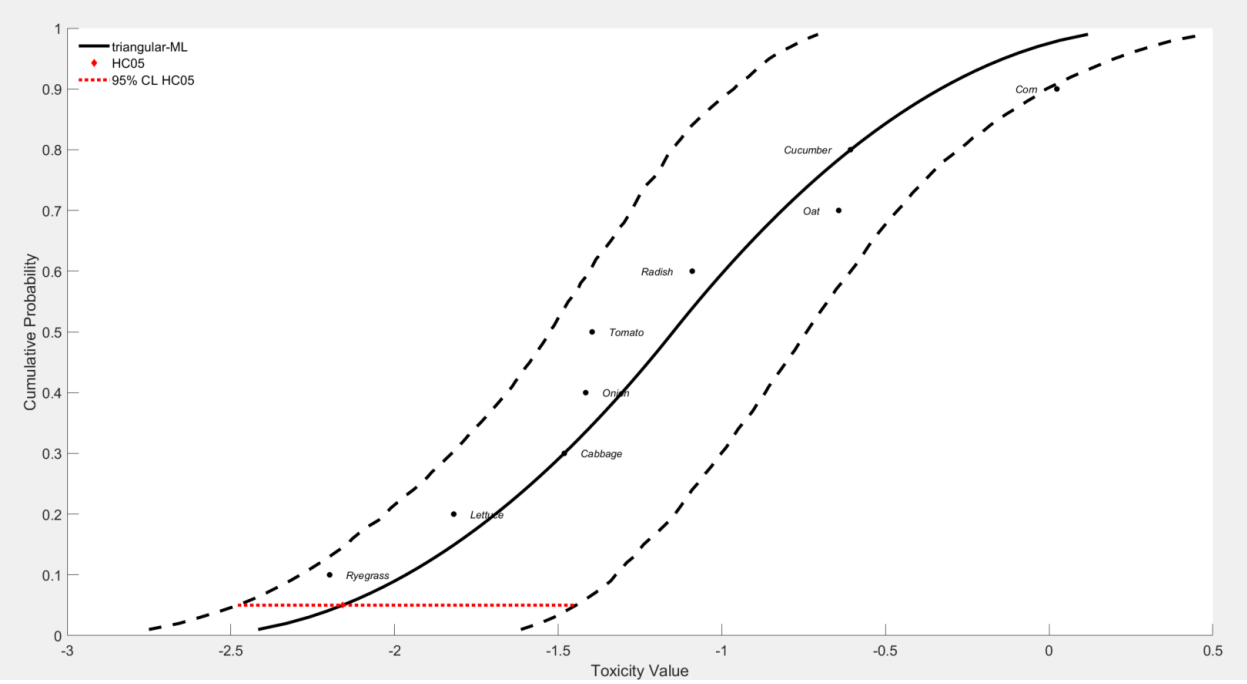
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -10.9575 | 0 | 0.2885 | 0.0069 | 0.0052 |
| 2 | gumbel | -10.3683 | 0.5892 | 0.2149 | 0.0078 | 0.0038 |
| 3 | normal | -10.3635 | 0.5939 | 0.2143 | 0.0058 | 0.0044 |
| 4 | logistic | -9.9115 | 1.0459 | 0.1710 | 0.0048 | 0.0041 |
| 5 | weibull | -8.6621 | 2.2953 | 0.0915 | 0.0017 | 0.0024 |
| 6 | burr | -5.6011 | 5.3564 | 0.0198 | 0.0076 | 0.0045 |

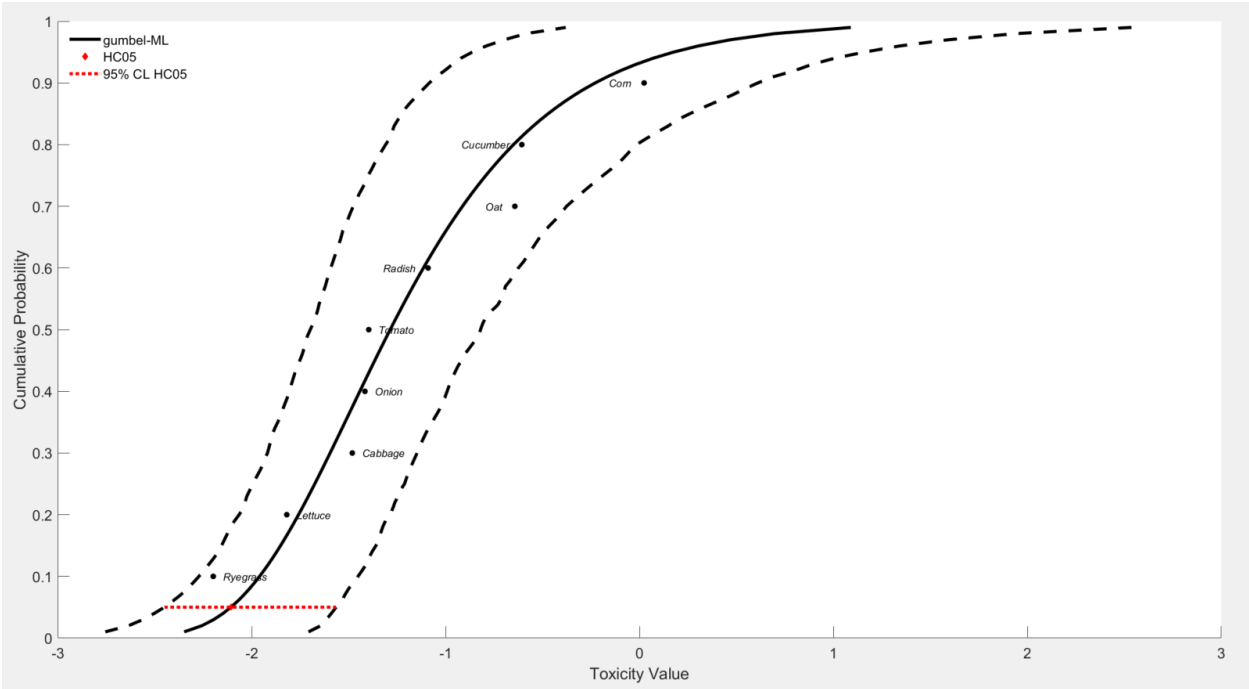
Based on the goodness of fit, EPA moved forward with triangular, normal, and Gumbel distributions, and ultimately selected the normal distribution for the height data from the seedling emergence toxicity tests.




**Normal (selected distribution)**




Triangular




Gumbel

## *Seedling Emergence Dry Weight Data*

Goodness of fit:

Results:

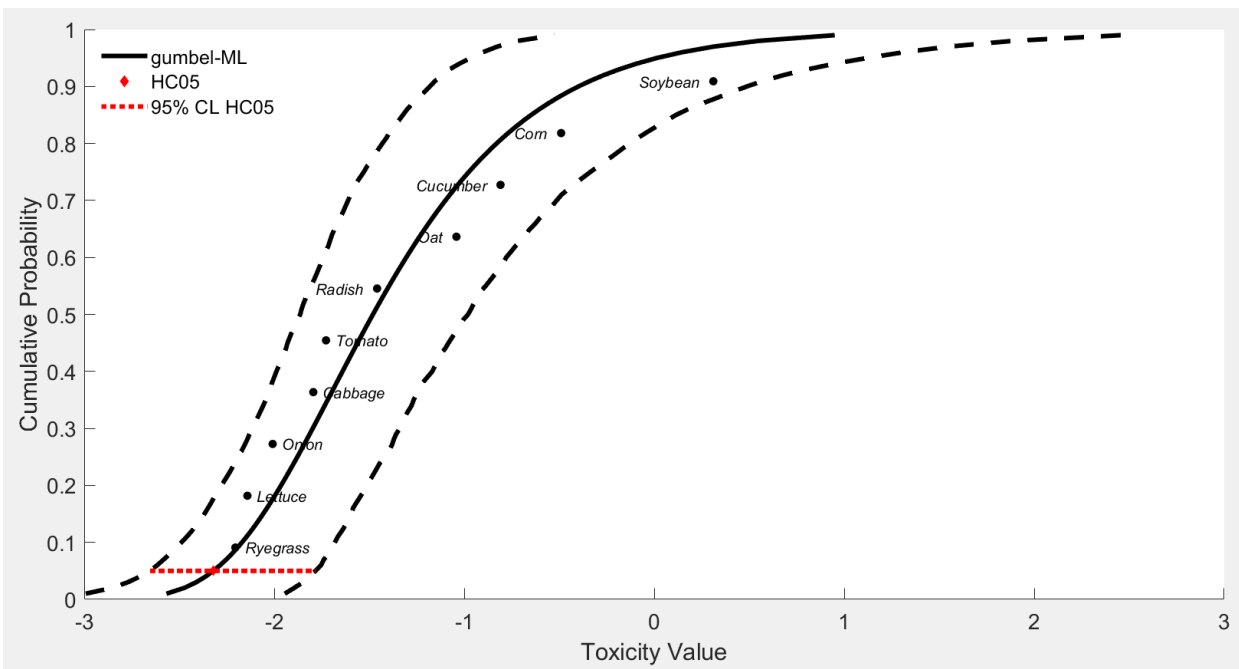
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0024 | 0.4196 |
| 2 | logistic | ML | 0.0018 | 0.4096 |
| 3 | triangular | ML | 0.0034 | 0.2268 |
| 4 | gumbel | ML | 0.0048 | 0.4366 |
| 5 | weibull | ML | 3.7274e-04 | 0.3407 |
| 6 | burr | ML | 0.0048 | 0.4086 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0036317 |
| Model-averaged SE of HCp: | 0.0027608 |
| CV of HCp: | 0.76021 |

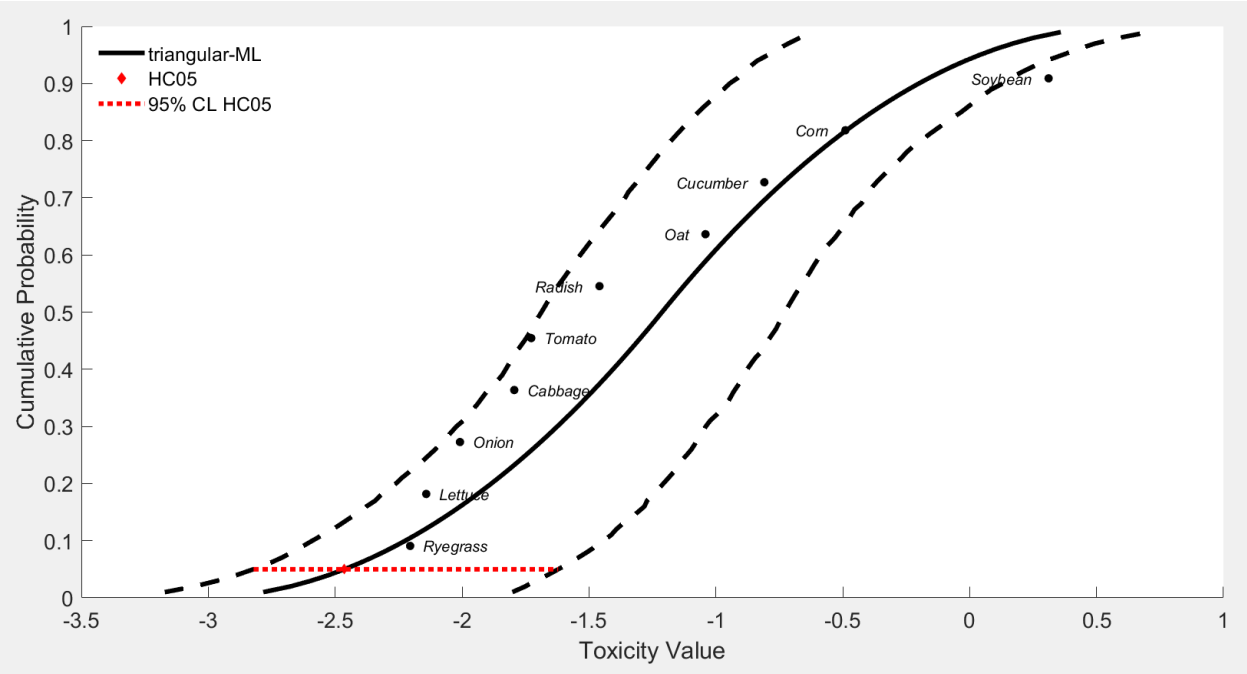
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -17.8923 | 0 | 0.4503 | 0.0048 | 0.0023 |
| 2 | triangular | -15.9464 | 1.9459 | 0.1702 | 0.0034 | 0.0035 |
| 3 | normal | -15.8267 | 2.0656 | 0.1603 | 0.0024 | 0.0021 |
| 4 | logistic | -15.4443 | 2.4481 | 0.1324 | 0.0018 | 0.0017 |
| 5 | burr | -13.5973 | 4.2950 | 0.0526 | 0.0048 | 0.0024 |
| 6 | weibull | -12.7324 | 5.1600 | 0.0341 | 3.7274e-04 | 6.1508e-04 |

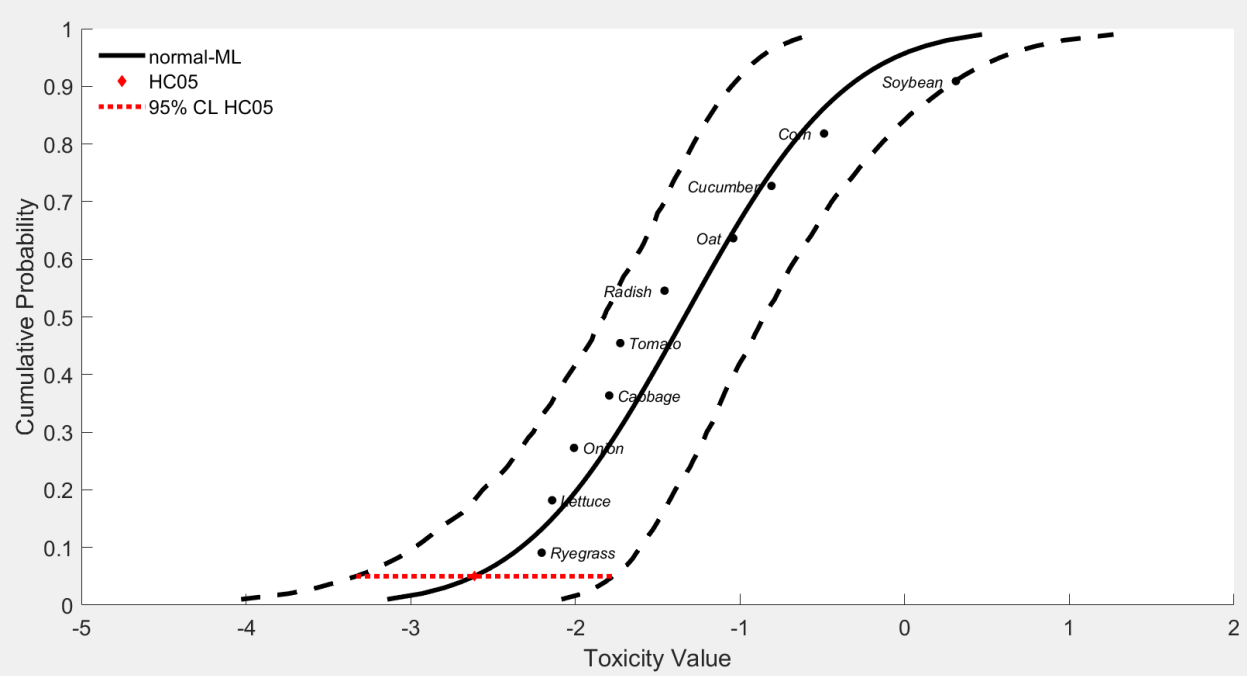
Based on the goodness of fit, EPA moved forward with triangular, normal, and Gumbel distributions, and ultimately selected the Gumbel distribution for the dry weight data from the seedling emergence toxicity tests.




**Gumbel (selected distribution)**




Triangular




Normal

*Vegetative Vigor Height Data*

Goodness of fit:

Results:

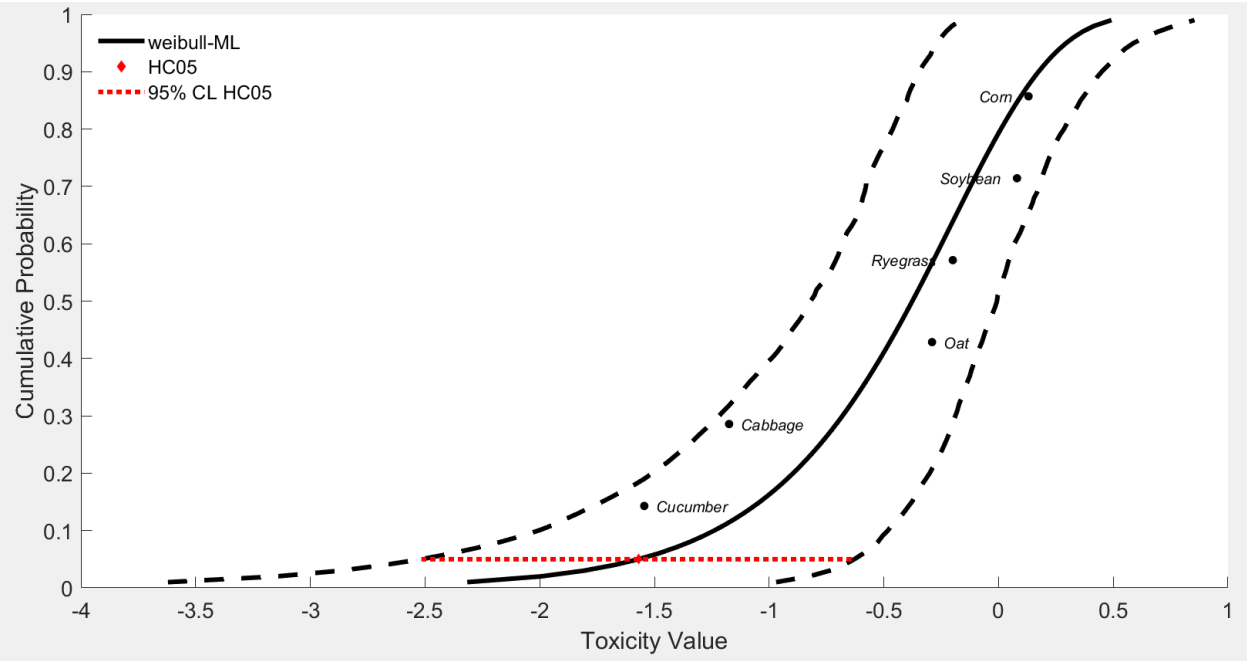
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0286 | 0.1109 |
| 2 | logistic | ML | 0.0282 | 0.1159 |
| 3 | triangular | ML | 0.0356 | 0.1768 |
| 4 | gumbel | ML | 0.0291 | 0.1059 |
| 5 | weibull | ML | 0.0270 | 0.1878 |
| 6 | burr | ML | 0 | 0.2810 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.029198 |
| Model-averaged SE of HCp: | 0.029742 |
| CV of HCp: | 1.0186 |

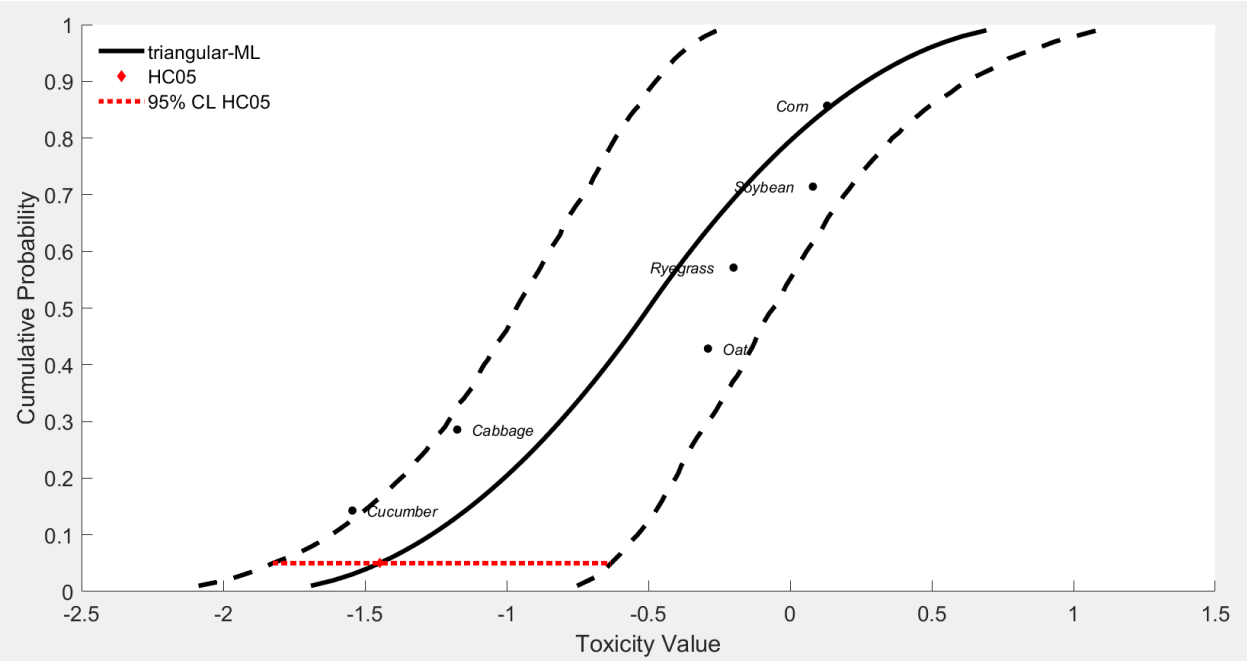
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | weibull | 14.4774 | 0 | 0.3480 | 0.0270 | 0.0353 |
| 2 | triangular | 15.3739 | 0.8966 | 0.2223 | 0.0356 | 0.0230 |
| 3 | normal | 15.7718 | 1.2944 | 0.1822 | 0.0286 | 0.0263 |
| 4 | logistic | 16.2946 | 1.8172 | 0.1403 | 0.0282 | 0.0327 |
| 5 | gumbel | 17.1137 | 2.6363 | 0.0931 | 0.0291 | 0.0193 |
| 6 | burr | 20.8832 | 6.4058 | 0.0141 | 0 | 0 |

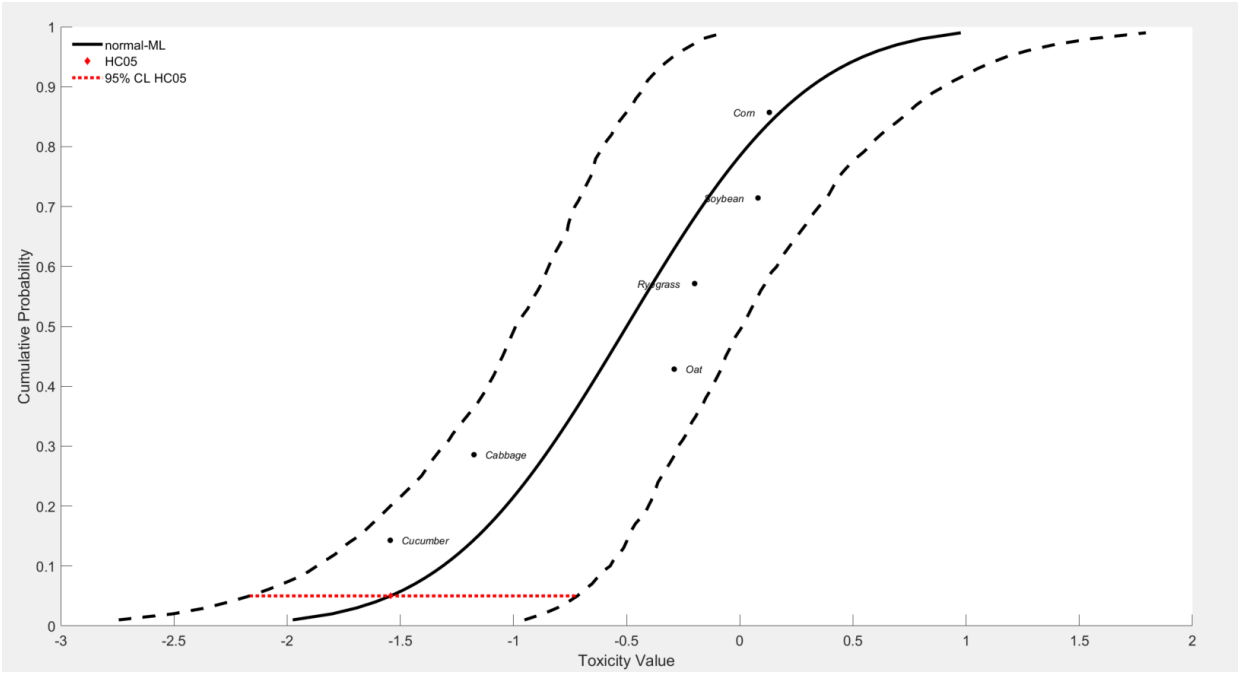
Based on the goodness of fit, EPA moved forward with triangular, normal, and Weibull distributions, and ultimately selected the Weibull distribution for the height data from the vegetative vigor toxicity tests.




**Weibull (selected distribution)**




Triangular




Normal

## *Vegetative Vigor Dry Weight Data*

Goodness of fit:

Results:

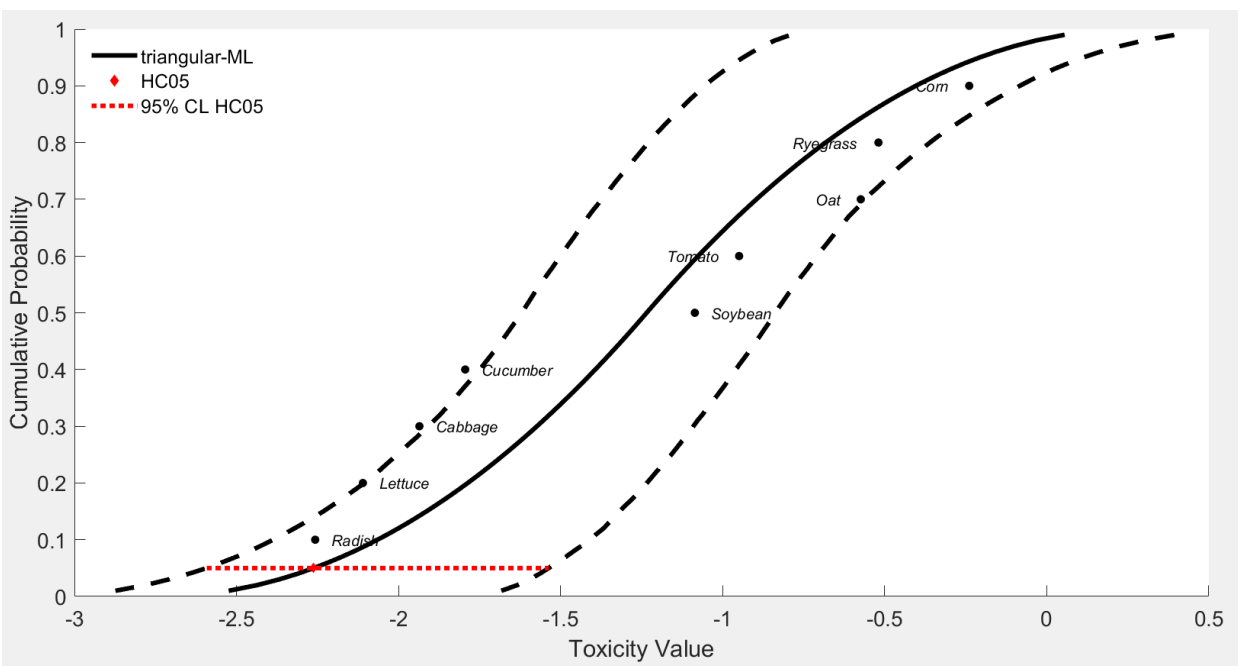
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0035 | 0.1555 |
| 2 | logistic | ML | 0.0025 | 0.1040 |
| 3 | triangular | ML | 0.0055 | 0.1725 |
| 4 | gumbel | ML | 0.0048 | 0.1223 |
| 5 | weibull | ML | 0.0017 | 0.2453 |
| 6 | burr | ML | 0 | 0.4106 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.0037822 |
| Model-averaged SE of HCp: | 0.0034129 |
| CV of HCp: | 0.90237 |

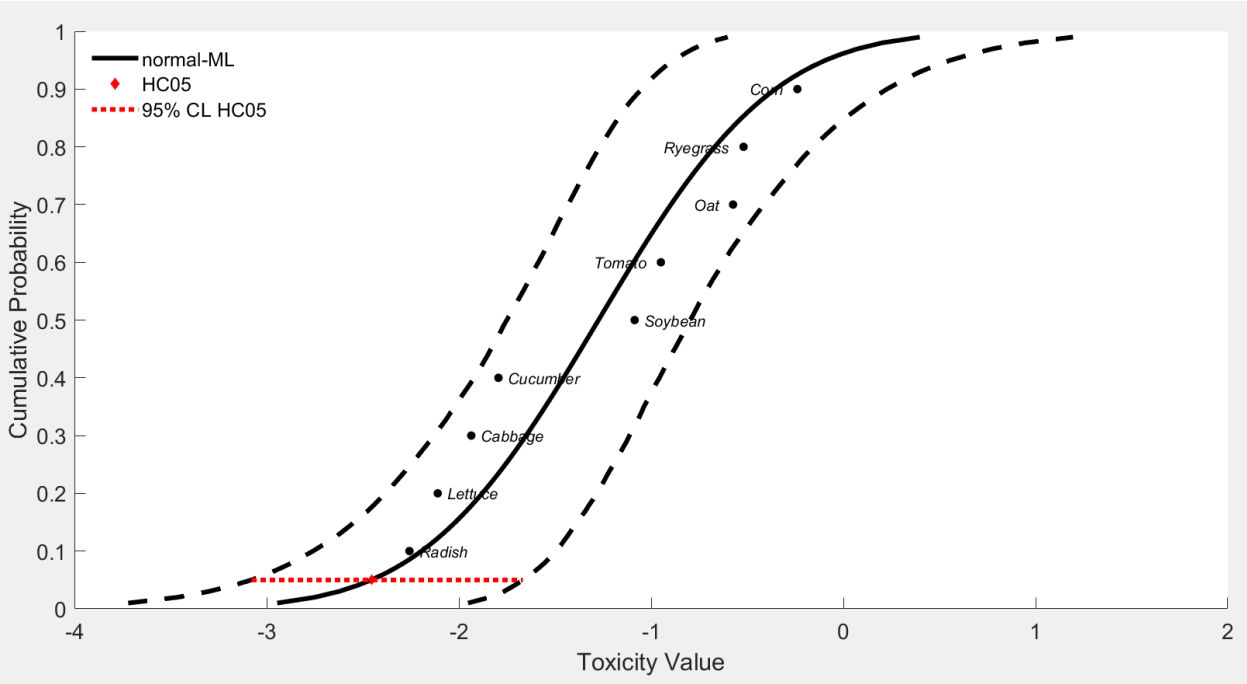
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -12.9830 | 0 | 0.2989 | 0.0055 | 0.0039 |
| 2 | normal | -12.1953 | 0.7877 | 0.2016 | 0.0035 | 0.0030 |
| 3 | weibull | -11.9698 | 1.0132 | 0.1801 | 0.0017 | 0.0023 |
| 4 | gumbel | -11.9240 | 1.0590 | 0.1760 | 0.0048 | 0.0026 |
| 5 | logistic | -11.1055 | 1.8775 | 0.1169 | 0.0025 | 0.0026 |
| 6 | burr | -8.1395 | 4.8435 | 0.0265 | 0 | 0 |

Based on the goodness of fit, EPA moved forward with triangular and normal distributions, and ultimately selected the normal distribution for the dry weight data from the vegetative vigor toxicity tests.




Triangular




**Normal (selected distribution)**

## 12.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 12-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for use on grape)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 10 | <5 | 0 * | 0 * |
| **Application Rate of 1.5 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 5 | <5 | 0 * | 0 * |
| **Application Rate of 0.75 lb a.i./A (maximum application rate for use on corn and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 0 * | 0 * | 0 * | 0 * |
| **Application Rate of 0.50 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 0.33 µg a.i./L for duckweed, *Lemna gibba* (MRID 45861103). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For oxyfluorfen, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 12.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 12-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 208.3 | 208.3 | 208.3 | 439.7 | 424.7 | 422.0 | 420.0 | 198.4 |
| 10 | 140.2 | 125.9 | 115.5 | 109.4 | 39.0 | 19.3 | 11.6 | 96.0 |
| 20 | 104.2 | 83.5 | 71.6 | 55.1 | 18.5 | 10.4 | 6.3 | 54.1 |
| 25 | 89.1 | 67.8 | 56.1 | 40.6 | 13.7 | 8.3 | 5.0 | 39.1 |
| 50 | 69.9 | 45.0 | 29.7 | 19.8 | 7.0 | 4.8 | 3.0 | 14.2 |
| 75 | 49.1 | 30.4 | 19.6 | 13.1 | 4.9 | 3.5 | 2.2 | 6.8 |
| 100 | 41.5 | 24.2 | 15.4 | 10.5 | 4.0 | 2.9 | 1.9 | 4.4 |
| 125 | 30.9 | 17.9 | 11.4 | 8.3 | 3.3 | 2.4 | 1.6 | 2.7 |
| 150 | 26.0 | 14.3 | 8.9 | 6.8 | 2.7 | 2.1 | 1.4 | 1.8 |
| 175 | 21.7 | 11.9 | 7.3 | 5.7 | 2.4 | 1.8 | 1.2 | 1.3 |
| 200 | 19.3 | 10.4 | 6.3 | 5.1 | 2.2 | 1.7 | 1.1 | 1.0 |
| 225 | 17.5 | 8.9 | 5.3 | 4.4 | 1.9 | 1.5 | 1.0 | 0.8 |
| 250 | 15.3 | 7.7 | 4.6 | 3.9 | 1.7 | 1.4 | 0.9 | 0.6 |
| 275 | 13.9 | 6.8 | 4.0 | 3.5 | 1.6 | 1.3 | 0.9 | 0.5 |
| 300 | 12.7 | 6.0 | 3.6 | 3.1 | 1.4 | 1.2 | 0.8 | 0.4 |
| 325 | 11.6 | 5.5 | 3.3 | 2.8 | 1.3 | 1.1 | 0.7 | 0.3 |
| 350 | 10.9 | 5.1 | 3.1 | 2.6 | 1.3 | 1.0 | 0.7 | 0.3 |
| 375 | 10.1 | 4.7 | 2.9 | 2.4 | 1.2 | 0.9 | 0.7 | 0.2 |
| 400 | 9.5 | 4.4 | 2.7 | 2.2 | 1.1 | 0.9 | 0.6 | 0.2 |
| 500 | 7.8 | 3.6 | 2.2 | 1.2 | 0.4 | 0.4 | 0.2 | 0.1 |
| 600 | 6.7 | 3.1 | 1.9 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 700 | 6.0 | 2.8 | 1.7 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 800 | 5.6 | 2.6 | 1.5 | 0.5 | 0.3 | 0.2 | 0.2 | <0.1 |
| 900 | 5.2 | 2.4 | 1.4 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 1000 | 4.9 | 2.2 | 1.3 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0048 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 76.9 | 76.9 | 76.9 | 162.3 | 156.8 | 155.8 | 155.1 | 73.3 |
| 10 | 51.8 | 46.5 | 42.7 | 40.4 | 14.4 | 7.1 | 4.3 | 35.5 |
| 20 | 38.5 | 30.8 | 26.4 | 20.4 | 6.8 | 3.8 | 2.3 | 20.0 |
| 25 | 32.9 | 25.0 | 20.7 | 15.0 | 5.1 | 3.0 | 1.8 | 14.4 |
| 50 | 25.8 | 16.6 | 11.0 | 7.3 | 2.6 | 1.8 | 1.1 | 5.2 |
| 75 | 18.1 | 11.2 | 7.2 | 4.8 | 1.8 | 1.3 | 0.8 | 2.5 |
| 100 | 15.3 | 8.9 | 5.7 | 3.9 | 1.5 | 1.1 | 0.7 | 1.6 |
| 125 | 11.4 | 6.6 | 4.2 | 3.0 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.6 | 5.3 | 3.3 | 2.5 | 1.0 | 0.8 | 0.5 | 0.7 |
| 175 | 8.0 | 4.4 | 2.7 | 2.1 | 0.9 | 0.7 | 0.4 | 0.5 |
| 200 | 7.1 | 3.8 | 2.3 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.5 | 3.3 | 1.9 | 1.6 | 0.7 | 0.6 | 0.4 | 0.3 |
| 250 | 5.7 | 2.8 | 1.7 | 1.4 | 0.6 | 0.5 | 0.3 | 0.2 |
| 275 | 5.1 | 2.5 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.7 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 4.0 | 1.9 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.7 | 1.7 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.5 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.9 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.2 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.1 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.8 | 0.8 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.5 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 156.2 | 156.2 | 156.2 | 329.8 | 318.5 | 316.5 | 315.0 | 148.8 |
| 10 | 105.2 | 94.4 | 86.7 | 82.0 | 29.2 | 14.5 | 8.7 | 72.0 |
| 20 | 78.1 | 62.6 | 53.7 | 41.4 | 13.8 | 7.8 | 4.7 | 40.6 |
| 25 | 66.8 | 50.8 | 42.1 | 30.4 | 10.3 | 6.2 | 3.8 | 29.3 |
| 50 | 52.4 | 33.8 | 22.3 | 14.8 | 5.3 | 3.6 | 2.2 | 10.7 |
| 75 | 36.8 | 22.8 | 14.7 | 9.8 | 3.7 | 2.6 | 1.7 | 5.1 |
| 100 | 31.1 | 18.2 | 11.5 | 7.9 | 3.0 | 2.2 | 1.4 | 3.3 |
| 125 | 23.2 | 13.4 | 8.6 | 6.2 | 2.4 | 1.8 | 1.2 | 2.0 |
| 150 | 19.5 | 10.7 | 6.7 | 5.1 | 2.1 | 1.6 | 1.0 | 1.4 |
| 175 | 16.2 | 8.9 | 5.5 | 4.3 | 1.8 | 1.4 | 0.9 | 1.0 |
| 200 | 14.4 | 7.8 | 4.7 | 3.8 | 1.6 | 1.3 | 0.8 | 0.8 |
| 225 | 13.1 | 6.7 | 4.0 | 3.3 | 1.4 | 1.1 | 0.8 | 0.6 |
| 250 | 11.5 | 5.8 | 3.4 | 2.9 | 1.3 | 1.0 | 0.7 | 0.4 |
| 275 | 10.5 | 5.1 | 3.0 | 2.6 | 1.2 | 0.9 | 0.6 | 0.4 |
| 300 | 9.5 | 4.5 | 2.7 | 2.3 | 1.1 | 0.9 | 0.6 | 0.3 |
| 325 | 8.7 | 4.1 | 2.5 | 2.1 | 1.0 | 0.8 | 0.6 | 0.2 |
| 350 | 8.2 | 3.8 | 2.4 | 2.0 | 0.9 | 0.8 | 0.5 | 0.2 |
| 375 | 7.6 | 3.6 | 2.2 | 1.8 | 0.9 | 0.7 | 0.5 | 0.2 |
| 400 | 7.1 | 3.3 | 2.0 | 1.6 | 0.8 | 0.7 | 0.5 | 0.1 |
| 500 | 5.9 | 2.7 | 1.7 | 0.9 | 0.3 | 0.3 | 0.2 | 0.1 |
| 600 | 5.1 | 2.3 | 1.4 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 700 | 4.5 | 2.1 | 1.2 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 800 | 4.2 | 1.9 | 1.1 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 900 | 3.9 | 1.8 | 1.0 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 1000 | 3.7 | 1.7 | 1.0 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0048 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.5 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 57.7 | 57.7 | 57.7 | 121.8 | 117.6 | 116.9 | 116.3 | 55.0 |
| 10 | 38.8 | 34.9 | 32.0 | 30.3 | 10.8 | 5.4 | 3.2 | 26.6 |
| 20 | 28.9 | 23.1 | 19.8 | 15.3 | 5.1 | 2.9 | 1.7 | 15.0 |
| 25 | 24.7 | 18.8 | 15.5 | 11.2 | 3.8 | 2.3 | 1.4 | 10.8 |
| 50 | 19.4 | 12.5 | 8.2 | 5.5 | 1.9 | 1.3 | 0.8 | 3.9 |
| 75 | 13.6 | 8.4 | 5.4 | 3.6 | 1.4 | 1.0 | 0.6 | 1.9 |
| 100 | 11.5 | 6.7 | 4.3 | 2.9 | 1.1 | 0.8 | 0.5 | 1.2 |
| 125 | 8.6 | 5.0 | 3.2 | 2.3 | 0.9 | 0.7 | 0.4 | 0.8 |
| 150 | 7.2 | 4.0 | 2.5 | 1.9 | 0.8 | 0.6 | 0.4 | 0.5 |
| 175 | 6.0 | 3.3 | 2.0 | 1.6 | 0.7 | 0.5 | 0.3 | 0.4 |
| 200 | 5.3 | 2.9 | 1.7 | 1.4 | 0.6 | 0.5 | 0.3 | 0.3 |
| 225 | 4.8 | 2.5 | 1.5 | 1.2 | 0.5 | 0.4 | 0.3 | 0.2 |
| 250 | 4.2 | 2.1 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.2 |
| 275 | 3.9 | 1.9 | 1.1 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 300 | 3.5 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 325 | 3.2 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 350 | 3.0 | 1.4 | 0.9 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 375 | 2.8 | 1.3 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 400 | 2.6 | 1.2 | 0.8 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 500 | 2.2 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 1.7 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.5 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 900 | 1.4 | 0.7 | 0.4 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.4 | 0.6 | 0.4 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.75 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 78.1 | 78.1 | 78.1 | 164.9 | 159.3 | 158.3 | 157.5 | 74.4 |
| 10 | 52.6 | 47.2 | 43.3 | 41.0 | 14.6 | 7.3 | 4.3 | 36.0 |
| 20 | 39.1 | 31.3 | 26.8 | 20.7 | 6.9 | 3.9 | 2.4 | 20.3 |
| 25 | 33.4 | 25.4 | 21.0 | 15.2 | 5.1 | 3.1 | 1.9 | 14.7 |
| 50 | 26.2 | 16.9 | 11.2 | 7.4 | 2.6 | 1.8 | 1.1 | 5.3 |
| 75 | 18.4 | 11.4 | 7.4 | 4.9 | 1.8 | 1.3 | 0.8 | 2.6 |
| 100 | 15.5 | 9.1 | 5.8 | 3.9 | 1.5 | 1.1 | 0.7 | 1.7 |
| 125 | 11.6 | 6.7 | 4.3 | 3.1 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.7 | 5.4 | 3.3 | 2.5 | 1.0 | 0.8 | 0.5 | 0.7 |
| 175 | 8.1 | 4.5 | 2.7 | 2.1 | 0.9 | 0.7 | 0.5 | 0.5 |
| 200 | 7.2 | 3.9 | 2.4 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.6 | 3.3 | 2.0 | 1.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| 250 | 5.7 | 2.9 | 1.7 | 1.5 | 0.7 | 0.5 | 0.3 | 0.2 |
| 275 | 5.2 | 2.5 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.7 | 2.3 | 1.4 | 1.2 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.3 | 2.1 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 4.1 | 1.9 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.8 | 1.8 | 1.1 | 0.9 | 0.4 | 0.4 | 0.2 | 0.1 |
| 400 | 3.5 | 1.7 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.9 | 1.4 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.3 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.1 | 1.0 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 2.0 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.8 | 0.8 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0048 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.75 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 28.8 | 28.8 | 28.8 | 60.9 | 58.8 | 58.4 | 58.1 | 27.5 |
| 10 | 19.4 | 17.4 | 16.0 | 15.1 | 5.4 | 2.7 | 1.6 | 13.3 |
| 20 | 14.4 | 11.6 | 9.9 | 7.6 | 2.6 | 1.4 | 0.9 | 7.5 |
| 25 | 12.3 | 9.4 | 7.8 | 5.6 | 1.9 | 1.1 | 0.7 | 5.4 |
| 50 | 9.7 | 6.2 | 4.1 | 2.7 | 1.0 | 0.7 | 0.4 | 2.0 |
| 75 | 6.8 | 4.2 | 2.7 | 1.8 | 0.7 | 0.5 | 0.3 | 0.9 |
| 100 | 5.7 | 3.4 | 2.1 | 1.5 | 0.6 | 0.4 | 0.3 | 0.6 |
| 125 | 4.3 | 2.5 | 1.6 | 1.1 | 0.5 | 0.3 | 0.2 | 0.4 |
| 150 | 3.6 | 2.0 | 1.2 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 175 | 3.0 | 1.6 | 1.0 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 200 | 2.7 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 225 | 2.4 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 250 | 2.1 | 1.1 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.8 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 325 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 400 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 500 | 1.1 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 0.9 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

[2] Although aerial application is not permitted on the oxyfluorfen labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 12.3.3.1** and **12.4.1**, the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.50 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 52.1 | 52.1 | 52.1 | 109.9 | 106.2 | 105.5 | 105.0 | 49.6 |
| 10 | 35.1 | 31.5 | 28.9 | 27.3 | 9.7 | 4.8 | 2.9 | 24.0 |
| 20 | 26.0 | 20.9 | 17.9 | 13.8 | 4.6 | 2.6 | 1.6 | 13.5 |
| 25 | 22.3 | 16.9 | 14.0 | 10.1 | 3.4 | 2.1 | 1.3 | 9.8 |
| 50 | 17.5 | 11.3 | 7.4 | 4.9 | 1.8 | 1.2 | 0.7 | 3.6 |
| 75 | 12.3 | 7.6 | 4.9 | 3.3 | 1.2 | 0.9 | 0.6 | 1.7 |
| 100 | 10.4 | 6.1 | 3.8 | 2.6 | 1.0 | 0.7 | 0.5 | 1.1 |
| 125 | 7.7 | 4.5 | 2.9 | 2.1 | 0.8 | 0.6 | 0.4 | 0.7 |
| 150 | 6.5 | 3.6 | 2.2 | 1.7 | 0.7 | 0.5 | 0.3 | 0.5 |
| 175 | 5.4 | 3.0 | 1.8 | 1.4 | 0.6 | 0.5 | 0.3 | 0.3 |
| 200 | 4.8 | 2.6 | 1.6 | 1.3 | 0.5 | 0.4 | 0.3 | 0.3 |
| 225 | 4.4 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.2 |
| 250 | 3.8 | 1.9 | 1.1 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 3.5 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 300 | 3.2 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 325 | 2.9 | 1.4 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 350 | 2.7 | 1.3 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 375 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 400 | 2.4 | 1.1 | 0.7 | 0.5 | 0.3 | 0.2 | 0.2 | <0.1 |
| 500 | 2.0 | 0.9 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.7 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 1.5 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.4 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 900 | 1.3 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.2 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0048 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-32. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.50 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 19.2 | 19.2 | 19.2 | 40.6 | 39.2 | 39.0 | 38.8 | 18.3 |
| 10 | 12.9 | 11.6 | 10.7 | 10.1 | 3.6 | 1.8 | 1.1 | 8.9 |
| 20 | 9.6 | 7.7 | 6.6 | 5.1 | 1.7 | 1.0 | 0.6 | 5.0 |
| 25 | 8.2 | 6.3 | 5.2 | 3.7 | 1.3 | 0.8 | 0.5 | 3.6 |
| 50 | 6.5 | 4.2 | 2.7 | 1.8 | 0.6 | 0.4 | 0.3 | 1.3 |
| 75 | 4.5 | 2.8 | 1.8 | 1.2 | 0.5 | 0.3 | 0.2 | 0.6 |
| 100 | 3.8 | 2.2 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 | 0.4 |
| 125 | 2.9 | 1.7 | 1.1 | 0.8 | 0.3 | 0.2 | 0.1 | 0.3 |
| 150 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.0 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.8 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-33. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.25 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 26.0 | 26.0 | 26.0 | 55.0 | 53.1 | 52.8 | 52.5 | 24.8 |
| 10 | 17.5 | 15.7 | 14.4 | 13.7 | 4.9 | 2.4 | 1.4 | 12.0 |
| 20 | 13.0 | 10.4 | 8.9 | 6.9 | 2.3 | 1.3 | 0.8 | 6.8 |
| 25 | 11.1 | 8.5 | 7.0 | 5.1 | 1.7 | 1.0 | 0.6 | 4.9 |
| 50 | 8.7 | 5.6 | 3.7 | 2.5 | 0.9 | 0.6 | 0.4 | 1.8 |
| 75 | 6.1 | 3.8 | 2.5 | 1.6 | 0.6 | 0.4 | 0.3 | 0.9 |
| 100 | 5.2 | 3.0 | 1.9 | 1.3 | 0.5 | 0.4 | 0.2 | 0.6 |
| 125 | 3.9 | 2.2 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 | 0.3 |
| 150 | 3.2 | 1.8 | 1.1 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 175 | 2.7 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 | 0.2 |
| 200 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 225 | 2.2 | 1.1 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.4 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 1.0 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.8 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.0048 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 12-34. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.25 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 9.6 | 9.6 | 9.6 | 20.3 | 19.6 | 19.5 | 19.4 | 9.2 |
| 10 | 6.5 | 5.8 | 5.3 | 5.0 | 1.8 | 0.9 | 0.5 | 4.4 |
| 20 | 4.8 | 3.9 | 3.3 | 2.5 | 0.9 | 0.5 | 0.3 | 2.5 |
| 25 | 4.1 | 3.1 | 2.6 | 1.9 | 0.6 | 0.4 | 0.2 | 1.8 |
| 50 | 3.2 | 2.1 | 1.4 | 0.9 | 0.3 | 0.2 | 0.1 | 0.7 |
| 75 | 2.3 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 100 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.4 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 150 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 225 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.013 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 13 Paraquat Case Study Example (PC Code 061601)

## 13.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 13.2 Use Information

Paraquat dichloride (referred to as 'paraquat' throughout this document) is a quaternary ammonium compound widely used for broadleaf weed control on agricultural, forestry, residential, commercial, and nursery use sites. It is a fast-acting contact herbicide used to suppress or eradicate a wide spectrum of post-emergent weeds and is quickly absorbed by living plant tissue. It also functions as a defoliant and desiccant and is most effective on growing plants with abundant green tissue. Paraquat is quickly absorbed by living (especially healthy) plant tissue and produces superoxides during photosynthesis, which destroy plant cells. It is less effective on dry, drought-stressed, woody, or fully mature plants. Paraquat is not likely to be transported systemically throughout the plant, because of the quick absorption by living plant tissues, followed by rapid plant death, but it can be transported only locally through diffusion. Paraquat is generally applied as a flowable solution and readily dissociates into its cation, paraquat, which is the only stressor of concern. No paraquat seed treatments nor granular products are currently registered.

Paraquat rapidly and strongly adsorbs to soil or sediments, rather than degrading under environmental conditions. Paraquat adsorbs faster to soil/sediment than it degrades via microbial degradation, as observed in the laboratory metabolism studies. Paraquat adsorbed strongly enough in the adsorption-desorption studies that no paraquat could be detected in the water phase of these studies, and the study authors could not calculate reliable soil/water partition coefficients ($K_d$). Therefore, paraquat environmental exposure estimates can have a degree of uncertainty. However, based on the observed paraquat properties, EPA assumed the following: 1) terrestrial exposures can occur on the field and via spray drift, 2) aquatic exposures likely occur through spray drift immediately after a drift event (acute exposure), and 3) exposure through runoff/erosion is unlikely.

**Table 13-1** includes the use information from the 2019 Draft Risk Assessment (DRA; DP430829) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Strategy. As this is an illustrative example of how the draft Strategy would be implemented for paraquat, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Interim Decision in August 2021) are not considered at this time but would be considered when EPA conducts assessments for paraquat for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2020 assessment. **Table 13-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 13.6** of this document. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on field corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5**.

EPA estimated exposures using the selected[182] uses and application information provided in **Table 13-1**. The application rates in **Table 13-1** are based on lb paraquat cation/A, where a rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A. The selected uses do not necessarily represent all registered uses of paraquat and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where paraquat usage is most common. Note that several crops (*e.g.,* cocoa, coffee, and pineapple) are labeled uses of paraquat; however, cocoa, coffee, and pineapple are not grown in the conterminous United States (CONUS), and therefore EPA did not evaluate these uses further as part of the draft Strategy. The selected uses are examples to illustrate the draft Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Herbicide Strategy, EPA only calculated estimated environmental concentrations (EECs) in AgDRIFT (v.2.1.1) based on spray drift from application of liquid spray formulations. Because of

[182] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2019 Draft Risk Assessment for Registration Review (DP430829) for paraquat. Any uses not evaluated in the 2019 assessment and any new uses since this assessment are not included in this example case study for the proposed Herbicide Strategy.

paraquat's rapid adsorption to soil, EPA did not generate EECs to model runoff/erosion exposure.

**Table 13-1. Summary of the Selected Agricultural Use Patterns Labeled for Paraquat (2019 Draft Risk Assessment for Registration Review, DP430829) [1]**

| Use Site | App Method | Max Single App Rate (lb paraquat cation/acre)[2] | Per Year Basis | | MRI (d) |
|---|---|---|---|---|---|
| | | | Max # Apps/yr | Max lb paraquat cation/A/yr[2] | |
| **Other Orchards Use Data Layer** | | | | | |
| Acerola (West Indies Cherry), Almond, Apple, Avocado, Banana, Fig, Papaya, Pear, Pistachio, Prune, Tree Nuts | G | 1.01 | 5 | NS | NS |
| Apricot, Cherry, Nectarine, Peach, Plum | G | 1.01 | 3 | NS | NS |
| Cocoa[3], Coffee[3] | G | 1.01 | 5 | NS | NS |
| Guava | G | 0.938 | 4 | NS | NS |
| Macadamia Nut (Bushnut) | G | 0.475 | 4 | NS | NS |
| Olive | G | 1.01 | 4 | NS | NS |
| Passion Fruit (Granadilla), Persimmon | G | 0.938 | 5 | NS | NS |
| Subtropical/Tropical Fruit | G | 0.938 | 4 | NS | 28 |
| **Citrus Use Data Layer** | | | | | |
| Citrus (Citrus) | G | 1.01 | 5 | NS | NS |
| **Alfalfa Use Data Layer** | | | | | |
| Alfalfa (Alfalfa) | A/G | 1.5 | 3 | 2 | NS |
| **Vegetables and Ground Fruit Use Data Layer** | | | | | |
| Artichoke | G | 1.01 | 3 | NS | 7 |
| Asparagus, Brassica (Head and Stem) Vegetables, Carrot (including tops), Corn (Pop), Cucurbit Vegetables, Eggplant, Fruiting Vegetables, Kiwi Fruit, Leafy Vegetables, Lettuce, Melons, Peas (unspecified), Pepper, Root and Tuber Vegetables, Tomato, Turnip (Greens) | A/G | 1.01 | 3 | NS | NS |
| Beans (Dried-Type), Lentils, Peas (Dried-Type) | A/G | 0.5 | 2 | NS | NS |
| Bushberries, Caneberries | G | 1.01 | 5 | NS | NS |
| Corn, Sweet | A/G | 1.01 | 3 | NS | 14 |
| Garlic, Onion | G | 1.01 | 1 | NS | NS |
| Ginger | G | 1.0 | 6 | NS | 30 |
| Guar, Strawberry | G | 0.5 | 3 | NS | NS |
| Legume Vegetables | A/G | 0.788 | 1 | NS | NS |
| Manioc (Cassava), Tyfon | G | 1.01 | 3 | NS | NS |
| Mint | A/G | 0.75 | 2 | NS | NS |
| Okra | G | 1.0 | 2 | NS | NS |
| Peas, Pigeon | G | 0.5 | 1 | NS | NS |
| Pineapple[3] | G | 1.01 | 3 | NS | NS |
| Potato, White/Irish (Or Unspecified) | A/G | 0.625 | 3 | NS | 5 |
| Rhubarb, Yam | G | 1.01 | 2 | NS | NS |
| Sage, Clary | A/G | 0.75 | NS | NS | NS |
| Taro | G | 0.788 | 2 | NS | NS |
| Tuberous and Corm Vegetables | A/G | 0.5 | 3 | NS | NS |
| Vegetables (Unspecified) | G | 0.75 | 2 | NS | NS |
| **Other Grains Use Data Layer** | | | | | |
| Barley, Safflower | A/G | 1.01 | 3 | NS | NS |

| Use Site | App Method | Max Single App Rate (lb paraquat cation/acre)[2] | Per Year Basis | | MRI (d) |
|---|---|---|---|---|---|
| | | | Max # Apps/yr | Max lb paraquat cation/A/yr[2] | |
| Sorghum | A/G | 1.01 | 3 | 1.99 | NS |
| Sugarcane | A/G | 0.938 | 2 | NS | NS |
| **Other Crops Use Data Layer** | | | | | |
| Clover | A/G | 1.5 | NS | NS | NS |
| Fallow Land | A/G | 1.01 | 3 | NS | NS |
| **Corn Use Data Layer** | | | | | |
| Corn, Field | A/G | 1.01 | 3 | NS | NS |
| **Cotton Use Data Layer** | | | | | |
| Cotton | A/G | 1.01 | 4 | NS | 7 |
| **Grapes Use Data Layer** | | | | | |
| Grapes | A/G | 1.01 | 5 | NS | NS |
| **Other Row Crops Use Data Layer** | | | | | |
| Hops | G | 0.5 | 3 | NS | NS |
| Peanuts | G | 0.938 | 2 | NS | 28 |
| Sugar Beet, Sunflower | A/G | 1.01 | 3 | NS | NS |
| Tobacco | G | 0.938 | 2 | NS | NS |
| **Rice Use Data Layer** | | | | | |
| Rice | A/G | 1.01 | 3 | NS | NS |
| **Soybeans Use Data Layer** | | | | | |
| Soybeans | A/G | 1.01 | 3 | NS | 14 |
| **Wheat Use Data Layer** | | | | | |
| Wheat | A/G | 1.01 | 3 | NS | NS |

App=application; MRI=minimum retreatment interval; d=days; A=aerial applications; G=ground applications; NS=not specified on labels.

[1] The use information presented in this table is identical to the agricultural uses included in the 2019 Draft Risk Assessment (DP430829).

[2] These application rates are based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[3] This crop is not grown within CONUS (conterminous United States), so although it is presented as a use in this table, mitigations for this use will not be determined as part of the Herbicide Strategy.

## 13.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of paraquat (**Section 13.3.1**), reported incidents (**Section 13.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 13.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 13.3.1 Toxicity Information

**Table 13-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for paraquat.

**Table 13-2. Summary of the Most Sensitive Toxicity Endpoints for Paraquat (As Summarized in the 2019 Draft Risk Assessment for Registration Review (DP430829))**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Oat (*Avena sativa*) | $IC_{25}$ = 0.635 lb cation/A NOAEC = 0.28 lb cation/A | 49320310 Supplemental (can be used quantitatively) | Test with TEP (22.4% cation); NOAEC based on significant 21.1% inhibition in both survival and emergence.[2] |
| | Dicot: Cocklebur (*Xanthium strumarium*) | $IC_{25}$ = 0.67 lb cation/A NOAEC = 0.171 lb cation/A | 42639601 Acceptable | Test with TEP (19.2% cation); NOAEC based on biologically significant 20.5% reduction in emergence.[3] |
| Vegetative Vigor | Monocot: Perennial Ryegrass (*Lolium perenne*) | $IC_{25}$ = 0.0208 lb cation/A NOAEC = 0.018 lb cation/A | 49320309 Acceptable | Test with TEP (22.4% cation); NOAEC based on significant 59.5% dry weight inhibition.[4] |
| | Dicot: Soybean (*Glycine max*) | $IC_{25}$ = 0.0217 lb cation/A NOAEC = 0.0048 lb cation/A | | Test with TEP (22.4% cation); NOAEC based on significant 19.8% height inhibition.[5] |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | **$IC_{50}$ = 71 µg cation/L** NOAEC = 23 µg cation/L | 42601003 Acceptable | Test with TGAI (Paraquat dichloride 32.7%, 23.7% cation); Based on 18% inhibition in frond number at the LOAEC. |
| Aquatic Nonvascular Plant | Freshwater Diatom (*Navicula pelliculosa*) | **$IC_{50}$ = 0.40 µg cation/L** NOAEC = 0.16 µg cation/L | 42601006 Acceptable | Test with TGAI (Paraquat dichloride 32.7%, 23.7% cation); Based on 54% inhibition in cell density at the LOAEC. |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}$/$IC_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; TEP=typical end-use product; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the paraquat vegetative vigor tests. See **Figure 13-1** and **Table 13-3** these SSD results.

[2] Monocot (oat): LOAEC was based on significant ($p$<0.05) inhibition in oat survival and emergence; all endpoints were based on measured concentrations. The 0.14 and 0.28 lb cation/A treatments also had a 15.8% reduction, which were not considered treatment related, although some uncertainty is acknowledged.

[3] Dicot (cocklebur): LOAEC was based on a biologically significant (although not statistically significant at $p$<0.05) 20.5% reduction in emergence at the LOAEC, along with demonstration of a dose-related general decrease in emergence.

[4] Monocot (ryegrass): LOAEC was based on significant (p<0.05) 59.5% inhibition at the LOAEC of 0.033 lb cation/A, followed by a dose-dependent 95.4% inhibition at 0.11 lb cation/A.

[5] Dicot (soybean): LOAEC was based on significant ($p<0.05$) 19.8% inhibition of height at 0.018 lb cation/A, followed by dose-dependent pattern of inhibition of 39.0% and 46.2% at the next two higher treatment levels.

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from one of the two standard terrestrial plant toxicity tests (vegetative vigor). EPA could not generate SSDs for the seedling emergence data because there were too few definitive endpoints (2 $IC_{25}$ values and 2 $EC_{25}$ values). See Appendix 1: Species Sensitivity Distribution Data (SSD) and Results for the data used to generate the SSDs and Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints for the process for calculating the SSDs. In total, EPA calculated two SSDs for paraquat by combining the results for tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to paraquat. Specifically, as summarized in Appendix 1: Species Sensitivity Distribution Data (SSD) and Results, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the vegetative vigor studies overlap when considering all definitive values available. Additionally, the mean and median $IC_{25}$ values for monocot and dicot height data only differ by a factor of 3 and 4, respectively. Similarly, the mean $IC_{25}$ values for monocot and dicot dry weight data are nearly identical (0.071 and 0.062 lb cation/A) and the median $IC_{25}$ values for monocots and dicots only differ by a factor of 2. Given these considerations, EPA did not create separate SSDs for monocots and dicots.

**Figure 13-1** shows the two SSDs that EPA generated. The SSD based on the vegetative vigor weight data resulted in the most sensitive 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values (represented as red and black dots in **Figure 13-1**, respectively). EPA used the most sensitive 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values from the SSD to calculate the spray drift distances for exposure in wetland and terrestrial habitats **Figure 13-1** and **Table 13-4**; see **Section 13.3.3**). By combining the monocot and dicot data, these 5$^{th}$ and 25$^{th}$ percentile values represent the sensitivities of both types of flowering plants to paraquat.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[183] are available to evaluate potential impacts of paraquat on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 13-2** and **Table 13-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[184].

[183] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[184] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1** in the **Case Study Summary and Process** document.

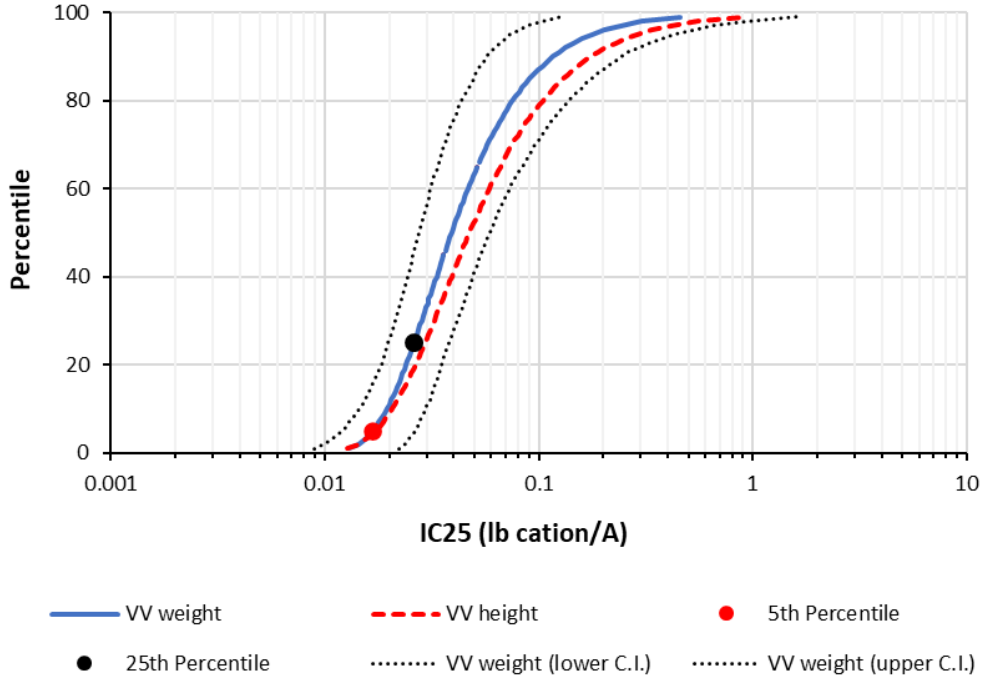



**Figure 13-1. Vegetative Vigor (VV) Study Species Sensitivity Distributions (SSDs) representing the Distributions of the Plant Weight and Height IC25s for Paraquat. The Upper and Lower Confidence Intervals (C.I.) are plotted for the VV plant weight SSD.**

**Table 13-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Paraquat**

| Percentile (x) | Vegetative Vigor Test[1] | |
|---|---|---|
| | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb cation/A | Height: x Percentile $IC_{25}$ from SSD (C.I.), lb cation/A |
| 5 | **0.017** (0.012 – 0.026) | 0.017 (0.011 – 0.039) |
| 25 | **0.026** (0.020 – 0.038) | 0.029 (0.020 – 0.055) |
| 50 | 0.039 (0.028 – 0.059) | 0.048 (0.028 – 0.094) |

**Bolded** endpoints indicate the most sensitive endpoints, which EPA used to identify the spray drift distances for listed monocots, dicots, and animals that depend on monocots/dicots.
[1] EPA did not generate SSDs for the seedling emergence data due to few definitive $IC_{25}$ values.

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 13.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that

obligately depend on these plants[185], EPA calculated the magnitude of difference as a ratio of the EEC to the 5th percentile of the vegetative vigor plant weight SSD (**Table 13-4**). For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[186] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25th percentile of the SSD (**Table 13-4**Table 6-4). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Table 13-4**).

**Table 13-4. Toxicity Endpoints used to Calculate the Spray Drift Distances for Paraquat[1].**

| Taxon | Habitat | Endpoint Used for Spray Drift Modeling |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial and Wetland Plants[2] | Terrestrial, Wetland | 0.017 lb cation/A |
| Listed Aquatic Plants | Small Waterbodies[3] | 71 µg cation/L (Vascular)<br>0.4 µg cation/L (Nonvascular) |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial/Wetland Animals that Obligately Rely on Terrestrial/Wetland Plants[4] | Terrestrial, Wetland | 0.017 lb cation/A |
| Terrestrial/Wetland Animals that Generally Rely on Terrestrial/Wetland Plants[4] | Terrestrial | 0.026 lb cation/A |
| Aquatic Animals that Generally Rely on Aquatic Plants[5] | EPA Farm Pond and Larger Waterbodies[6] | Vascular: 71 µg cation/L<br>Nonvascular: 0.4 µg cation/L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Herbicide Strategy. In this case study for paraquat, EPA calculated two sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa and because EPA only conducted spray drift modeling for paraquat.
[2] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[3] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1** of the **Case Study Summary and Process** document).
[4] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[5] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[6] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1** of the **Case Study Summary and Process** document).

[185] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[186] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

### 13.3.2 Incidents

The incident information from the 2019 Draft Risk Assessment (DP430829) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[187] (as discussed in **Section 13.3.3.3**), which informs the potential population-level impacts (**Section 13.6**), and to identify the proposed level of mitigation (**see Section 13.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 13.3.3.3**)[188]. Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents reported since registration and up to June 14, 2018, the date of the most recent search for paraquat. EPA searched the database for ecological incidents involving paraquat dichloride (PC code 061601), paraquat (PC code 061603), and paraquat bis (methyl sulfate) (PC code 061602). Although paraquat and paraquat bis (methyl sulfate) are no longer registered for use in the United States, like paraquat dichloride, paraquat is the active ingredient of both of these chemicals. Therefore, EPA assumed that incidents associated with paraquat and paraquat bis (methyl sulfate) are representative of paraquat dichloride incidents.

The 2019 Draft Risk Assessment (DP430829) provides a list of the available incident reports found. The incident reports include 27 plant damage incidents. Aggregated counts of wildlife, plant, and other non-target species incidents are also available; the totals (including 78 plant incidents) are presented in the 2019 Draft Risk Assessment (DP430829).

Because the incidents of paraquat damage to non-target, off-field plants are few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for paraquat. In other words, the paraquat incidents do not indicate an unexpected pathway of off-

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[187] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[188] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 13.3.3.3**) are unaltered by the available paraquat incident data.

### 13.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint. The relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and animals with an obligate relationship to plants using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *13.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 13-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of paraquat ($5^{th}$ percentile of SSD = 0.017 lb cation/A). **Table 13-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of paraquat ($25^{th}$ percentile of SSD = 0.026 lb cation/A). Within **Table 13-5** and **Table 13-6**, the modeled application rate of 1.5 lb cation/A is the maximum single application rate currently registered for use of paraquat on alfalfa and clover. Rates of 1.0 and 0.5 lb cation/A are representative of maximum single application rates for other uses (**Table 13-1**). **Table 13-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 13-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat effects to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 13.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 13.9**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, which resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 13-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb cation/A (maximum application rate for use on alfalfa and clover)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 1000 | 375 | 250 | 225 | 75 | 50 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.7** [300] | **1.3** [300] | **1.3** [200] | **1.1** [200] | 0.8 [100] | 0.6 [100] | 0.4 [100] |
| **Application Rate of 1.01 lb cation/A (maximum application rate for multiple uses and an example of a reduced application rate)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 600 | 275 | 175 | 150 | 50 | 50 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.8** [300] | 0.9 [300] | 0.9 [200] | 0.7 [200] | 0.6 [100] | 0.4 [100] | 0.3 [100] |
| **Application Rate of 0.5 lb cation/A (maximum application rate for multiple uses)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 275 | 150 | 125 | 75 | 25 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.9 [300] | 0.4 [300] | 0.4 [200] | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] These application rates are based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[3] For paraquat, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 13.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[4] If the distance to medium MoE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 13.9** contains the full output of results.

**Table 13-6. Spray Drift Distances to the Population-Level Impacts Endpoint (25th Percentile of the SSD) for Listed Generalist Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application[2] | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb cation/A (maximum application rate for use on alfalfa and clover)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 550 | 275 | 175 | 150 | 50 | 50 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.8** [300] | 0.8 [300] | 0.9 [200] | 0.7 [200] | 0.6 [100] | 0.4 [100] | 0.3 [100] |
| **Application Rate of 1.01 lb cation/A (maximum application rate for multiple uses and an example of a reduced application rate)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 350 | 200 | 150 | 100 | 50 | 20 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.2** [300] | 0.6 [300] | 0.6 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 0.5 lb cation/A (maximum application rate for multiple uses)[2]** | | | | | | | |
| Distance to Medium MoE[3,4] (ft) | 175 | 125 | 75 | 50 | 20 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] These application rates are based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[3] For paraquat, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 13.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[4] If the distance to medium MoE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. . **Section 13.9** contains the full output of results.

#### *13.3.3.2 Runoff/Erosion Magnitude of Difference*

For paraquat, EPA did not generate magnitude of difference values for runoff/erosion exposure, because paraquat binds very tightly to clay in soil, resulting in no expected runoff of the dissolved phase nor desorption of the fraction that may erode with soil particles.

#### *13.3.3.3 Magnitude of Effect*

For the purpose of identifying spray drift mitigation measures (**Section 13.4.1**) for paraquat and conducting a population-level impact analysis (**Section 13.6**), EPA determined the magnitude of effect for each taxonomic group. These magnitude of effects conclusions are based on the magnitudes of difference between spray drift deposition EECs and toxicity endpoints that are presented **Section 13.3.3.1** and Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). For paraquat, given the toxicity profile (including only about a 1.5X difference between the 5$^{th}$ and 25$^{th}$ percentiles of the most sensitive SSD with a relatively steep slope for the SSD)[189], EPA would assign a low magnitude of effect on a use basis to groups of listed species and critical habitats (CHs)[190] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. Based on the spray drift magnitude of difference values exceeding 1.0 off the treated field (see **Table 13-5** and **Table 13-6**), EPA assigned a medium magnitude of effect to all uses for listed terrestrial and wetland plants and animals that depend on these plants. For listed aquatic plants and animals that depend on these plants, the magnitude of effect is low because of the short spray drift distances (see **Section 13.9**) and the very limited potential runoff/erosion exposure due to paraquat's strong binding to soil.

## 13.4 Framework Step 2: Identify Mitigation Measures

**Section 13.4** outlines the mitigation measures identified for paraquat for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 13.4.1**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Given the strong binding of paraquat to soil, EPA did not identify runoff/erosion mitigation measures. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

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[189] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[190] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 13.4.1 Spray Drift Mitigation Measures Identified

**Table 13-7** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 13-8** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 13-7. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb cation/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.5 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,f,g] | 75[f,g] | 50[f,g] | 50[f,g] |
| 1.01 | 300[a,b,c] | 275[a,b,c] | 175[a,b,d] | 150[e,f,g] | 50[f,g] | 50[f,g] | 20[h] |
| 0.5 | 275[a,b,c] | 150[b,d] | 125[b,d] | 75[f,g] | 25[h] | 20[h] | 10[h] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[3] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 13-1** These application rates are based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.
[3] See **Section 5.1** in the **Strategy Framework** document for discussion of these mitigation practices.

**Table 13-8. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb cation/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 1.5 | 300[a,b,c] | 275[a,b,c] | 175[a,b,d] | 150[e,f,g] | 50[f,g] | 50[f,g] | 20[h] |
| 1.01 | 300[a,b,c] | 200[a,b] | 150[b,d] | 100[e,f,g] | 50[f,g] | 20[h] | 20[h] |
| 0.5 | 175[a,b,d] | 125[b,d] | 75[b,d] | 50[f,g] | 20[h] | 10[h] | None[3] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] Single maximum label rates reflect the range of uses represented in **Table 13-1.** These application rates are based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[3] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is ≤0.5 at 10 ft off the treated field.

[4] See **Section 5.1** in the **Strategy Framework** document for discussion of these mitigation practices.

### 13.4.2 Runoff/Erosion Mitigation Measures Identified

Because paraquat binds very tightly to clay in soil (DP430829), EPA does not expect runoff of dissolved phase paraquat. Additionally, EPA does not expect the fraction that does erode with soil particles to desorb into the water column (MRID 40762701; Amondham *et al.* 2006[191]). Therefore, runoff/erosion mitigation is not identified for paraquat.

[191] Amondham, W., P. Parkpian, C. Polprasert, R.D. DeLaune, and A. Jugsujinda. 2006. "Paraquat Adsorption, Degradation, and Remobilization in Tropical Soils of Thailand." *Journal of Environmental Science and Health -Part B* 41 (*5*): 485–507. doi: 10.1080/03601230600701635.

## 13.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for paraquat are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 13-7**) and one for generalist animals that depend on plants (**Table 13-8**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are different for these two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For paraquat, the less restrictive mitigations relevant to generalists animals that are depicted in **Table 13-8** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 13-7** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur. Because the spray drift distances are equivalent for both habitat types (*i.e.,* terrestrial, wetland and aquatic) and for all groups of listed plants and listed animals that obligately depend on plants, the spray drift distances in **Table 13-7** would apply to all four PULAs.

Because paraquat binds very tightly to clay in soil, EPA does not expect runoff of dissolved phase paraquat nor desorption of the fraction eroded with soil particles into the water column. Therefore, EPA did not identify runoff/erosion mitigation for paraquat.

## 13.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**.. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 13.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of paraquat. For major crops (*e.g.,* corn, cotton, wheat), EPA selected the crop-specific UDLs. For other uses such as on asparagus and barley, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). EPA's overlap analysis was based on the offsite transport

area where spray drift of paraquat may lead to exposures for listed species. This offsite transport area is represented by extending the on-field portion of the individual UDLs that represent potential paraquat use sites (see **Appendix C of the Strategy Framework document for more information**) to include areas of potential offsite drift exposure.

As outlined in **Section 13.3.3.1** and **Section 13.4.1**, drift distances identified depend on: 1) the maximum single application rate for any use within the UDL (*i.e.,* 1.5 lb paraquat cation/A or 1.01 lb paraquat cation/A (**Table 13-1)** ; 2) the application method (aerial vs. ground; see **Table 13-1**); and 3) the endpoint relevant for the taxonomic group (5$^{th}$ percentile of the SSD for listed plants and obligate animals vs. 25$^{th}$ percentile of the SSD for generalist animals and critical habitats (CH)). Specifically in the population-level impacts analysis for paraquat, EPA used the following offsite distances:

- Alfalfa and Other Crops UDLs: EPA used an aerial drift distance of 300 m and a ground drift distance of 90 m for listed plants and obligate animals. For listed generalist animals and CHs, EPA used drift distances of 180 m (aerial) and 60 m (ground).
- Other Orchards and Citrus UDLs: Aerial applications are not permitted for the uses assigned to these UDLs, so EPA used a ground drift distance of 60 m for listed plants and obligate animals and 30 m for generalist animals and CHs.
- All other UDLs: EPA used 180 m and 60 m for aerial and ground applications, respectively, for listed plants and obligate animal obligate. For listed generalist animals and CHs, EPA used 120 m and 30 m for aerial and ground applications, respectively.

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL at the specified drift distance and if the use-specific magnitude of effect was medium or high (**Section 13.3.3.3**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 13-9** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected paraquat UDLs[192] are considered. For illustrative purposes of the Herbicide Strategy, the Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for paraquat based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For paraquat's UDLs, fewer species (356) and CHs (66) have overlap >5%. An important consideration for the purposes of this example is that EPA did not necessarily evaluate all registered uses of paraquat (see **Section 13.2**), so additional species could be identified in the

[192] The selected use data layers (UDLs) do not necessarily represent every registered use of paraquat. See **Section 13.2** for more information on the uses evaluated in this example.

future for paraquat. Additionally, the UDL-specific offsite distances for paraquat are generally shorter than the default distance that EPA used to generate the PULAs (*e.g.,* 180 m vs. 300 m), resulting in fewer species having >5% overlap for paraquat as compared to the PULAs. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of paraquat; however, the PULAs include some species and CHs that have <5% overlap with paraquat's potential exposure area for the considered uses.

**Table 13-9. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Paraquat Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.[1]**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[2] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Other Orchards[3] | 469 / 142 | 40 | 15 |
| Citrus[3] | | 25 | 2 |
| Alfalfa | | 141 | 32 |
| Vegetables and Ground Fruit | | 91 | 19 |
| Other Grains | | 173 | 29 |
| Other Crops | | 324 | 55 |
| Corn | | 130 | 17 |
| Cotton | | 50 | 7 |
| Grapes | | 97 | 19 |
| Other Row Crops | | 33 | 1 |
| Rice | | 7 | 0 |
| Soybeans | | 75 | 6 |
| Wheat | | 136 | 22 |
| Total across all UDLs above[4] | | 356 | 66 |
| Cultivated | | 383 | 70* |
| **Listed Animal Generalists** | | | |
| Other Orchards[3] | 534 / 316 | 24 | 24 |
| Citrus[3] | | 2 | 1 |
| Alfalfa | | 106 | 52 |
| Vegetables and Ground Fruit | | 57 | 35 |
| Other Grains | | 151 | 70 |
| Other Crops | | 316 | 143 |
| Corn | | 217 | 85 |
| Cotton | | 85 | 37 |
| Grapes | | 32 | 19 |
| Other Row Crops | | 40 | 23 |
| Rice | | 9 | 4 |
| Soybeans | | 156 | 63 |
| Wheat | | 180 | 70 |
| Total across all UDLs above[4] | | 345 | 163 |
| Cultivated | | 381 | 179 |

CH=designated critical habitat

[1] For paraquat, only drift exposure is relevant so EPA used UDL-specific drift distances in the predictions of population-level impacts. See the preceding text for a description of the specific distances used on a UDL basis.
[2] These values are based on EPA's analyses for example purposes for paraquat. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.
[3] Only ground applications are permitted for the uses assigned to the Other Orchards and Citrus UDLs.
[4] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for paraquat (excluding the Cultivated UDL, which is summarized below this row).
*This value for the Cultivated UDL represents the number of CHs with potential population-level impacts at the maximum offsite drift distance of 180 m for paraquat. The four Pesticide Use Limitation Areas (PULAs) include more CHs (n=85) than represented in this table because the default offsite distance is 300 m for the PULAs, meaning that more CHs will have overlap >5% when the offsite buffer is larger.

## 13.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

Because definitive endpoints were limited for the seedling emergence data (2 $IC_{25}$ values and 2 $EC_{25}$ values), EPA could only reliably generate two SSDs in total for paraquat.

The ranges of $IC_{25}$ values for plant dry weight from the vegetative vigor studies are 0.021 to 0.244 lb cation/A (excluding non-definitive endpoints[193]) for monocots and 0.0175 to 0.137 lb cation/A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.071 and 0.062 lb cation/A, respectively. The ranges of $IC_{25}$ values for plant height data in the vegetative vigor studies are 0.0208 to 0.0633 lb cation/A (excluding non-definitive endpoints) for monocots and 0.0217 to 0.218 lb cation/A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.042 and 0.13 lb cation/A, respectively.

[193] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 4 lb paraquat cation/A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 13.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed paraquat. EPA developed separate SSDs for height and weight. Because definitive endpoints were limited for the seedling emergence data (2 $IC_{25}$ values and 2 $EC_{25}$ values), EPA could only reliably generate two SSDs in total for paraquat.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion (AIC)c weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the diuron data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

## Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA compared the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

## Species Sensitivity Distribution (SSD) for Paraquat

The toxicity endpoints included in the SSDs and the resulting percentiles of the $IC_{25}$ values from the SSD are presented here. Because there were limited definitive endpoints for the SE data (2 $IC_{25}$ values and 2 $EC_{25}$ values), EPA could not determine SSDs for these data for paraquat.

### *Vegetative Vigor Height Data*

Goodness of fit:

Results:

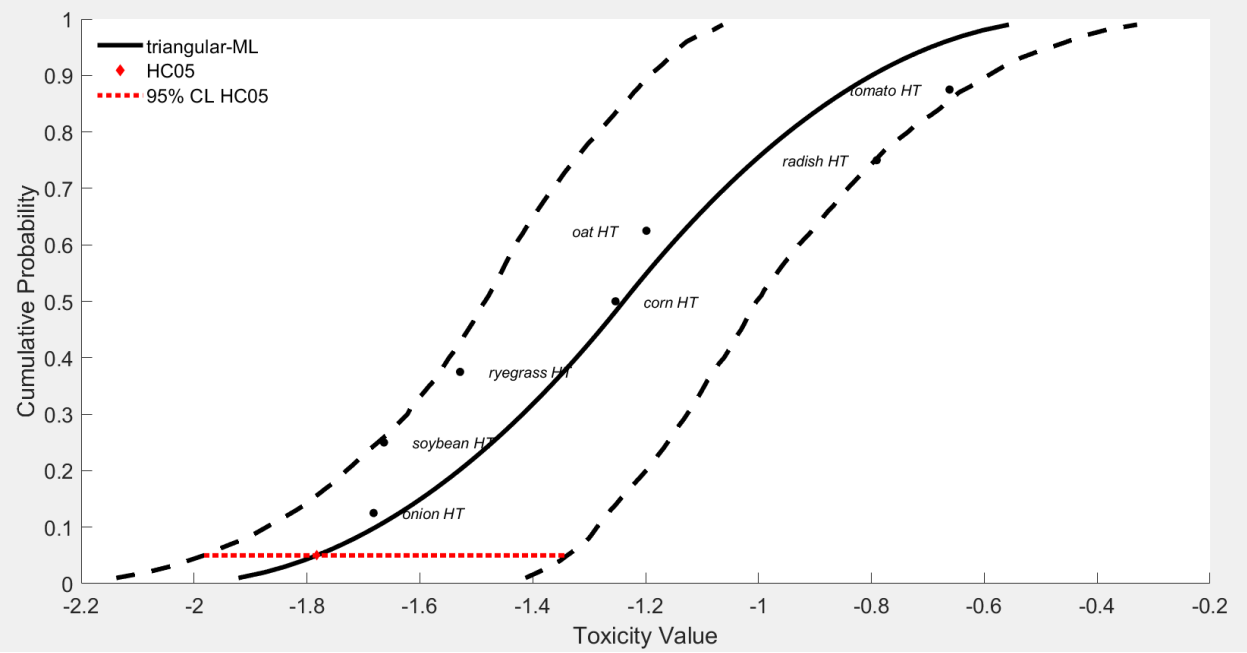
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0134 | 0.3836 |
| 2 | logistic | ML | 0.0111 | 0.3477 |
| 3 | triangular | ML | 0.0165 | 0.3516 |
| 4 | gumbel | ML | 0.0172 | 0.3746 |
| 5 | weibull | ML | 0.0072 | 0.2867 |
| 6 | burr | ML | 0.0172 | 0.3437 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.014388 |
| Model-averaged SE of HCp: | 0.0075391 |
| CV of HCp: | 0.52399 |

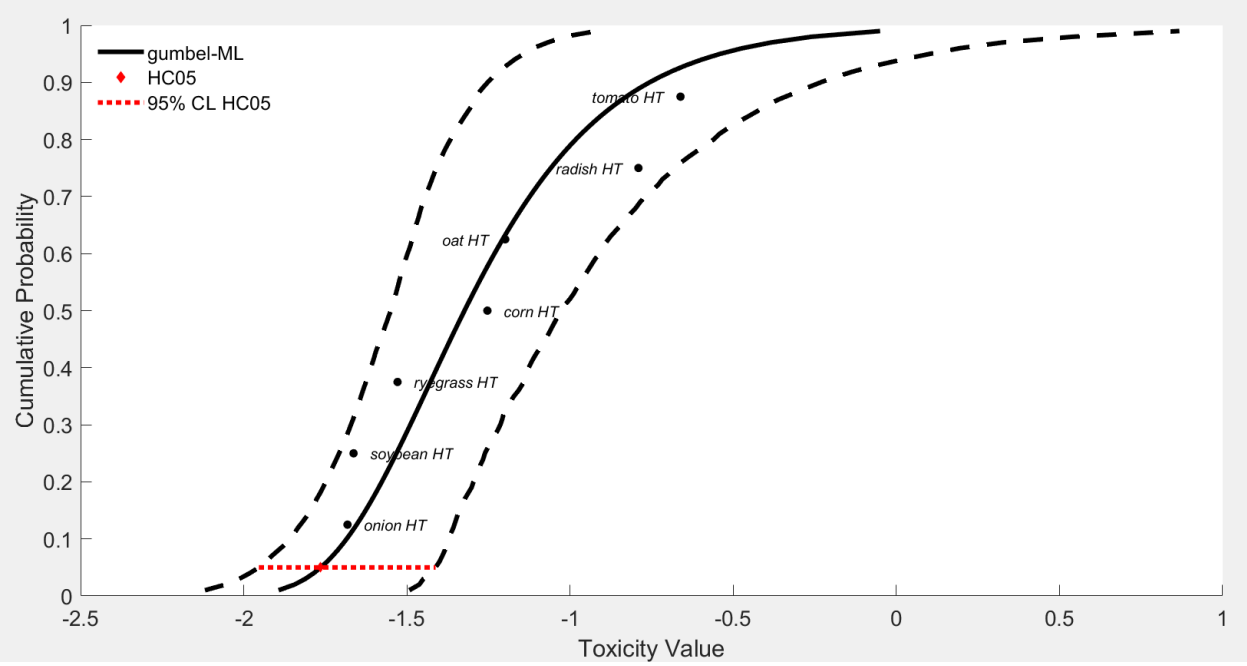
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | -16.5040 | 0 | 0.3033 | 0.0165 | 0.0082 |
| 2 | gumbel | -16.1997 | 0.3042 | 0.2605 | 0.0172 | 0.0052 |
| 3 | normal | -15.5382 | 0.9658 | 0.1871 | 0.0134 | 0.0067 |
| 4 | logistic | -14.8677 | 1.6363 | 0.1338 | 0.0111 | 0.0064 |
| 5 | weibull | -14.4269 | 2.0770 | 0.1074 | 0.0072 | 0.0064 |
| 6 | burr | -9.1979 | 7.3060 | 0.0079 | 0.0172 | 0.0052 |

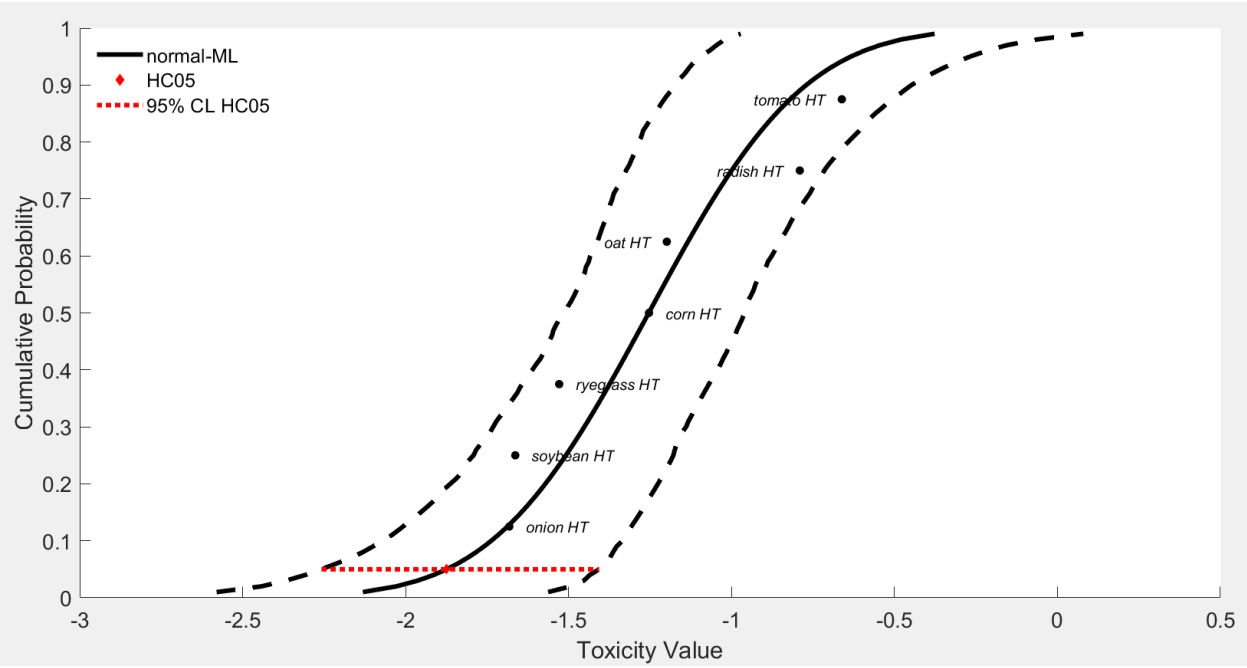
Based on the goodness of fit, EPA moved forward with triangular, Gumbel, and normal distributions, and ultimately selected the Gumbel distribution for the height data from the vegetative vigor toxicity tests.




Triangular




**Gumbel (selected distribution)**


normal-ML
HC05
95% CL HC05
tomato HT
radish HT
oat HT
corn HT
ryegrass HT
soybean HT
onion HT
Cumulative Probability
Toxicity Value
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5

Normal

### *Vegetative Vigor Dry Weight Data*

Goodness of fit:

Results:

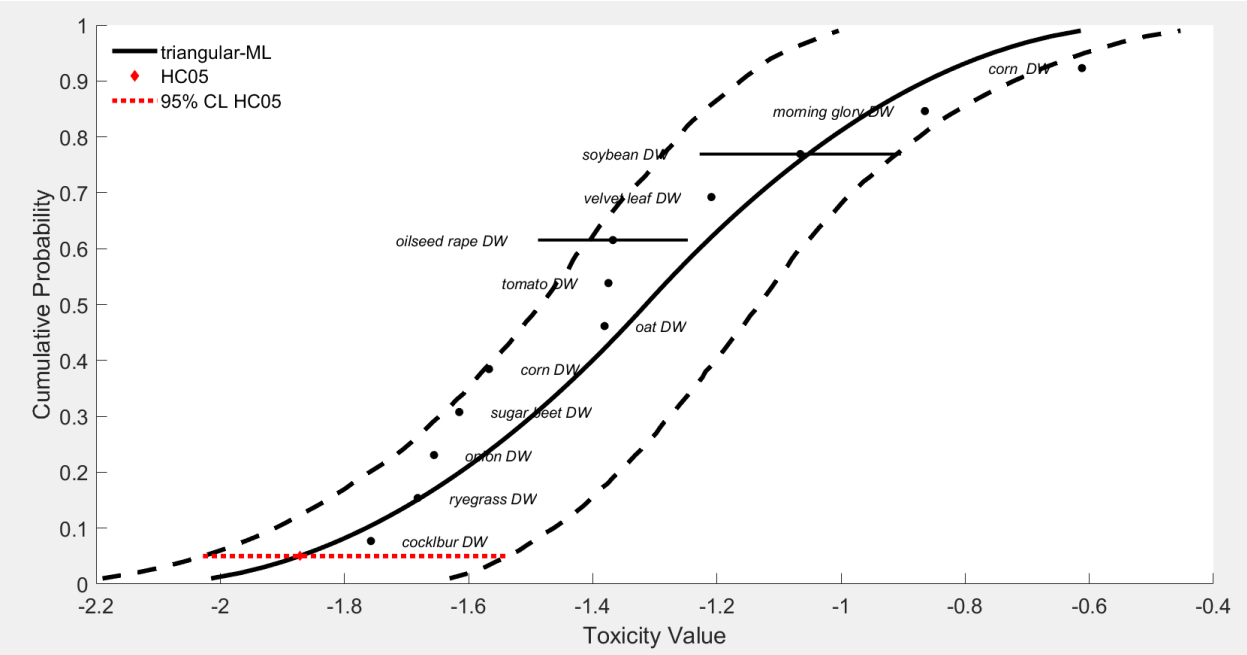
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0125 | 0.3307 |
| 2 | logistic | ML | 0.0111 | 0.3806 |
| 3 | triangular | ML | 0.0134 | 0.3616 |
| 4 | gumbel | ML | 0.0167 | 0.4525 |
| 5 | weibull | ML | 0.0055 | 0.1379 |
| 6 | burr | ML | 0.0167 | 0.3636 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.014676 |
| Model-averaged SE of HCp: | 0.0048178 |
| CV of HCp: | 0.32827 |

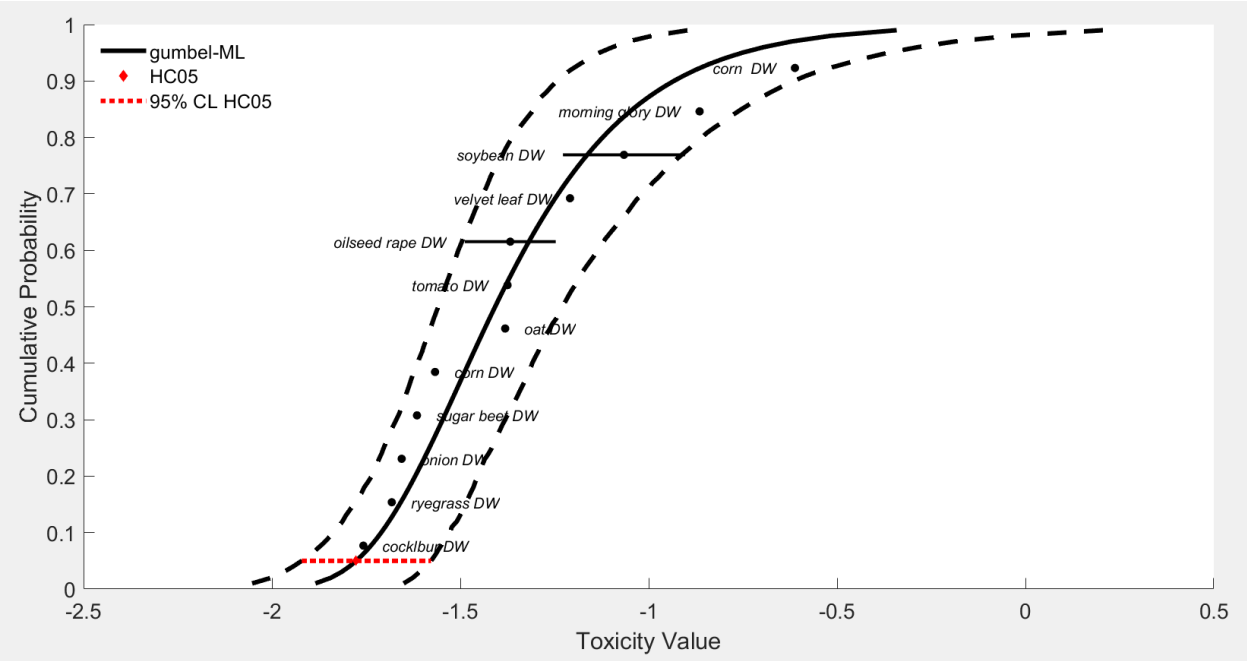
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | gumbel | -43.4374 | 0 | 0.4730 | 0.0167 | 0.0032 |
| 2 | triangular | -41.3918 | 2.0456 | 0.1701 | 0.0134 | 0.0059 |
| 3 | normal | -41.0177 | 2.4198 | 0.1411 | 0.0125 | 0.0043 |
| 4 | logistic | -40.6795 | 2.7579 | 0.1191 | 0.0111 | 0.0041 |
| 5 | burr | -39.7675 | 3.6699 | 0.0755 | 0.0167 | 0.0032 |
| 6 | weibull | -37.2364 | 6.2010 | 0.0213 | 0.0055 | 0.0036 |

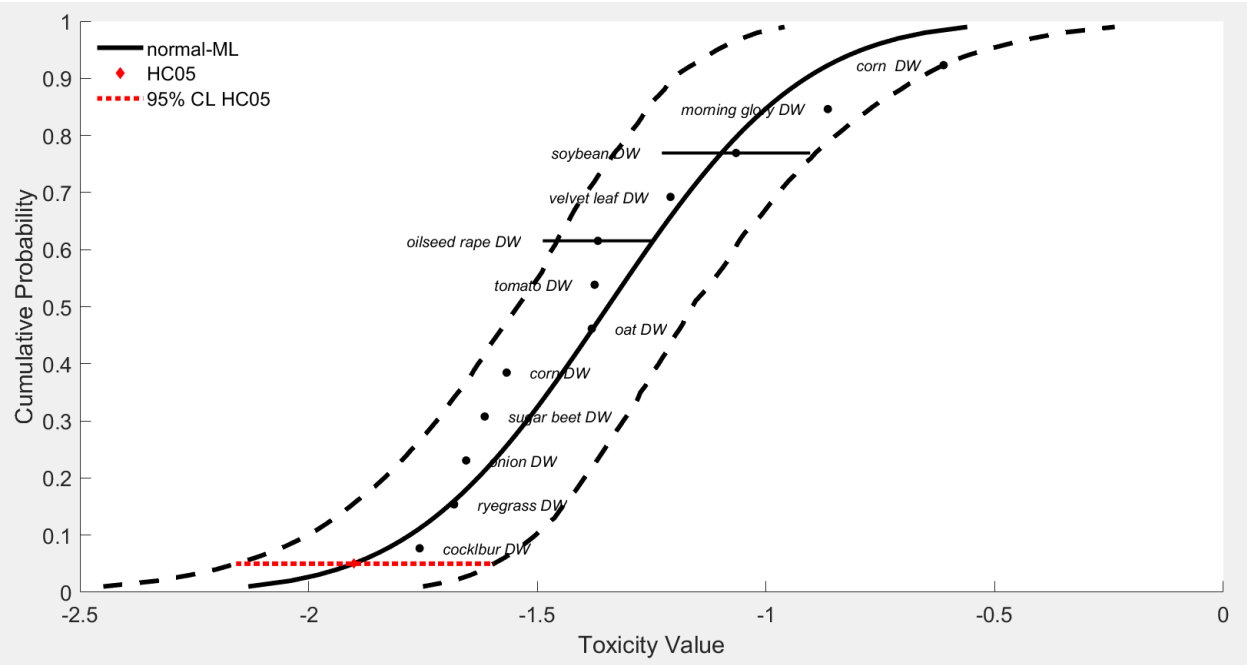
Based on the goodness of fit, EPA moved forward with triangular, normal, and Gumbel distributions, and ultimately selected the Gumbel distribution for the dry weight data from the vegetative vigor toxicity tests.




Triangular




**Gumbel (selected distribution)**


normal-ML
HC05
95% CL HC05
Cumulative Probability
Toxicity Value
corn DW
morning glory DW
soybean DW
velvet leaf DW
oilseed rape DW
tomato DW
oat DW
corn DW
sugar beet DW
onion DW
ryegrass DW
cocklbur DW
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2.5
-2
-1.5
-1
-0.5
0

Normal

## 13.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 13-10. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 1.5 lb cation/A (maximum application rate for use on alfalfa and clover)[2]** | | | | | | | |
| Distance to Medium MoE[3,4,5] (ft) | 20 | 20 | 20 | 10 | <5 | 0 * | 0 * |
| **Application Rate of 1.01 lb cation/A (maximum application rate for use on alfalfa and clover)[2]** | | | | | | | |
| Distance to Medium MoE[3,4,5] (ft) | 10 | 10 | 10 | 5 | <5 | 0 * | 0 * |
| **Application Rate of 0.5 lb cation/A (maximum application rate for use on alfalfa and clover)[2]** | | | | | | | |
| Distance to Medium MoE[3,4,5] (ft) | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 0.40 µg cation/L for the freshwater diatom, *Navicula pelliculosa* (MRID 42601006). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 3 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[3] For paraquat, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1. This is explained further in **Section 13.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[4] The distances represented in this table were estimated using a $K_{OC}$ of 6,800 (based on the $K_d$ of 68 L/kg-o.c. and a conversion factor of 100).

[5] The distances represented in this table are rounded to the nearest 5 ft for summarization purposes.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 13-11. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.5 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 44.1 | 44.1 | 44.1 | 93.1 | 89.9 | 89.4 | 88.9 | 42.0 |
| 10 | 29.7 | 26.7 | 24.5 | 23.2 | 8.3 | 4.1 | 2.5 | 20.3 |
| 20 | 22.1 | 17.7 | 15.2 | 11.7 | 3.9 | 2.2 | 1.3 | 11.5 |
| 25 | 18.9 | 14.3 | 11.9 | 8.6 | 2.9 | 1.7 | 1.1 | 8.3 |
| 50 | 14.8 | 9.5 | 6.3 | 4.2 | 1.5 | 1.0 | 0.6 | 3.0 |
| 75 | 10.4 | 6.4 | 4.2 | 2.8 | 1.0 | 0.7 | 0.5 | 1.4 |
| 100 | 8.8 | 5.1 | 3.3 | 2.2 | 0.8 | 0.6 | 0.4 | 0.9 |
| 125 | 6.6 | 3.8 | 2.4 | 1.7 | 0.7 | 0.5 | 0.3 | 0.6 |
| 150 | 5.5 | 3.0 | 1.9 | 1.4 | 0.6 | 0.4 | 0.3 | 0.4 |
| 175 | 4.6 | 2.5 | 1.5 | 1.2 | 0.5 | 0.4 | 0.3 | 0.3 |
| 200 | 4.1 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.2 | 0.2 |
| 225 | 3.7 | 1.9 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 250 | 3.2 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 3.0 | 1.4 | 0.9 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 300 | 2.7 | 1.3 | 0.8 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 325 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 350 | 2.3 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 375 | 2.1 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 400 | 2.0 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | <0.1 |
| 500 | 1.7 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.4 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.3 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.2 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 1.1 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.0 | 0.5 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 5th Percentile of SSD = 0.017 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 13-12. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.5 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 28.8 | 28.8 | 28.8 | 60.9 | 58.8 | 58.4 | 58.1 | 27.5 |
| 10 | 19.4 | 17.4 | 16.0 | 15.1 | 5.4 | 2.7 | 1.6 | 13.3 |
| 20 | 14.4 | 11.6 | 9.9 | 7.6 | 2.6 | 1.4 | 0.9 | 7.5 |
| 25 | 12.3 | 9.4 | 7.8 | 5.6 | 1.9 | 1.1 | 0.7 | 5.4 |
| 50 | 9.7 | 6.2 | 4.1 | 2.7 | 1.0 | 0.7 | 0.4 | 2.0 |
| 75 | 6.8 | 4.2 | 2.7 | 1.8 | 0.7 | 0.5 | 0.3 | 0.9 |
| 100 | 5.7 | 3.4 | 2.1 | 1.5 | 0.6 | 0.4 | 0.3 | 0.6 |
| 125 | 4.3 | 2.5 | 1.6 | 1.1 | 0.5 | 0.3 | 0.2 | 0.4 |
| 150 | 3.6 | 2.0 | 1.2 | 0.9 | 0.4 | 0.3 | 0.2 | 0.2 |
| 175 | 3.0 | 1.6 | 1.0 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 200 | 2.7 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 225 | 2.4 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 250 | 2.1 | 1.1 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.8 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 325 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 400 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 500 | 1.1 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 0.9 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 25th Percentile of SSD = 0.026 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 13-13. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.01 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 29.7 | 29.7 | 29.7 | 62.7 | 60.6 | 60.2 | 59.9 | 28.3 |
| 10 | 20.0 | 18.0 | 16.5 | 15.6 | 5.6 | 2.8 | 1.7 | 13.7 |
| 20 | 14.9 | 11.9 | 10.2 | 7.9 | 2.6 | 1.5 | 0.9 | 7.7 |
| 25 | 12.7 | 9.7 | 8.0 | 5.8 | 2.0 | 1.2 | 0.7 | 5.6 |
| 50 | 10.0 | 6.4 | 4.2 | 2.8 | 1.0 | 0.7 | 0.4 | 2.0 |
| 75 | 7.0 | 4.3 | 2.8 | 1.9 | 0.7 | 0.5 | 0.3 | 1.0 |
| 100 | 5.9 | 3.5 | 2.2 | 1.5 | 0.6 | 0.4 | 0.3 | 0.6 |
| 125 | 4.4 | 2.6 | 1.6 | 1.2 | 0.5 | 0.3 | 0.2 | 0.4 |
| 150 | 3.7 | 2.0 | 1.3 | 1.0 | 0.4 | 0.3 | 0.2 | 0.3 |
| 175 | 3.1 | 1.7 | 1.0 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 200 | 2.7 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 |
| 225 | 2.5 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 250 | 2.2 | 1.1 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 2.0 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.8 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 325 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 |
| 350 | 1.6 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 400 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 500 | 1.1 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 1.0 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 5th Percentile of SSD = 0.017 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 13-14. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.01 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 19.4 | 19.4 | 19.4 | 41.0 | 39.6 | 39.3 | 39.2 | 18.5 |
| 10 | 13.1 | 11.7 | 10.8 | 10.2 | 3.6 | 1.8 | 1.1 | 9.0 |
| 20 | 9.7 | 7.8 | 6.7 | 5.1 | 1.7 | 1.0 | 0.6 | 5.0 |
| 25 | 8.3 | 6.3 | 5.2 | 3.8 | 1.3 | 0.8 | 0.5 | 3.6 |
| 50 | 6.5 | 4.2 | 2.8 | 1.8 | 0.7 | 0.4 | 0.3 | 1.3 |
| 75 | 4.6 | 2.8 | 1.8 | 1.2 | 0.5 | 0.3 | 0.2 | 0.6 |
| 100 | 3.9 | 2.3 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 | 0.4 |
| 125 | 2.9 | 1.7 | 1.1 | 0.8 | 0.3 | 0.2 | 0.1 | 0.3 |
| 150 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.0 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.8 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 25th Percentile of SSD = 0.026 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 13-15. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 0.5 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 14.7 | 14.7 | 14.7 | 31.0 | 30.0 | 29.8 | 29.6 | 14.0 |
| 10 | 9.9 | 8.9 | 8.2 | 7.7 | 2.8 | 1.4 | 0.8 | 6.8 |
| 20 | 7.4 | 5.9 | 5.1 | 3.9 | 1.3 | 0.7 | 0.4 | 3.8 |
| 25 | 6.3 | 4.8 | 4.0 | 2.9 | 1.0 | 0.6 | 0.4 | 2.8 |
| 50 | 4.9 | 3.2 | 2.1 | 1.4 | 0.5 | 0.3 | 0.2 | 1.0 |
| 75 | 3.5 | 2.1 | 1.4 | 0.9 | 0.3 | 0.2 | 0.2 | 0.5 |
| 100 | 2.9 | 1.7 | 1.1 | 0.7 | 0.3 | 0.2 | 0.1 | 0.3 |
| 125 | 2.2 | 1.3 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 150 | 1.8 | 1.0 | 0.6 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 |
| 175 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 200 | 1.4 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 250 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 500 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 5th Percentile of SSD = 0.017 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 13-16. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 0.5 lb paraquat cation/A[1]**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[2] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 9.6 | 9.6 | 9.6 | 20.3 | 19.6 | 19.5 | 19.4 | 9.2 |
| 10 | 6.5 | 5.8 | 5.3 | 5.0 | 1.8 | 0.9 | 0.5 | 4.4 |
| 20 | 4.8 | 3.9 | 3.3 | 2.5 | 0.9 | 0.5 | 0.3 | 2.5 |
| 25 | 4.1 | 3.1 | 2.6 | 1.9 | 0.6 | 0.4 | 0.2 | 1.8 |
| 50 | 3.2 | 2.1 | 1.4 | 0.9 | 0.3 | 0.2 | 0.1 | 0.7 |
| 75 | 2.3 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 100 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 125 | 1.4 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 150 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 175 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 225 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] This application rate is based on lb paraquat cation/A. A rate of 1 lb cation/A is equivalent to 1.417 lb paraquat dichloride/A.

[2] Based on the 25th Percentile of SSD = 0.026 lb paraquat cation/A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 14 Pendimethalin Case Study Example (PC Code 108501)

## 14.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 14.2 Use Information

Pendimethalin is a non-selective, broad-spectrum dinitroaniline herbicide that inhibits cell growth, preventing seedling development. It is herbicidally active on the roots and coleoptiles of susceptible weeds. It is generally immobile and persistent and is systemic in plants. Pendimethalin can be applied pre-plant, pre-emergence, or post-emergence to control certain broadleaf weeds and grassy weeds in a wide range of agricultural crops and non-crop use sites, including vegetables, peanuts, citrus, pome and nut trees, corn, cotton, sugarcane, turfgrass, and ornamental species. Applications may be made as ground or aerial sprays or through chemigation.

**Table 14-1** includes the use information from the 2017 Draft Risk Assessment (DRA; DP438210) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Herbicide Strategy. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for pendimethalin, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the March 2018 Interim Decision) are not considered at

this time but would be considered when EPA conducts assessments for pendimethalin for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2017 assessment.

**Table 14-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 14.6** of this document. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5.**

EPA estimated exposures using the selected[194] uses and application information provided in **Table 14-1**. The selected uses do not necessarily represent all registered uses of pendimethalin and instead include large acreage uses sites (*e.g.,* corn) and the agricultural use sites where pendimethalin usage is most common. These selected uses are examples to illustrate the draft Herbicide Strategy framework; however, this is not intended to be an ESA effects determination that would assess all use patterns. For the draft Herbicide Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of pendimethalin as this application method represents the greatest source of potential offsite movement.

Although granular formulations of pendimethalin are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application method and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

[194] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2017 Draft Risk Assessment (DP438210) for pendimethalin. Any uses not evaluated in the 2017 assessment and any new uses since this assessment are not included in this example case study for the Herbicide Strategy.

**Table 14-1. Summary of the Selected Agricultural Use Patterns Labeled for Pendimethalin (2017 Draft Risk Assessment for Registration Review, DP438210)[1]**

| Use Site/Location | App Target | App Type | App Equip | App Time[2] | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d) |
|---|---|---|---|---|---|---|---|---|
| **Other Crops[3] and Alfalfa Use Data Layers** | | | | | | | | |
| Forage Grasses, Alfalfa grown for Forage/Hay/Seed | Soil | Broadcast, Impregnated material | A, G, C | Early spring | 4 | 1 | 4 | N/A |
| **Vegetables and Ground Fruit Use Data Layer** | | | | | | | | |
| African Marigold | Soil | Broadcast, Impregnated material | A, G, C | Within 60 d of planting | 2 | 2 | 4 | 30 |
| Artichoke, Asparagus | Soil | Broadcast, Banded | A, G, C | 60 d pre-harvest | 3.895 | 1 | 3.895 | N/A |
| Carrot | Soil | Broadcast | A, G, C | Pre-emergence | 2 | 1 | 2 | N/A |
| Fruiting Vegetables | Soil | Broadcast | A, G, C | Pre-planting | 1.5 | 1 | 1.5 | N/A |
| Green Onion | Soil | Broadcast | A, G, C | Pre-planting | 1 | 2 | 2 | 30 |
| Mint (Pepper, Spear) | Soil | Broadcast, Impregnated material | A, G, C | Pre-emergence[4] | 2 | 1 | 2 | N/A |
| Potato | Soil | Broadcast, Impregnated material | A, G, C | Pre-emergence | 1.5 | 1 | 1.5 | N/A |
| Lettuce, Brassica | Soil | Broadcast | A, G, C | Pre-planting | 1 | 1 | 1 | N/A |
| Garlic, Lentil, Shallots | Soil | Broadcast | A, G, C | Fall or spring | 1.5 | 1 | 1.5 | N/A |
| Bushberries, Caneberries | Soil | Broadcast, Banded | G | Pre-crop plant | 6 | 1 | 6 | N/A |
| Juneberry | Soil | Broadcast, Banded | A, G, C | Pre-emergence[4] | 4 | 1[5] | 4 | N/A |
| Strawberry | Soil | Broadcast | A, G, C | Pre-transplanting | 1.65 | 2 | 2.85 | NS |
| **Citrus Use Data Layer** | | | | | | | | |
| Citrus | Soil | Broadcast, Banded | G | Pre-transplanting | 6 | 1[5] | 6 | N/A |
| **Corn Use Data Layer** | | | | | | | | |
| Corn (Field, Pop, Seed, Sweet) | Soil | Broadcast, Impregnated material | A, G, C | Pre-emergence | 2 | 1 | 2 | N/A |
| **Cotton Use Data Layer** | | | | | | | | |
| Cotton | Soil | Broadcast, Impregnated material | A, G, C | 15 d pre-planting | 2 | 1 | 2 | N/A |
| **Grapes Use Data Layer** | | | | | | | | |

| Use Site/Location | App Target | App Type | App Equip | App Time[2] | Max Single Rate (lb ai/A) | Max # App/yr | Max Annual Rate (lb ai/A/yr) | MRI (d) |
|---|---|---|---|---|---|---|---|---|
| Grape (Bearing and Nonbearing) Small Fruit Climbing Vines (Bearing and Nonbearing) | Soil | Broadcast, Banded | G | Any time after fall harvest | 6 | 1[5] | 6 | N/A |
| **Other Grains Use Data Layer** | | | | | | | | |
| Sorghum | Soil | Broadcast | A, G, C | Early post-emergence | 1.5 | 1 | 1.5 | N/A |
| Sugarcane | Soil | Broadcast | A, G, C | 60 d pre-planting | 4 | 2 | 6 | NS (30) |
| **Other Orchards Use Data Layer** | | | | | | | | |
| Date, Fig, Olive, Pomegranate, Tree nuts | Soil | Broadcast, Banded | G | Pre-planting | 6 | 1[5] | 6 | N/A |
| Pome Fruit, Stone Fruit | Soil | Broadcast, Banded | G | Pre-emergence[4] | 4 | 1[5] | 4 | N/A |
| **Other Row Crops Use Data Layer** | | | | | | | | |
| Peanut | Soil | Broadcast | A, G, C | At planting | 1.5 | 1 | 1.5 | N/A |
| Sunflower | Soil | Broadcast, Impregnated material | A, G, C | Pre-emergence[4] | 1.73 | 1 | 1.73 | N/A |
| Hops | Soil | Broadcast, Banded | A, G, C | June to July | 4 | 1 | 4 | N/A |
| Tobacco | Soil | Broadcast, Impregnated material | A, G, C | Within 60 d of transplanting | 1.73 | 1 | 1.73 | N/A |

App=application; equip=equipment; MRI=Minimum retreatment interval; ai=active ingredient; d=day; A=aerial; G=ground; C=chemigation; NS=not specified on the label; () values in parentheses are not on the label but are the values assumed for modeling.

[1] The use information presented in this table is identical to the agricultural uses included in the 2017 Draft Risk Assessment for Registration Review (DP438210).

[2] EPA gathered the application timing presented in this table from the 2017 Draft Risk Assessment (DP438210) using the use information (Section 3.1) and the aquatic modeling inputs and results (Section 3.2.2). For the purposes of the Herbicide Strategy, EPA conducted modeling for all uses assuming that the first application occurs 10 days pre-emergence.

[3] This use on forage grasses and alfalfa falls into two different Use Data Layers (UDL) depending on the specific use as alfalfa for forage/hay (Alfalfa UDL) or alfalfa for seed (Other Crops UDL). In **Section 14.6**, EPA considered both of these UDLs.

[4] Application timing was not specified within the 2017 Draft Risk Assessment (DP438210); however, for the purposes of the Herbicide Strategy, EPA conducted modeling for this use assuming that application occurs 10 days pre-emergence.

[5] The number of applications per year in this table reflects the modeling that EPA conducted as part of the Herbicide Strategy. For these uses, the 2017 Draft Risk Assessment (DP438210) indicated that additional applications are permitted but did not clarify the appropriate single maximum and/or annual maximum application rate. For example, for use on date, fig, olive, and pomegranate trees and tree nuts, the 2017 assessment says that 3 applications are permitted but both the maximum single and annual application rates are 6 lb a.i./A.

## 14.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of pendimethalin (**Section 14.3.1**), reported incidents (**Section 14.3.2**), and the EECs. EPA uses the toxicity endpoints and EECs to calculate magnitude of difference values (**Section 14.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 14.3.1 Toxicity Information

**Table 14-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for pendimethalin.

**Table 14-2. Summary of the Most Sensitive Toxicity Endpoints for Pendimethalin (As Summarized in the 2017 Draft Risk Assessment for Registration Review, DP438210)**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Ryegrass (*Lolium perenne*) | NOAEC = 0.01 lb a.i./A<br>$IC_{25}$ = 0.02 lb a.i./A | 42372201 Acceptable | Test with TGAI; based on effects on dry weight |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.063 lb a.i./A<br>$IC_{25}$ = 0.09 lb a.i./A | | Test with TGAI; based on effects on dry weight |
| Vegetative Vigor | Monocot: Ryegrass (*Lolium perenne*) | NOAEC = 0.0008 lb a.i./A<br>$IC_{25}$ = 0.034 lb a.i./A | 42372203 Supplemental | Test with TGAI; based on effects on dry weight |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.003 lb a.i./A<br>$IC_{25}$ = 0.10 lb a.i./A | | Test with TGAI; based on effects on dry weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 5.6 µg a.i./L<br>**$IC_{50}$ = 12.5 µg a.i./L** | 42137101 Acceptable | Based on reduced frond number |
| Aquatic Nonvascular Plant | Marine diatom (*Skeletonema costatum*) | NOAEC = 0.7 µg a.i./L<br>**$IC_{50}$ = 5.2 µg a.i./L** | 42372205 Acceptable | Based on growth inhibition, inhibited by 27% at the LOAEC (1.5 µg a.i./L) |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}$/$IC_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration

**Bolded** endpoints indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed aquatic plants.

[1] To calculate the magnitude of difference between the EEC and toxicity endpoint for all species except listed aquatic plants, EPA generated Species Sensitivity Distributions (SSDs) using results for all terrestrial plant test species (*i.e.,* not only the most sensitive) from the pendimethalin seedling emergence and vegetative vigor tests. See **Table 14-3** and **Figure 14-1** for the SSD results.

EPA calculated Species Sensitivity Distributions (SSDs) separately for the plant height and weight endpoints from the two standard terrestrial plant toxicity tests (vegetative vigor and seedling emergence). See **Section 14.7** for the data used to generate the SSDs and **Section 14.8** for the process for calculating the SSDs. Because definitive endpoints were limited for the vegetative vigor height data (6 $IC_{25}$ values), EPA could not reliably generate an SSD for these height data. In total, EPA generated three SSDs for pendimethalin by combining the results for tested monocot and dicot species because monocots and dicots do not appear to be substantially different in sensitivity to pendimethalin. Specifically, as summarized in **Section 14.7**, the range of growth toxicity endpoints (*i.e.,* the concentration resulting in 25% inhibition in growth ($IC_{25}$ values)) for monocot and dicot height and weight data from the seedling emergence and vegetative vigor studies (weight only) overlap when considering all definitive values available. Additionally, the mean and median $IC_{25}$ values for monocot and dicot height data (seedling emergence only) and dry weight data only differ by a factor of 3 when EPA compared the data within the same test design (seedling emergence or vegetative vigor). Therefore, EPA did not create separate SSDs for monocots and dicots.

**Figure 14-1** shows the three SSDs that EPA generated. The SSD based on the vegetative vigor weight data resulted in the most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values (represented as red and black dots in **Figure 14-1,** respectively). EPA used the resulting most sensitive $5^{th}$ and $25^{th}$ percentile $IC_{25}$ values from the SSD to calculate the ratio of EEC to toxicity endpoint (**Table 14-3** and **Table 14-4**; see **Section 14.3.3**). By combining the monocot and dicot data, these $5^{th}$ and $25^{th}$ percentile values represent the sensitivities of both types of flowering plants to pendimethalin.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[195] are available to evaluate potential impacts of pendimethalin on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 14-2** and **Table 14-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[196].

[195] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[196] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

**Table 14-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Pendimethalin**

| Percentile (x) | Seedling Emergence Test | | Vegetative Vigor Test |
|---|---|---|---|
| | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Height: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A | Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A |
| 5 | 0.12 (0.033 – 0.56) | 0.33 (0.19 – 0.67) | **0.039** (0.0097 – 0.23) |
| 25 | 0.58 (0.25 – 1.4) | 0.71 (0.44 – 1.2) | **0.17** (0.058 – 0.60) |
| 50 | 1.3 (0.67 – 2.3) | 1.2 (0.76 – 1.8) | 0.48 ( 0.18 – 1.4) |

**Bolded** values indicate the most sensitive toxicity endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed monocots, dicots, and animals that depend on monocots/dicots.

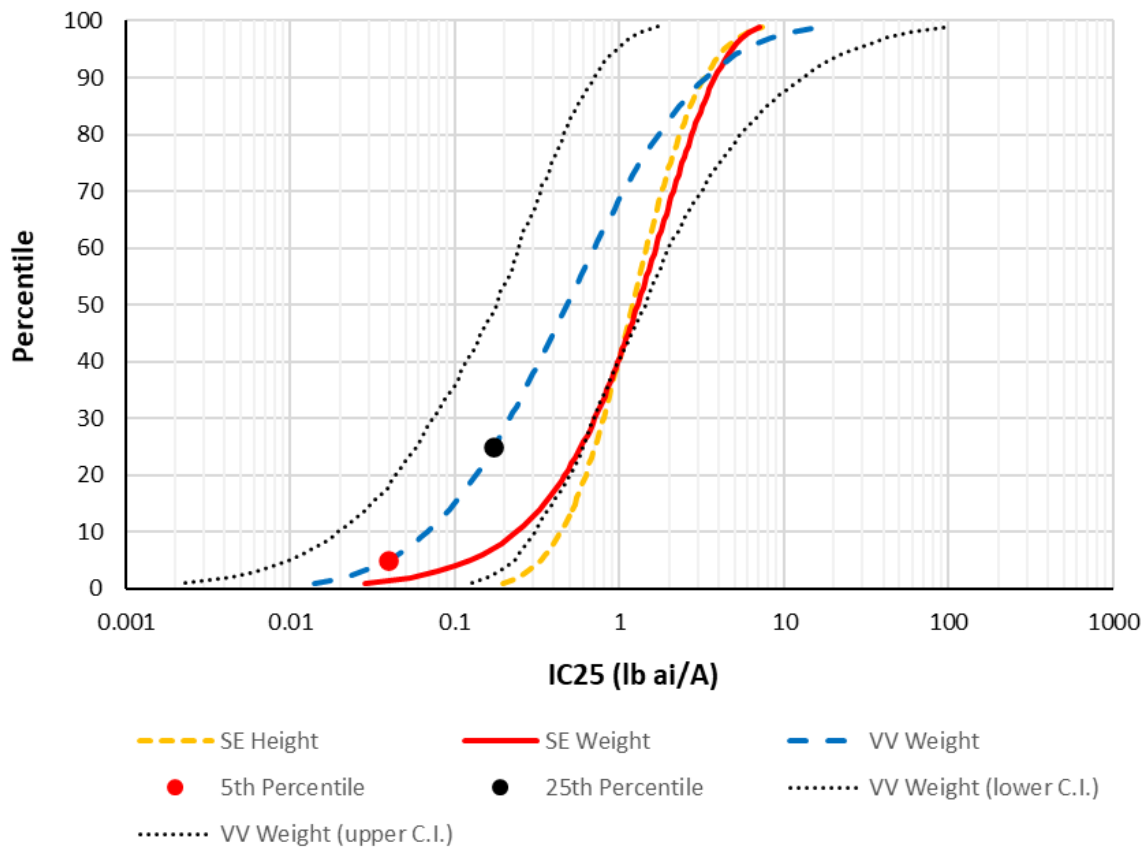



**Figure 14-1. Seedling Emergence (SE) and Vegetative Vigor (VV) Study Species Sensitivity Distributions representing the Distributions of the Plant Height and Weight IC25s for Pendimethalin. The Upper and Lower Confidence Intervals (C.I.) are plotted for the VV plant weight SSD.**

For the Herbicide Strategy, EPA proposes to calculate the magnitude of difference between the EEC and the relevant toxicity endpoint (see **Section 14.3.3**). Overall, the magnitude of difference between the toxicity endpoint and EEC is specific to the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship). For listed terrestrial and wetland plants and animals that obligately depend on plants[197], EPA calculated the magnitude of difference as a ratio of the EEC to the 5th percentile of the vegetative vigor plant weight SSD (**-4**). For listed animals that generally rely upon terrestrial or wetland plants for diet or habitat[198] and for designated critical habitats of listed plants and listed animals that rely on terrestrial/wetland plants, EPA determined the magnitude of difference by comparing the EEC to the 25th percentile of the SSD (**Figure 14-1**). For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ value since a robust distribution-based analysis using an SSD was not possible given the available data (**Figure 14-1).**

**Table 14-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Pendimethalin[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[1] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.039 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.039 lb a.i./A |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.039 lb a.i./A |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.039 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.039 lb a.i./A |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.17 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoints: 0.17 lb a.i./A |
| | | Based on terrestrial plant endpoints: 12.5 µg a.i./L (Vascular) 5.2 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[9] | Vascular: 12.5 µg a.i./L Nonvascular: 5.2 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated for the draft Herbicide Strategy. In this case study for pendimethalin,

[197] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.

[198] Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 14.3.2 Incident Data

The incident information from the 2017 Draft Risk Assessment for Registration Review (DP438210) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[199] (as discussed in **Section 14.3.3.3**), which informs the potential population-level impacts (**Section 14.6**), and to identify the proposed level of mitigation (see **Section 14.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 14.3.3.3**).[200] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

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[199] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.
[200] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

EPA completed a review of the Incident Data System and Aggregate Incident databases for ecological incidents involving pendimethalin on January 11, 2017. This database consists of exposure incident reports submitted to the EPA from 1994 to present.

Incidents listed in IDS are categorized by the likelihood that a particular pesticide is associated with that particular incident. These classifications include “highly probable”, “probable”, “possible”, “unlikely”, or “unrelated”. The number of reports listed in the IDS database is believed to be only a small fraction of the total incidents involving organism mortality and damage caused by pesticides. Few resources are assigned to incident reporting. Reporting by states is only voluntary, and individuals discovering incidents may not be informed on the procedure of reporting these occurrences. Additionally, much of the database is generated from registrant-submitted incident reports. In addition, incident reports for non-target organisms typically provide information only on mortality events and plant damage incidents. Except for phytotoxic effects in terrestrial plants, sublethal effects for organisms such as reduced growth or impaired reproduction are rarely reported. Because of these logistical difficulties, IDS is most likely a minimal representation of all pesticide-related ecological incidents.

Registrants are legally required to provide detailed reports of only “major” ecological incidents involving pesticides, while “minor” incidents are reported aggregately. Based on 40 CFR §159.184, an ecological incident involving plants is considered major and the registrant must submit it to the Agency if the effect is alleged to have occurred on more than 45% of the acreage exposed to the pesticide.

The IDS database contained 70 major incidents involving pendimethalin, including 65 terrestrial plant incidents. With respect to the likelihood that pendimethalin caused the reported incidents, the certainty ranged from “unlikely” to “highly probable”. The majority of reported incidents were identified as “probable” or “highly probable”. Twenty-seven of the incidents resulted from registered uses, four were misuses, and the remaining use patterns are unknown.

All other incidents are classified as ‘minor’. Ecological incidents reported in aggregate reports include those categorized ‘minor plant’ (P-B). For pendimethalin, the registrants have reported 1,035 minor plant incidents. Unless additional information on these aggregated incidents becomes available, they will be assumed to be representative of registered uses of pendimethalin in the risk assessment.

The high number of incidents of direct impacts to plants off the treated field is one line of evidence that the magnitude of effect categories should be shifted to a lower magnitude of difference threshold for pendimethalin (**Section 14.3.3.3**). In other words, the pendimethalin incidents indicate that an unexpected level of off-field exposure may occur, and EPA considered this potential off-field exposure within this case study.

### 14.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint. The relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and animals with an obligate relationship to plants using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants.

#### *14.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 14-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of pendimethalin ($5^{th}$ percentile of SSD = 0.039 lb a.i./A). **Table 14-6** demonstrates the impact of these variables on drift exposure when compared with the terrestrial plant toxicity endpoint for diet and habitat impacts to listed generalist animals from use of pendimethalin ($25^{th}$ percentile of SSD = 0.17 lb a.i./A). Within **Table 14-5** and **Table 14-6**, the modeled application rates are representative of the maximum single application rate currently registered for pendimethalin (6.0 lb a.i./A) and reduced rates (4.0, 2.0, 1.73, and 1.0 lb a.i./A)[201] representative of maximum single application rates for other uses (**Table 14-1**). **Table 14-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint evaluated ($5^{th}$ percentile of the SSD), which is relevant for listed terrestrial and wetland plants and animals that obligately depend on these plants. **Table 14-6** gives the distance at which the spray drift deposition equals the terrestrial plant toxicity endpoint evaluated ($25^{th}$ percentile of the SSD) for diet and habitat impacts to listed animals that generally depend on terrestrial and wetland plants. These tables also give the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 14.4.1**).

[201] Aerial applications of pendimethalin are permitted for all of these lower application rates but are not permitted for an application rate of 6 lb a.i./A for use on citrus, date, fig, olive, pomegranate, tree nuts, grapes, small fruits, bushberries, and caneberries.

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 14.9**). This is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 14-5. Spray Drift Distances to the Population-Level Impacts Endpoint (5th Percentile of the SSD) for Listed Terrestrial and Wetland Plants and Obligate Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 325 | 150 | 125 | 75 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | **1.9** [200] | **1.5** [100] | **1.1** [100] | 0.7 [100] |
| **Application Rate of 4.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 450 | 275 | 250 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **3.1** [300] | **1.5** [300] | **1.5** [200] | **1.3** [200] | 1.0 [100] | 0.7 [100] | 0.5 [100] |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 500 | 250 | 175 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.6** [300] | 0.7 [300] | 0.8 [200] | 0.6 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |
| **Application Rate of 1.73 lb a.i./A (maximum application rate for use on sunflower and tobacco and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 400 | 225 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.3** [300] | 0.6 [300] | 0.7 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 1.0 lb a.i./A (maximum application rate for use on green onion and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 250 | 150 | 100 | 75 | 25 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.8 [300] | 0.4 [300] | 0.4 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 5th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For pendimethalin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 14.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 14.9** contains the full output of results.

**Table 14-6. Spray Drift Distances to the Population-Level Effects Endpoint (25th Percentile of the SSD) for Listed Generalist Animals and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | Not permitted on labels | | | 100 | 50 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | | | | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.2 [100] |
| **Application Rate of 4.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 225 | 125 | 100 | 75 | 20 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.7 [300] | 0.3 [300] | 0.4 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 125 | 75 | 50 | 50 | 20 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.4 [300] | 0.2 [300] | 0.2 [200] | 0.1 [200] | 0.1 [100] | 0.1 [100] | 0.1 [100] |
| **Application Rate of 1.73 lb a.i./A (maximum application rate for use on sunflower and tobacco and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 100 | 75 | 50 | 25 | 10 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.3 [300] | 0.1 [300] | 0.2 [200] | 0.1 [200] | 0.1 [100] | 0.1 [100] | <0.1 [100] |

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | **F-M** | **M-C** | **C-VC** | **VF-F High Boom** | **VF-F Low Boom** | **F-MC High Boom** | **F-MC Low Boom** |
| **Application Rate of 1.0 lb a.i./A (maximum application rate for use on green onion and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 50 | 25 | 20 | 20 | 10 | <10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.2 [300] | 0.1 [300] | 0.1 [200] | 0.1 [200] | 0.1 [100] | <0.1 [100] | <0.1[100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the 25th percentile of the SSD are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For pendimethalin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 14.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 14.9** contains the full output of results.

#### *14.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 14-7** through **Table 14-11** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, 5th or 25th percentile of the terrestrial plant SSD).

**Table 14-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 22 | 1.7 | 4.1 |
| Corn | 6.3 | 0.50 | 1.2 |
| Stone fruit | 11 – 14 | 0.92 – 1.1 | 2.2 – 2.6 |
| Cotton | 6.1 | 0.49 | 1.2 |
| Forage grasses | 28 | 2.2 | 5.3 |
| Asparagus | 11 | 0.86 | 2.1 |
| African marigold | 6.7 | 0.54 | 1.3 |
| Fruiting vegetables (tomato) | 11 – 22 | 0.87 – 1.7 | 2.1 – 4.1 |
| Green onions | 12 | 0.94 | 2.3 |
| Mint (pepper spear) | 11 | 0.89 | 2.1 |
| Potato | 4.5 – 5.4 | 0.36 – 0.43 | 0.86 – 1.0 |
| Sorghum | 4.2 – 5.1 | 0.33 – 0.40 | 0.80 – 0.97 |
| Peanut | 3.5 – 4.3 | 0.28 – 0.34 | 0.68 – 0.82 |
| Lettuce brassica | 2.8 | 0.22 | 0.53 |
| Citrus fruit trees | 17 | 1.3 | 3.2 |
| Garlic, lentil, shallots | 4.9 | 0.39 | 0.95 |
| Strawberry | 7.3 | 0.58 | 1.4 |
| Carrot | 7.1 – 11 | 0.56 – 0.90 | 1.4 – 2.2 |
| Date, fig, olive, pomegranate, tree nut | 11 – 17 | 0.87 – 1.3 | 2.1 – 3.2 |
| Grapes, small fruit | 18 | 1.5 | 3.5 |
| Sunflower | 5.4 | 0.43 | 1.0 |
| Bushberries, caneberries | 18 | 1.4 | 3.4 |
| Juneberry | 12 | 0.95 | 2.3 |
| Sugarcane | 11 – 14 | 0.89 – 1.1 | 2.1 – 2.6 |
| Hops | 12 | 0.93 | 2.2 |
| Tobacco | 4.8 | 0.38 | 0.92 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for pendimethalin, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between

the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 14-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | Aquatic Nonvascular Plants[4] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Artichoke | 0.69 | 18 | 60 | 4.8 | 12 |
| Corn | 1.1 | 29 | 16 | 1.2 | 3.0 |
| Stone fruit | 0.57 – 1.2 | 15 – 31 | 31 – 32 | 2.5 | 6.0 – 6.1 |
| Cotton | 0.78 | 20 | 16 | 1.2 | 3.0 |
| Forage grasses | 0.62 | 16 | 78 | 6.2 | 15 |
| Asparagus | 0.42 | 11 | 30 | 2.4 | 5.8 |
| African marigold | 0.69 | 18 | 17 | 1.3 | 3.2 |
| Fruiting vegetables (tomato) | 0.49 – 0.64 | 13 – 16 | 30 – 60 | 2.4 – 4.8 | 5.8 – 12 |
| Green onions | 0.71 | 18 | 31 | 2.5 | 6.0 |
| Mint (pepper spear) | 0.25 | 6.4 | 31 | 2.5 | 5.9 |
| Potato | 0.50 – 0.60 | 13 – 15 | 10 – 12 | 0.81 – 0.98 | 1.9 – 2.3 |
| Sorghum | 0.42 – 0.51 | 11 – 13 | 9.7 – 12 | 0.78 – 0.94 | 1.9 – 2.3 |
| Peanut | 0.33 – 0.40 | 8.5 – 10 | 9.6 – 12 | 0.77 – 0.94 | 1.9 – 2.3 |
| Lettuce brassica | 0.09 | 2.3 | 7.7 | 0.61 | 1.5 |
| Citrus fruit trees | 0.69 | 18 | 46 | 3.7 | 8.9 |
| Garlic, lentil, shallots | 0.31 | 7.9 | 12 | 0.92 | 2.2 |
| Strawberry | 0.34 | 8.7 | 13 | 1.1 | 2.5 |
| Carrot | 0.31 – 0.38 | 7.9 – 9.7 | 15 – 31 | 1.2 – 2.5 | 2.9 – 5.9 |
| Date, fig, olive, pomegranate, tree nut | 0.32 – 1.1 | 8.2 – 29 | 31 – 46 | 2.5 – 3.7 | 5.9 – 8.9 |
| Grapes, small fruit | 2.6 | 66 | 48 | 3.8 | 9.2 |
| Sunflower | 0.98 | 25 | 14 | 1.1 | 2.6 |
| Bushberries, caneberries | 1.1 | 29 | 47 | 3.7 | 9.0 |
| Juneberry | 0.76 | 20 | 31 | 2.5 | 6.0 |
| Sugarcane | 0.83 – 2.1 | 21 – 53 | 24 – 25 | 1.9 – 2.0 | 4.6 – 4.8 |
| Hops | 0.63 | 16 | 31 | 2.5 | 6.0 |
| Tobacco | 0.18 | 4.6 | 13 | 1.1 | 2.6 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference.

**Table 14-9. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[4] |
| Artichoke | 0.69 | 4.1 |
| Corn | 1.1 | 6.7 |
| Stone fruit | 0.57 – 1.2 | 3.4 – 7.0 |
| Cotton | 0.78 | 4.6 |
| Forage grasses | 0.62 | 3.6 |
| Asparagus | 0.42 | 2.5 |
| African marigold | 0.69 | 4.1 |
| Fruiting vegetables (tomato) | 0.49 – 0.64 | 2.9 – 3.8 |
| Green onions | 0.71 | 4.2 |
| Mint (pepper spear) | 0.25 | 1.5 |
| Potato | 0.50 – 0.60 | 2.9 – 3.5 |
| Sorghum | 0.42 – 0.51 | 2.5 – 3.0 |
| Peanut | 0.33 – 0.40 | 1.9 – 2.4 |
| Lettuce brassica | 0.09 | 0.53 |
| Citrus fruit trees | 0.69 | 4.1 |
| Garlic, lentil, shallots | 0.31 | 1.8 |
| Strawberry | 0.34 | 2.0 |
| Carrot | 0.31 – 0.38 | 1.8 – 2.2 |
| Date, fig, olive, pomegranate, tree nut | 0.32 – 1.1 | 1.9 – 6.6 |
| Grapes, small fruit | 2.6 | 15 |
| Sunflower | 0.98 | 5.8 |
| Bushberries, caneberries | 1.1 | 6.7 |
| Juneberry | 0.76 | 4.5 |
| Sugarcane | 0.83 – 2.1 | 4.9 – 12 |
| Hops | 0.63 | 3.7 |
| Tobacco | 0.18 | 1.1 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference as outlined in **Table 14-8**.
[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 14-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 1.1 | 28 |
| Corn | 1.7 | 44 |
| Stone fruit | 1.1 – 1.6 | 28 – 40 |
| Cotton | 1.5 | 38 |
| Forage grasses | 1.4 | 36 |
| Asparagus | 0.74 | 19 |
| African marigold | 1.1 | 29 |
| Fruiting vegetables (tomato) | 1.0 | 26 |
| Green onions | 1.1 | 27 |
| Mint (pepper spear) | 0.32 | 8.2 |
| Potato | 0.70 – 0.85 | 18 – 22 |
| Sorghum | 0.65 – 0.78 | 17 – 20 |
| Peanut | 0.54 – 0.66 | 14 – 17 |
| Lettuce brassica | 0.32 | 8.2 |
| Citrus fruit trees | 2.1 | 53 |
| Garlic, lentil, shallots | 0.54 | 14 |
| Strawberry | 0.91 | 23 |
| Carrot | 0.63 – 0.65 | 16 – 17 |
| Date, fig, olive, pomegranate, tree nut | 1.1 – 2.1 | 28 – 55 |
| Grapes, small fruit | 4.3 | 110 |
| Sunflower | 1.3 | 34 |
| Bushberries, caneberries | 1.8 | 47 |
| Juneberry | 1.2 | 31 |
| Sugarcane | 2.3 – 3.1 | 58 – 79 |
| Hops | 1.0 | 26 |
| Tobacco | 0.34 | 8.7 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 14-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots |
|---|---|---|
| | | Range of Magnitude of Difference[2] |
| Artichoke | 1.1 | 6.4 |
| Corn | 1.7 | 10 |
| Stone fruit | 1.1 – 1.6 | 6.4 – 9.1 |
| Cotton | 1.5 | 8.7 |
| Forage grasses | 1.4 | 8.2 |
| Asparagus | 0.74 | 4.4 |
| African marigold | 1.1 | 6.6 |
| Fruiting vegetables (tomato) | 1.0 – 1.0 | 5.9 – 6.0 |
| Green onions | 1.1 | 6.3 |
| Mint (pepper spear) | 0.32 | 1.9 |
| Potato | 0.70 – 0.85 | 4.1 – 5.0 |
| Sorghum | 0.65 – 0.78 | 3.8 – 4.6 |
| Peanut | 0.54 – 0.66 | 3.2 – 3.9 |
| Lettuce brassica | 0.32 | 1.9 |
| Citrus fruit trees | 2.1 | 12 |
| Garlic, lentil, shallots | 0.54 | 3.2 |
| Strawberry | 0.91 | 5.4 |
| Carrot | 0.63 – 0.65 | 3.7 – 3.8 |
| Date, fig, olive, pomegranate, tree nut | 1.1 – 2.1 | 6.4 – 13 |
| Grapes, small fruit | 4.3 | 25 |
| Sunflower | 1.3 | 7.7 |
| Bushberries, caneberries | 1.8 | 11 |
| Juneberry | 1.2 | 7.1 |
| Sugarcane | 2.3 – 3.1 | 13 – 18 |
| Hops | 1.0 | 6.1 |
| Tobacco | 0.34 | 2.0 |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *14.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 14-12**. These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 14.3.3.1** and **14.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential

for identifying mitigation measures (**Section 14.4**) and conducting a population-level impact analysis (**Section 14.6**).

For pendimethalin, given the toxicity profile (including only about a 4X difference between the 5th and 25th percentiles of the most sensitive SSD with a relatively steep slope for the most sensitive SSD (**Figure 14-1**)[202] and given the high number of major and minor plant incidents (see **Section 14.3.2**), EPA assigned a low magnitude of effect in **Table 14-12** on a use basis to groups of listed species and critical habitats (CHs)[203] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned a medium magnitude of effect in **Table 14-12** when the magnitude of difference is from 1 to 10. EPA assigned a magnitude of effect of high or very high based on a magnitude of difference of 10 to 100 or greater than 100, respectively.

**Table 14-12. Use-Based Magnitude of Effect for Pendimethalin.[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Artichoke | High | Medium | High | High | Medium | Medium |
| Corn | High | Medium | High | Medium | Medium | Medium |
| Stone fruit | High | Medium | High | Medium | Medium | Medium |
| Cotton | High | Medium | High | Medium | Medium | Medium |
| Forage grasses | High | Medium | High | High | Medium | Medium |
| Asparagus | High | Medium | High | Medium | Medium | Medium |
| African marigold | High | Medium | High | Medium | Medium | Medium |
| Fruiting vegetables (tomato) | High | Medium | High | High | Medium | Medium |
| Green onions | High | Medium | High | Medium | Medium | Medium |
| Mint (pepper spear) | Medium | Medium | Medium | Medium | Medium | Medium |
| Potato | High | Medium | High | Medium | Low | Low |
| Sorghum | High | Medium | High | Medium | Low | Low |
| Peanut | High | Medium | High | Medium | Low | Low |
| Lettuce brassica | Medium | Medium | Medium | Medium | Low | Low |

[202] See **Section 3.3.3** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[203] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) | |
|---|---|---|---|---|---|---|
| | Plants and Obligate Animals | Generalist Animals and CHs | Plants and Obligate Animals | Generalist Animals and CHs | Plants[4] and Obligate Animals[5] | Generalist Animals and CHs |
| Citrus fruit trees | High | High | High | Medium | Medium | Medium |
| Garlic, lentil, shallots | High | Medium | Medium | Medium | Low | Low |
| Strawberry | High | Medium | Medium | Medium | Medium | Medium |
| Carrot | High | Medium | Medium | Medium | Medium | Medium |
| Date, fig, olive, pomegranate, tree nut | High | High | High | Medium | Medium | Medium |
| Grapes, small fruit | Very High | High | High | High | Medium | Medium |
| Sunflower | High | Medium | High | Medium | Low | Low |
| Bushberries, caneberries | High | High | High | Medium | Medium | Medium |
| Juneberry | High | Medium | High | Medium | Medium | Medium |
| Sugarcane | High | High | High | High | Medium | Medium |
| Hops | High | Medium | High | Medium | Medium | Medium |
| Tobacco | Medium | Medium | Medium | Medium | Low | Low |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 14.4**) and to conduct the population-level impacts analysis (**Section 14.6**). If the magnitude of effect is medium or higher for pendimethalin, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[5] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies. This column is retained for example purposes in the event that an obligate animal is listed in the future.

## 14.4 Framework Step 2: Identify Mitigation Practices

**Section 14.4** outlines the mitigation measures identified for pendimethalin for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 14.4.1**) and runoff/erosion (**Section 14.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 14.4.1 Spray Drift Mitigations Identified

**Table 14-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants and listed animals that obligately depend on these plants. **Table 14-14** presents the spray drift buffers identified for this example of the proposed Strategy Framework to address potential population-level impacts to listed animals that generally depend on terrestrial and/or wetland plants. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation practices such as hooded sprayers, windbreaks, or reduced windspeeds.

**Table 14-13. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants and Obligate Animals as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 6.0 | Not permitted on labels | | | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 75[f,g,h] |
| 4.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 75[g,h] | 50[g,h] |
| 2.0 | 300[a,b,c] | 250[a,b,c] | 175[a,b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| 1.73 | 300[a,b,c] | 225[a,b] | 150[b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| 1.0 | 250[a,b,c] | 150[b,d] | 100[b,d] | 75[g,h] | 25[i] | 20[i] | 10[i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances [3] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 14-1**.
[3] See **Section 5.1** in the **Strategy Framework** document for discussion of these mitigation practices.

**Table 14-14. Spray Drift Mitigation Measures Identified for Listed Animal Generalists as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1]**

| Single Maximum Application Rate (lb ai/A)[2] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 6.0 | Not permitted on labels | | | 100[e,f,g] | 50[f,g] | 20[h] | 10[h] |
| 4.0 | 225[a,b] | 125[b,c] | 100[b,c] | 75[f,g] | 20[h] | 20[h] | 10[h] |
| 2.0 | 125[b,c] | 75[b,c] | 50[b] | 50[f,g] | 20[h] | 10[h] | None[3] |
| 1.73 | 100[b,c] | 75[b,c] | 50[b] | 25[h] | 10[h] | 10[h] | None[3] |
| 1.0 | 50[b] | 25[d] | 20[d] | 20[h] | 10[h] | None[3] | None[3] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half<br>[c] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour<br>[d] The applicator would achieve sufficient mitigation with a windbreak (release height below the top of the windbreak) alone without a buffer. | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] Single maximum label rates reflect the range of uses represented in **Table 14-1**.
[3] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is ≤0.5 at 10 ft off the treated field.
[4] See **Section 5.1** in the **Strategy Framework** document for discussion of these mitigation practices.

### 14.4.2 Runoff/Erosion Mitigation Practices Identified

EPA's identification of the proposed runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts differs across uses and, as shown in **Figure 14-2**, the level of mitigation is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed plants (5$^{th}$ percentile endpoint), generalists (25$^{th}$ percentile endpoint)). **Figure 14-2** visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for pendimethalin.

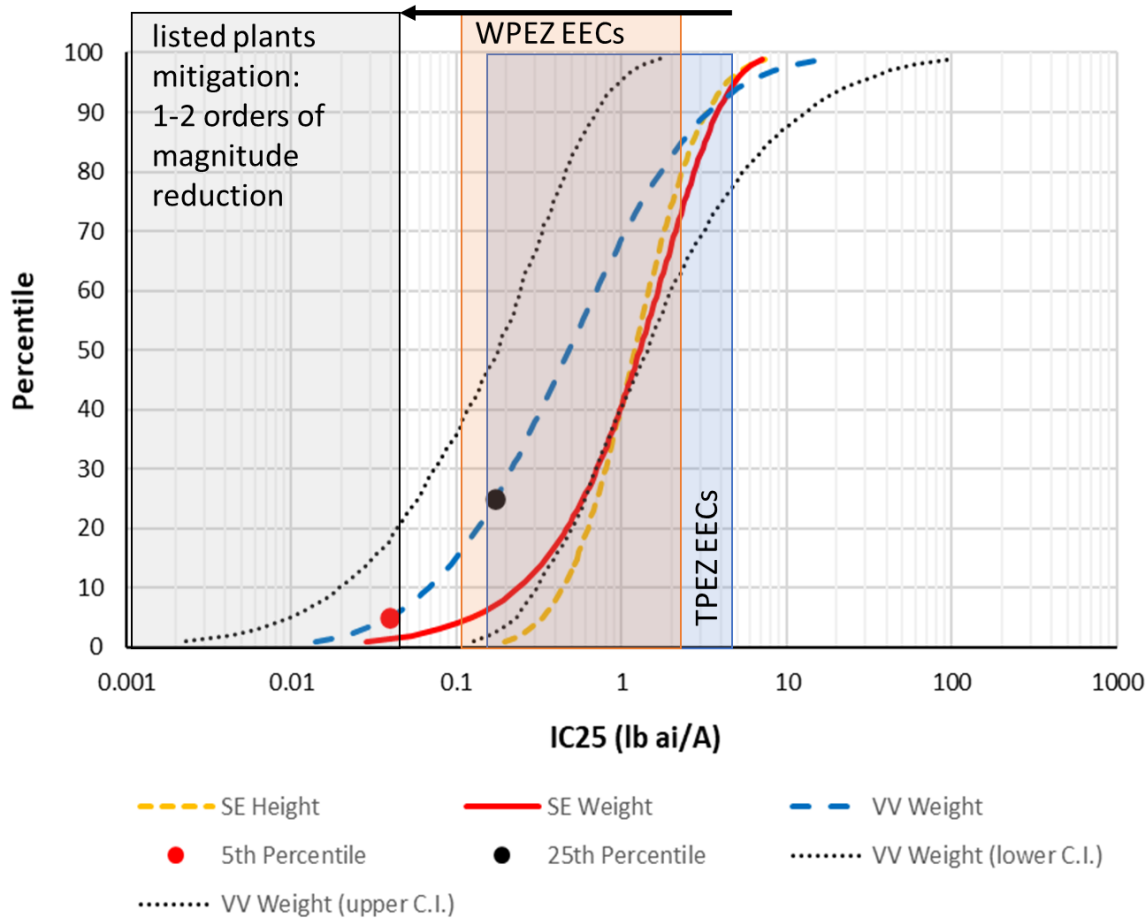


**Figure 14-2. Pendimethalin Seedling Emergence (SE) and Vegetative Vigor (VV) Species Sensitivity Distributions (SSDs) Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA selected the 5$^{th}$ percentile (represents listed plants and animals with obligate relationships to plants) and the 25$^{th}$ percentile (represents generalists and designated critical habitats) from the VV weight SSD. Upper and lower confidence intervals (C.I.) are provided for the VV weight SSD.**

For pendimethalin, see **Section 14.3.3.2** for details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in detail in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of pendimethalin is >1,000 L/kg-o.c. (mean $K_{OC}$ = 17,040 L/kg-o.c.), EPA identified fewer mitigation points for this erosion-prone herbicide (as compared to a different runoff-prone herbicide).

As described in the **Strategy Framework**, for the draft Strategy, EPA would identify mitigations for runoff/erosion exposure whenever the magnitude of difference between the EEC and

toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference (*i.e.,* ratio of EEC to toxicity endpoint) is between 1 and 10, EPA would identify low mitigation. If the magnitude of difference is between 10 and 100, medium mitigation would apply, and if it is between 100 and 1,000, high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (low/medium/high) if the weight of evidence indicates that more or less mitigation would apply. For pendimethalin, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for pendimethalin, EPA identified runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed species in waterbodies similar in size to the EPA farm pond or larger[204], EPA set the mitigation category[205] as no mitigation for about one-third of the pendimethalin uses (*e.g.,* use on potato, use on sorghum) for listed aquatic plants and animals that depend on aquatic plants[206] (**Table 14-15**). For the remaining uses, the mitigation category is low for listed aquatic plants and animals that depend on aquatic plants (**Table 14-15**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies (**Table 14-15**).
- Depending on the use, the mitigation category is low or medium for listed wetland plants and animals that obligately depend on these plants[207] (**Table 14-16**). For example, for use on mint (pepper spears) and lettuce brassica, the mitigation category is low, but for use on artichoke and corn, the mitigation category is medium.
- For listed aquatic plants in wetlands or small waterbodies[208] and for animals that obligately depend on these plants (both obligately[207] and generally[209]), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. The resulting mitigation category is medium for use on artichoke, forage grasses, and fruiting vegetables (**Table 14-16**). The mitigation category is low[210] for all other uses (**Table 14-16**).
- For listed terrestrial plants and animals that obligately rely on terrestrial plants[207], the mitigation category is medium with the exception of: 1) pendimethalin use on mint

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[204] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[205] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).
[206] None of the listed aquatic animals have obligate relationships to plants.
[207] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[208] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[209] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.
[210] Although EPA set the mitigation category as no mitigation for aquatic vascular plants for some uses, EPA identified low mitigation for all of these uses based on the nonvascular plant toxicity endpoint.

(pepper spear), lettuce brassica, and tobacco, for which the category is low, and 2) pendimethalin use on grapes and small fruits, for which the category high (**Table 14-18**).

- For animals that have a generalist relationship to wetland or terrestrial plants (*i.e.,* do not obligately depend on plants)[209], the mitigation category is low or medium (depending on the specific use) with the exceptions for pendimethalin use on lettuce brassica, for which EPA set the mitigation category as no mitigation for animals that generally rely on wetland plants (**Table 14-17** and **Table 14-19**). Specifically, for use on grapes and sugarcane, the mitigation category is medium for animals that generally rely on wetland plants (**Table 14-17**). For use on citrus trees, date, fig, olive, pomegranate, tree nut, grapes, bushberries, caneberries, and sugarcane, the mitigation category is medium for animals that generally rely on terrestrial plants (**Table 14-19**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland and terrestrial plants and for animals that depend on wetland and/or terrestrial plants.

**Table 14-15. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Artichoke | 22 | 1.7 | Low | 4.1 | Low |
| Corn | 6.3 | 0.50 | No mitigation | 1.2 | Low |
| Stone fruit | 11 – 14 | 0.92 – 1.1 | Low | 2.2 – 2.6 | Low |
| Cotton | 6.1 | 0.49 | No mitigation | 1.2 | Low |
| Forage grasses | 28 | 2.2 | Low | 5.3 | Low |
| Asparagus | 11 | 0.86 | No mitigation | 2.1 | Low |
| African marigold | 6.7 | 0.54 | No mitigation | 1.3 | Low |
| Fruiting vegetables (tomato) | 11 – 22 | 0.87 – 1.7 | Low | 2.1 – 4.1 | Low |
| Green onions | 12 | 0.94 | No mitigation | 2.3 | Low |
| Mint (pepper spear) | 11 | 0.89 | No mitigation | 2.1 | Low |
| Potato | 4.5 – 5.4 | 0.36 – 0.43 | No mitigation | 0.86 – 1.0 | No mitigation[5] |
| Sorghum | 4.2 – 5.1 | 0.33 – 0.40 | No mitigation | 0.80 – 0.97 | No mitigation |
| Peanut | 3.5 – 4.3 | 0.28 – 0.34 | No mitigation | 0.68 – 0.82 | No mitigation |
| Lettuce brassica | 2.8 | 0.22 | No mitigation | 0.53 | No mitigation |
| Citrus fruit trees | 17 | 1.3 | Low | 3.2 | Low |
| Garlic, lentil, shallots | 4.9 | 0.39 | No mitigation | 0.95 | No mitigation |
| Strawberry | 7.3 | 0.58 | No mitigation | 1.4 | Low |
| Carrot | 7.1 – 11 | 0.56 – 0.90 | No mitigation | 1.4 – 2.2 | Low |
| Date, fig, olive, pomegranate, tree nut | 11 – 17 | 0.87 – 1.3 | Low | 2.1 – 3.2 | Low |
| Grapes, small fruit | 18 | 1.5 | Low | 3.5 | Low |
| Sunflower | 5.4 | 0.43 | No mitigation | 1.0 | No mitigation[5] |
| Bushberries, caneberries | 18 | 1.4 | Low | 3.4 | Low |

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Juneberry | 12 | 0.95 | No mitigation | 2.3 | Low |
| Sugarcane | 11 – 14 | 0.89 – 1.1 | Low | 2.1 – 2.6 | Low |
| Hops | 12 | 0.93 | No mitigation | 2.2 | Low |
| Tobacco | 4.8 | 0.38 | No mitigation | 0.92 | No mitigation |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for pendimethalin, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.
[5] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 14-15** outlines the proposed mitigation categories for listed aquatic plants and animals that rely on those plants in larger waterbodies[211]. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[212]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in Section 4. **.3**. For pendimethalin, EPA determined the proposed mitigation categories presented in **Table 14-15** based on the weight of evidence discussed below, which is specifically relevant for use on potato and sunflower.

For use on potato and sunflower, the maximum magnitude of difference for nonvascular plants is equivalent to the lower threshold triggering the low mitigation category (*i.e.,* magnitude of difference = 1.0). Because the maximum ratio is equal to (but does not exceed) the threshold for the low mitigation category, EPA set the mitigation category as no mitigation for these two uses.

[211] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger. This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** in the **Case Study Summary and Process** document for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[212] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.2** in the **Case Study Summary and Process** document.

**Table 14-16. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants and Animals that Obligately Rely on Those Plants in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[5] | | Range of Magnitude of Difference[3] | Mitigation Category[5] | Range of Magnitude of Difference[3] | Mitigation Category[5] |
| Artichoke | 0.69 | 18 | Medium | 60 | 4.8 | Low | 12 | Medium |
| Corn | 1.1 | 29 | Medium | 16 | 1.2 | Low | 3.0 | Low |
| Stone fruit | 0.57 – 1.2 | 15 – 31 | Medium | 31 – 32 | 2.5 | Low | 6.0 – 6.1 | Low |
| Cotton | 0.78 | 20 | Medium | 16 | 1.2 | Low | 3.0 | Low |
| Forage grasses | 0.62 | 16 | Medium | 78 | 6.2 | Low | 15 | Medium |
| Asparagus | 0.42 | 11 | Medium | 30 | 2.4 | Low | 5.8 | Low |
| African marigold | 0.69 | 18 | Medium | 17 | 1.3 | Low | 3.2 | Low |
| Fruiting vegetables (tomato) | 0.49 – 0.64 | 13 – 16 | Medium | 30 – 60 | 2.4 – 4.8 | Low | 5.8 – 12 | Medium |
| Green onions | 0.71 | 18 | Medium | 31 | 2.5 | Low | 6.0 | Low |
| Mint (pepper spear) | 0.25 | 6.4 | Low | 31 | 2.5 | Low | 5.9 | Low |
| Potato | 0.50 – 0.60 | 13 – 15 | Medium | 10 – 12 | 0.81 – 0.98 | No mitigation | 1.9 – 2.3 | Low |
| Sorghum | 0.42 – 0.51 | 11 – 13 | Medium | 9.7 – 12 | 0.78 – 0.94 | No mitigation | 1.9 – 2.3 | Low |
| Peanut | 0.33 – 0.40 | 8.5 – 10 | Medium | 9.6 – 12 | 0.77 – 0.94 | No mitigation | 1.9 – 2.3 | Low |
| Lettuce brassica | 0.09 | 2.3 | Low | 7.7 | 0.61 | No mitigation | 1.5 | Low |
| Citrus fruit trees | 0.69 | 18 | Medium | 46 | 3.7 | Low | 8.9 | Low |
| Garlic, lentil, shallots | 0.31 | 7.9 | Low | 12 | 0.92 | No mitigation | 2.2 | Low |
| Strawberry | 0.34 | 8.7 | Low | 13 | 1.1 | Low | 2.5 | Low |
| Carrot | 0.31 – 0.38 | 7.9 – 9.7 | Low | 15 – 31 | 1.2 – 2.5 | Low | 2.9 – 5.9 | Low |
| Date, fig, olive, pomegranate, tree nut | 0.32 – 1.1 | 8.2 – 29 | Medium | 31 – 46 | 2.5 – 3.7 | Low | 5.9 – 8.9 | Low |
| Grapes, small fruit | 2.6 | 66 | Medium | 48 | 3.8 | Low | 9.2 | Low |
| Sunflower | 0.98 | 25 | Medium | 14 | 1.1 | Low | 2.6 | Low |

| Use | Range of EECs (lb a.i./A)[2] | Wetland Dicots and Monocots | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[4] | | Aquatic Nonvascular Plants[4] | |
|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[5] | | Range of Magnitude of Difference[3] | Mitigation Category[5] | Range of Magnitude of Difference[3] | Mitigation Category[5] |
| Bushberries, caneberries | 1.1 | 29 | Medium | 47 | 3.7 | Low | 9.0 | Low |
| Juneberry | 0.76 | 20 | Medium | 31 | 2.5 | Low | 6.0 | Low |
| Sugarcane | 0.83 – 2.1 | 21 – 53 | Medium | 24 – 25 | 1.9 – 2.0 | Low | 4.6 – 4.8 | Low |
| Hops | 0.63 | 16 | Medium | 31 | 2.5 | Low | 6.0 | Low |
| Tobacco | 0.18 | 4.6 | Low | 13 | 1.1 | Low | 2.6 | Low |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories.

[5] Mitigations were identified whenever the magnitude of difference is >1.

**Table 14-17. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Wetland Plants and Designated Critical Habitats in Wetlands or Small Waterbodies[1,2]**

| Use | Range of EECs (lb a.i./A)[3] | Animals Generally Relying on Wetland Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category[5] |
| Artichoke | 0.69 | 4.1 | Low |
| Corn | 1.1 | 6.7 | Low |
| Stone fruit | 0.57 – 1.2 | 3.4 – 7.0 | Low |
| Cotton | 0.78 | 4.6 | Low |
| Forage grasses | 0.62 | 3.6 | Low |
| Asparagus | 0.42 | 2.5 | Low |
| African marigold | 0.69 | 4.1 | Low |
| Fruiting vegetables (tomato) | 0.49 – 0.64 | 2.9 – 3.8 | Low |
| Green onions | 0.71 | 4.2 | Low |
| Mint (pepper spear) | 0.25 | 1.5 | Low |
| Potato | 0.50 – 0.60 | 2.9 – 3.5 | Low |
| Sorghum | 0.42 – 0.51 | 2.5 – 3.0 | Low |
| Peanut | 0.33 – 0.40 | 1.9 – 2.4 | Low |
| Lettuce brassica | 0.09 | 0.53 | No mitigation |
| Citrus fruit trees | 0.69 | 4.1 | Low |
| Garlic, lentil, shallots | 0.31 | 1.8 | Low |
| Strawberry | 0.34 | 2.0 | Low |
| Carrot | 0.31 – 0.38 | 1.8 – 2.2 | Low |
| Date, fig, olive, pomegranate, tree nut | 0.32 – 1.1 | 1.9 – 6.6 | Low |
| Grapes, small fruit | 2.6 | 15 | Medium |
| Sunflower | 0.98 | 5.8 | Low |
| Bushberries, caneberries | 1.1 | 6.7 | Low |
| Juneberry | 0.76 | 4.5 | Low |
| Sugarcane | 0.83 – 2.1 | 4.9 – 12 | Medium |
| Hops | 0.63 | 3.7 | Low |
| Tobacco | 0.18 | 1.1 | Low |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A) are compared to the terrestrial plant toxicity endpoints as discussed in **Section 3.2.**.

[2] Because a Species Sensitivity Distribution is not available for aquatic plants, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining magnitude of difference for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitudes of difference and equivalent mitigation categories as outlined in **Table 14-16**.

[3] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).

[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[5] Mitigations were identified whenever the magnitude of difference is >1.

**Table 14-18. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants and Animals that Obligately Rely on Those Plants**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Dicots and Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 1.1 | 28 | Medium |
| Corn | 1.7 | 44 | Medium |
| Stone fruit | 1.1 – 1.6 | 28 – 40 | Medium |
| Cotton | 1.5 | 38 | Medium |
| Forage grasses | 1.4 | 36 | Medium |
| Asparagus | 0.74 | 19 | Medium |
| African marigold | 1.1 | 29 | Medium |
| Fruiting vegetables (tomato) | 1.0 | 26 | Medium |
| Green onions | 1.1 | 27 | Medium |
| Mint (pepper spear) | 0.32 | 8.2 | Low |
| Potato | 0.70 – 0.85 | 18 – 22 | Medium |
| Sorghum | 0.65 – 0.78 | 17 – 20 | Medium |
| Peanut | 0.54 – 0.66 | 14 – 17 | Medium |
| Lettuce brassica | 0.32 | 8.2 | Low |
| Citrus fruit trees | 2.1 | 53 | Medium |
| Garlic, lentil, shallots | 0.54 | 14 | Medium |
| Strawberry | 0.91 | 23 | Medium |
| Carrot | 0.63 – 0.65 | 16 – 17 | Medium |
| Date, fig, olive, pomegranate, tree nut | 1.1 – 2.1 | 28 – 55 | Medium |
| Grapes, small fruit | 4.3 | 110 | High |
| Sunflower | 1.3 | 34 | Medium |
| Bushberries, caneberries | 1.8 | 47 | Medium |
| Juneberry | 1.2 | 31 | Medium |
| Sugarcane | 2.3 – 3.1 | 58 – 79 | Medium |
| Hops | 1.0 | 26 | Medium |
| Tobacco | 0.34 | 8.7 | Low |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 14-19. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Animals that Generally Rely on Terrestrial Plants and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Animals Generally Relying on Terrestrial Dicots and/or Monocots | |
|---|---|---|---|
| | | Range of Magnitude of Difference[2] | Mitigation Category |
| Artichoke | 1.1 | 6.4 | Low |
| Corn | 1.7 | 10 | Low[3] |
| Stone fruit | 1.1 – 1.6 | 6.4 – 9.1 | Low |
| Cotton | 1.5 | 8.7 | Low |
| Forage grasses | 1.4 | 8.2 | Low |
| Asparagus | 0.74 | 4.4 | Low |
| African marigold | 1.1 | 6.6 | Low |
| Fruiting vegetables (tomato) | 1.0 – 1.0 | 5.9 – 6.0 | Low |
| Green onions | 1.1 | 6.3 | Low |
| Mint (pepper spear) | 0.32 | 1.9 | Low |
| Potato | 0.70 – 0.85 | 4.1 – 5.0 | Low |
| Sorghum | 0.65 – 0.78 | 3.8 – 4.6 | Low |
| Peanut | 0.54 – 0.66 | 3.2 – 3.9 | Low |
| Lettuce brassica | 0.32 | 1.9 | Low |
| Citrus fruit trees | 2.1 | 12 | Medium |
| Garlic, lentil, shallots | 0.54 | 3.2 | Low |
| Strawberry | 0.91 | 5.4 | Low |
| Carrot | 0.63 – 0.65 | 3.7 – 3.8 | Low |
| Date, fig, olive, pomegranate, tree nut | 1.1 – 2.1 | 6.4 – 13 | Medium |
| Grapes, small fruit | 4.3 | 25 | Medium |
| Sunflower | 1.3 | 7.7 | Low |
| Bushberries, caneberries | 1.8 | 11 | Medium |
| Juneberry | 1.2 | 7.1 | Low |
| Sugarcane | 2.3 – 3.1 | 13 – 18 | Medium |
| Hops | 1.0 | 6.1 | Low |
| Tobacco | 0.34 | 2.0 | Low |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications, different application rates) as well as different PWC scenarios (based on PWC version 2.001).
[2] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] The range for the magnitude of difference spans more than one mitigation category. EPA chose the mitigation category using a weight evidence approach and the category does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 14-19** outlines the proposed mitigation categories for listed animals that generally rely on terrestrial plants. In some instances, the range of ratios of EEC to toxicity endpoint span nearly an order of magnitude and/or span two different mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 14.4** For

pendimethalin, EPA determined the proposed mitigation categories presented in **Table 14-19** based on the weight of evidence discussed below, which is specifically relevant for use on corn.

For use on corn, the maximum magnitude of difference for animals that generally rely on terrestrial plants is equivalent to the lower threshold for the medium mitigation category (*i.e.,* magnitude of difference = 10). Because the maximum ratio is equal to (but does not exceed) the threshold for the medium mitigation category, EPA set the mitigation category as low mitigation for use on corn to protect generalist animals.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 14-15** and **Table 14-16**) and wetland plants (**Table 14-16** and **Table 14-17**). The mitigation points for these aquatic (including wetland) habitats are different depending on whether the area is for protection of listed plants and/or obligate animals or protection of generalist animals, because mitigation points for listed plants and obligate animals will be higher than points for generalist animals as generalist animals are less sensitive to diet/habitat impacts on plants given their lack of obligate dependency on plants. For terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use for listed plants and obligate animals (**Table 14-18**) and for generalist animals (**Table 14-19**). **Table 14-20** and **Table 14-21** provide the runoff/erosion mitigation points identified for each evaluated use of pendimethalin.

**Table 14-20. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic and Wetland Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Artichoke | Medium (5 pts) | Medium (5 pts) |
| Corn | Medium (5 pts) | Low (3 pts) |
| Stone fruit | Medium (5 pts) | Low (3 pts) |
| Cotton | Medium (5 pts) | Low (3 pts) |
| Forage grasses | Medium (5 pts) | Medium (5 pts) |
| Asparagus | Medium (5 pts) | Low (3 pts) |
| African marigold | Medium (5 pts) | Low (3 pts) |
| Fruiting vegetables (tomato) | Medium (5 pts) | Medium (5 pts) |
| Green onions | Medium (5 pts) | Low (3 pts) |
| Mint (pepper spear) | Low (3 pts) | Low (3 pts) |
| Potato | Medium (5 pts) | Low (3 pts) |
| Sorghum | Medium (5 pts) | Low (3 pts) |
| Peanut | Medium (5 pts) | Low (3 pts) |
| Lettuce brassica | Low (3 pts) | Low (3 pts) |
| Citrus fruit trees | Medium (5 pts) | Low (3 pts) |
| Garlic, lentil, shallots | Low (3 pts) | Low (3 pts) |

| Use | Aquatic and Wetland Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Strawberry | Low (3 pts) | Low (3 pts) |
| Carrot | Low (3 pts) | Low (3 pts) |
| Date, fig, olive, pomegranate, tree nut | Medium (5 pts) | Low (3 pts) |
| Grapes, small fruit | Medium (5 pts) | Medium (5 pts) |
| Sunflower | Medium (5 pts) | Low (3 pts) |
| Bushberries, caneberries | Medium (5 pts) | Low (3 pts) |
| Juneberry | Medium (5 pts) | Low (3 pts) |
| Sugarcane | Medium (5 pts) | Medium (5 pts) |
| Hops | Medium (5 pts) | Low (3 pts) |
| Tobacco | Low (3 pts) | Low (3 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 14-15** and **Table 14-16**), listed animals that obligately depend on aquatic and wetland plants (**Table 14-15** and **Table 14-16**), and listed animals that generally depend on aquatic and wetland plants (**Table 14-15**, **Table 14-16**, and **Table 14-17**).

### Table 14-21. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Terrestrial Habitats.[1,2]

| Use | Terrestrial Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Artichoke | Medium (5 pts) | Low (3 pts) |
| Corn | Medium (5 pts) | Low (3 pts) |
| Stone fruit | Medium (5 pts) | Low (3 pts) |
| Cotton | Medium (5 pts) | Low (3 pts) |
| Forage grasses | Medium (5 pts) | Low (3 pts) |
| Asparagus | Medium (5 pts) | Low (3 pts) |
| African marigold | Medium (5 pts) | Low (3 pts) |
| Fruiting vegetables (tomato) | Medium (5 pts) | Low (3 pts) |
| Green onions | Medium (5 pts) | Low (3 pts) |
| Mint (pepper spear) | Low (3 pts) | Low (3 pts) |
| Potato | Medium (5 pts) | Low (3 pts) |
| Sorghum | Medium (5 pts) | Low (3 pts) |
| Peanut | Medium (5 pts) | Low (3 pts) |
| Lettuce brassica | Low (3 pts) | Low (3 pts) |
| Citrus fruit trees | Medium (5 pts) | Medium (5 pts) |
| Garlic, lentil, shallots | Medium (5 pts) | Low (3 pts) |
| Strawberry | Medium (5 pts) | Low (3 pts) |
| Carrot | Medium (5 pts) | Low (3 pts) |
| Date, fig, olive, pomegranate, tree nut | Medium (5 pts) | Medium (5 pts) |
| Grapes, small fruit | High (7 pts) | Medium (5 pts) |
| Sunflower | Medium (5 pts) | Low (3 pts) |

| Use | Terrestrial Habitats | |
|---|---|---|
| | Plants and Obligate Animals (Mitigation Points) | Generalist Animals and CHs (Mitigation Points) |
| Bushberries, caneberries | Medium (5 pts) | Medium (5 pts) |
| Juneberry | Medium (5 pts) | Low (3 pts) |
| Sugarcane | Medium (5 pts) | Medium (5 pts) |
| Hops | Medium (5 pts) | Low (3 pts) |
| Tobacco | Low (3 pts) | Low (3 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial habitat for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed terrestrial plants (**Table 14-18**), listed animals that obligately depend on terrestrial plants (**Table 14-18**), and listed animals that generally depend on terrestrial plants (**Table 14-19**).

## 14.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for pendimethalin are discussed in this section.

For spray drift, for this example, EPA would generate two different sets of mitigation measures: one for listed plants (**Table 14-13**) and one for generalist animals that depend on plants (**Table 8-14**). These two spray drift mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). EPA identified separate mitigations to be applied on the general label and using Bulletins because the spray drift buffer distances are different for these two groups of species (*i.e.,* for listed plants and obligate animals vs. for generalist animals). For pendimethalin, the less restrictive mitigations relevant to generalist animals that are depicted in **Table 8-14** would be applied to the general label because generalist animals are distributed widely across the United States. The more restrictive mitigations identified in **Table 14-13** would be applied using Bulletins because these mitigations are applicable to smaller and specific geographic areas where listed plants and listed obligate animals occur.

For runoff/erosion, EPA identified mitigations for terrestrial and aquatic/wetland habitats. These two habitat types are defined in Section 6.3 of the Strategy Framework document. For both sets of habitats, there are different levels of mitigations identified for generalist animals vs. for listed plants and animals with obligate relationships to plants (see **Table 14-20** and **Table 14-21**). **Table 14-22** summarizes the points identified for the different pendimethalin uses in this example; these points would be included in the general label for terrestrial and

wetland/aquatic habitats, with higher points applied to the specific geographic areas covered by the four PULAs. PULAs 1 and 2 are grouped because the same mitigations would be applied to monocots and dicots in terrestrial habitats; this is supported by pendimethalin's similar toxicity to both monocots and dicots (see **Section 14.3.1**). The same grouping and rational applies for PULAs 3 and 4, which represent monocots and dicots in wetland and aquatic habitats.

**Table 14-22. Summary of Use-Based Runoff/Erosion Mitigation Points Identified for the General Label Based on Different Types of Habitats and 4 Pesticide Use Limitation Areas (PULAs).**

| Use | Mitigations Points on the General Label | | Geographically Specific Mitigation Points | |
|---|---|---|---|---|
| | Terrestrial Habitats | Aquatic and Wetland Habitats | PULAs 1,2, 3 and 4 (Terrestrial Habitats)[1] | PULAs 3 and 4 (Aquatic and Wetland Habitats)[1] |
| Artichoke | 3 | 5 | 5 | 5 |
| Corn | 3 | 3 | 5 | 5 |
| Stone fruit | 3 | 3 | 5 | 5 |
| Cotton | 3 | 3 | 5 | 5 |
| Forage grasses | 3 | 5 | 5 | 5 |
| Asparagus | 3 | 3 | 5 | 5 |
| African marigold | 3 | 3 | 5 | 5 |
| Fruiting vegetables (tomato) | 3 | 5 | 5 | 5 |
| Green onions | 3 | 3 | 5 | 5 |
| Mint (pepper spear) | 3 | 3 | 3 | 3 |
| Potato | 3 | 3 | 5 | 5 |
| Sorghum | 3 | 3 | 5 | 5 |
| Peanut | 3 | 3 | 5 | 5 |
| Lettuce brassica | 3 | 3 | 3 | 3 |
| Citrus fruit trees | 5 | 3 | 5 | 5 |
| Garlic, lentil, shallots | 3 | 3 | 5 | 3 |
| Strawberry | 3 | 3 | 5 | 3 |
| Carrot | 3 | 3 | 5 | 3 |
| Date, fig, olive, pomegranate, tree nut | 5 | 3 | 5 | 5 |
| Grapes, small fruit | 5 | 5 | 7 | 5 |
| Sunflower | 3 | 3 | 5 | 5 |
| Bushberries, caneberries | 5 | 3 | 5 | 5 |
| Juneberry | 3 | 3 | 5 | 5 |
| Sugarcane | 5 | 5 | 5 | 5 |
| Hops | 3 | 3 | 5 | 5 |
| Tobacco | 3 | 3 | 3 | 3 |

[1] Many of the listed wetland species that occur in PULAs 3 and 4 also occur in terrestrial habitats. EPA proposes that if mitigations are applicable for terrestrial habitats (PULAs 1 and 2), these mitigations for terrestrial habitats would also apply to areas covered by PULAs 3 and 4. The result would be that PULAs 3 and 4 would have two sets of mitigations—one set for terrestrial habitats and one for the wetland/aquatic habitats. See **Section 7.2.2 in the Strategy Framework document for the full explanation of this proposal**.

## 14.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 14.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of pendimethalin. For major crops (*e.g.,* corn, cotton), EPA selected the crop-specific UDLs. For other uses such as on asparagus and sorghum, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential pendimethalin use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 14-12**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. **Table 14-22** summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected pendimethalin UDLs[213] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

As discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. For the PULAs, EPA identified 383 species and 85 CHs as having >5% overlap with the cultivated landcover. For pendimethalin's UDLs, fewer species (363) and CHs (78) have overlap >5%. An important

[213] The selected use data layers (UDLs) do not necessarily represent every registered use of pendimethalin. See **Section 14.2** for more information on the uses evaluated in this example.

consideration for the purposes of this example is that EPA did not necessarily evaluate all registered uses of pendimethalin (see **Section 14.2**), so additional species could be identified in the future for pendimethalin. Nonetheless, overall this indicates that the PULA approach would be protective for the considered uses of pendimethalin; however, the PULAs include some species and CHs that have <5% overlap with pendimethalin's potential exposure area for the considered uses.

**Table 14-23. The Number of Listed Species and Designated Critical Habitats Identified where there may be Potential for Population-Level Impacts in CONUS for Pendimethalin Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Other Crops | 469 / 142 | 324 | 63 |
| Alfalfa | | 141 | 42 |
| Vegetables and Ground Fruit | | 147 | 28 |
| Other Grains | | 236 | 51 |
| Other Row Crops | | 58 | 5 |
| Citrus | | 50 | 10 |
| Other Orchards | | 131 | 36 |
| Grapes | | 117 | 31 |
| Corn | | 150 | 30 |
| Cotton | | 71 | 13 |
| Total across all UDLs above[2] | | 363 | 78 |
| Cultivated | | 383 | 85 |
| **Listed Animal Generalists** | | | |
| Other Crops | 534 / 316 | 413 | 197 |
| Alfalfa | | 152 | 82 |
| Vegetables and Ground Fruit | | 166 | 83 |
| Other Grains | | 284 | 137 |
| Other Row Crops | | 110 | 46 |
| Citrus | | 33 | 5 |
| Other Orchards | | 132 | 80 |
| Grapes | | 54 | 30 |
| Corn | | 317 | 148 |
| Cotton | | 186 | 83 |
| Total across all UDLs above[2] | | 439 | 220 |
| Cultivated | | 460 | 225 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for pendimethalin. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for pendimethalin (excluding the Cultivated UDL, which is summarized below this row).

## 14.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

Because definitive endpoints were limited for the vegetative vigor height data (6 $IC_{25}$ values), EPA could only reliably generate three SSDs in total for pendimethalin.

The ranges of $IC_{25}$ values for plant height from the seedling emergence studies are 0.05 to 1.99 lb a.i./A (excluding non-definitive endpoints[214]) for monocots and 0.19 to 5.7 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.82 and 2.2 lb a.i./A, respectively. The ranges of $IC_{25}$ values for plant height from the vegetative vigor study are 0.1 to 1.6 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.48 to 3.5 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.84 and 1.99 lb a.i./A, respectively. However as noted above, EPA did not generate an SSD for the height data from the vegetative vigor study.

For the dry weight data, the ranges of $IC_{25}$ values from the seedling emergence studies are 0.01 to 1.6 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.09 to 4.7 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.63 and 2.2 lb a.i./A, respectively. The ranges of $IC_{25}$ values for dry weight data in the vegetative vigor study are 0.034 to 2.8 lb a.i./A (excluding non-definitive endpoints) for monocots and 0.1 to 4.8 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 1.0 and 1.4 lb a.i./A, respectively.

[214] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 4 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 14.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to pendimethalin. EPA developed separate SSDs for height and weight. Because definitive endpoints were limited for the vegetative vigor height data (6 $IC_{25}$ values), EPA could only reliably generate three SSDs in total for pendimethalin.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. Following EPA's standard process, the Agency used the 5th and 25th percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. The $IC_{25}$ values that EPA included in the analysis were all height or dry weight endpoints that followed the OCSPP 850.4100 or 850.4150 guideline. EPA did not use endpoints without definitive values to derive SSDs. The data EPA used to derive SSDs are from registrant-submitted studies.

### Determining Distribution with Best Fit

#### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the pendimethalin data and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

#### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5th percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5th percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5th percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

## Distributions

The cumulative distribution functions for the SSDs, which EPA chose based on the process described above, are provided below. EPA compared the 5th and 25th percentiles of the $IC_{25}$ values from the SSD across all endpoints and studies.

## Species Sensitivity Distribution (SSD) for Pendimethalin

Because there were limited definitive endpoints for the VV height data (n = 6; 4 monocots and 2 dicots), EPA did not generate an SSD for these data for pendimethalin.

### *Seedling Emergence Height Data*

Goodness of fit:

Status:

Ready

Results:

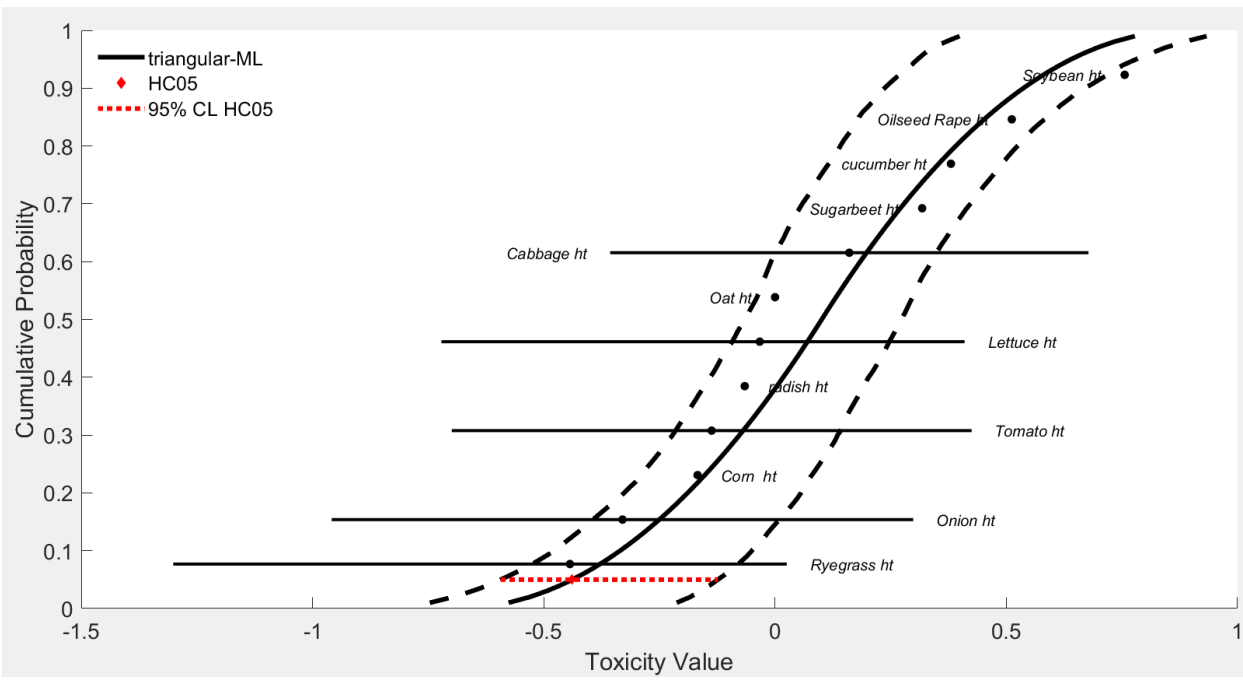
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.3311 | 0.6384 |
| 2 | logistic | ML | 0.2950 | 0.5724 |
| 3 | triangular | ML | 0.3645 | 0.6723 |
| 4 | gumbel | ML | 0.4001 | 0.9181 |
| 5 | weibull | ML | 0.1695 | 0.4186 |
| 6 | burr | ML | 0.4001 | 0.8771 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.34725 |
| Model-averaged SE of HCp: | 0.12503 |
| CV of HCp: | 0.36005 |

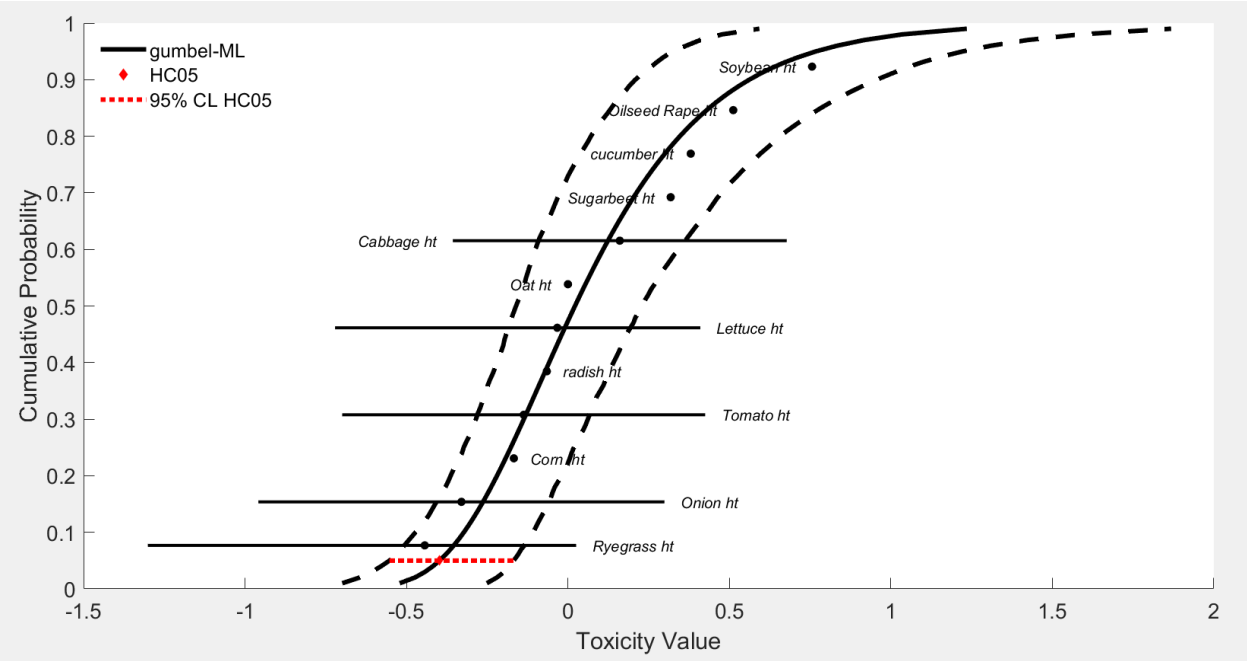
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 37.3199 | 0 | 0.2741 | 0.3645 | 0.1320 |
| 2 | gumbel | 37.3451 | 0.0252 | 0.2707 | 0.4001 | 0.0859 |
| 3 | normal | 37.8897 | 0.5698 | 0.2061 | 0.3311 | 0.1148 |
| 4 | logistic | 38.5493 | 1.2294 | 0.1482 | 0.2950 | 0.1142 |
| 5 | weibull | 40.4393 | 3.1194 | 0.0576 | 0.1695 | 0.1061 |
| 6 | burr | 41.0122 | 3.6923 | 0.0433 | 0.4001 | 0.0860 |

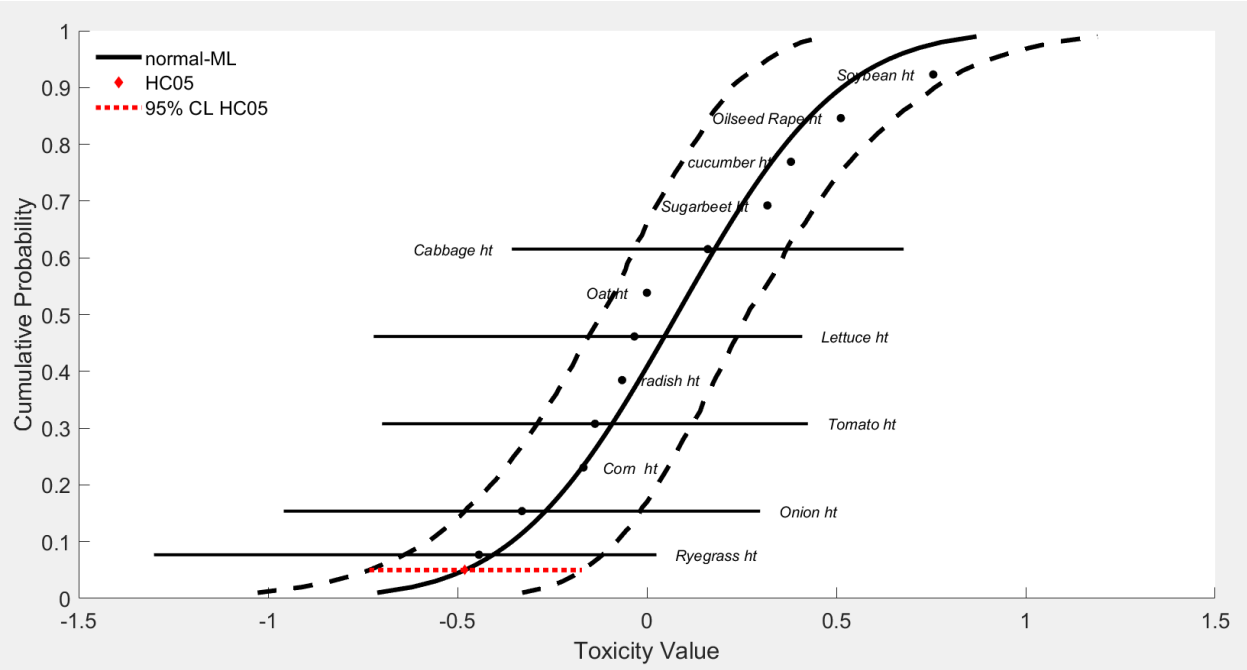
Based on the goodness of fit, EPA moved forward with Weibull, triangular, and normal distributions, and ultimately selected the normal distribution for the height data from the seedling emergence toxicity tests.




Triangular




Gumbel




**Normal (selected distribution)**

### *Seedling Emergence Dry Weight Data*

Goodness of fit:

Results:

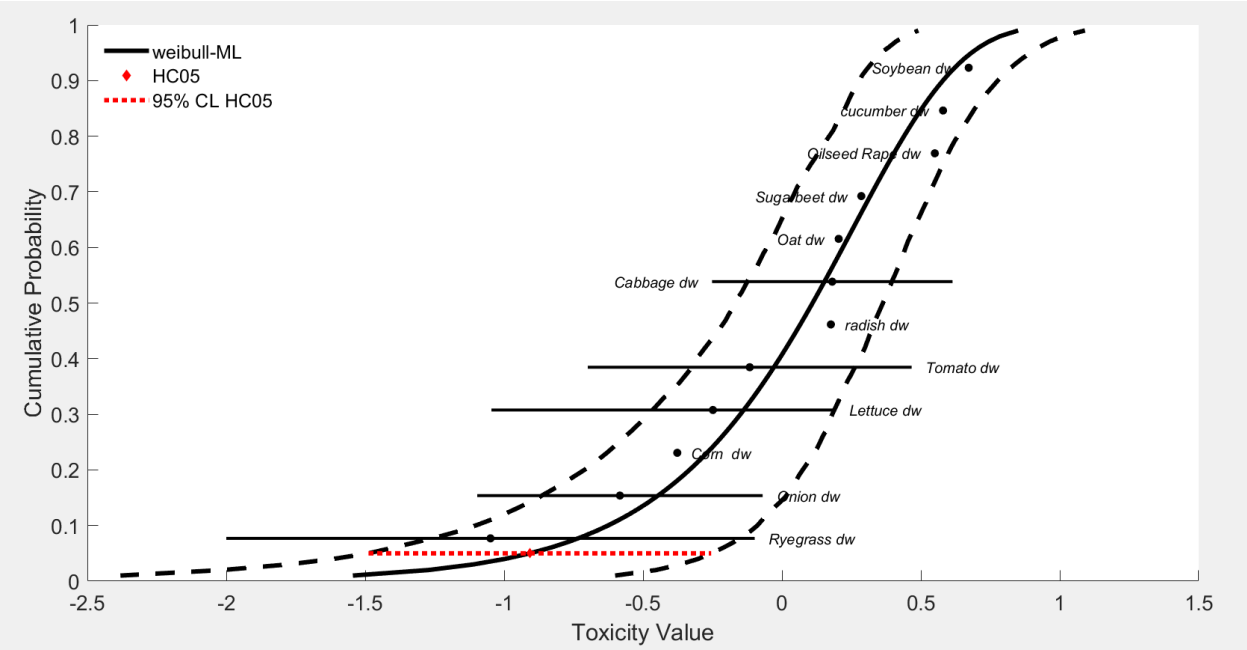
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.1623 | 0.5514 |
| 2 | logistic | ML | 0.1658 | 0.4845 |
| 3 | triangular | ML | 0.1390 | 0.3187 |
| 4 | gumbel | ML | 0.1518 | 0.3437 |
| 5 | weibull | ML | 0.1238 | 0.6104 |
| 6 | burr | ML | 0 | 0.4500 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.1237 |
| Model-averaged SE of HCp: | NaN |
| CV of HCp: | NaN |

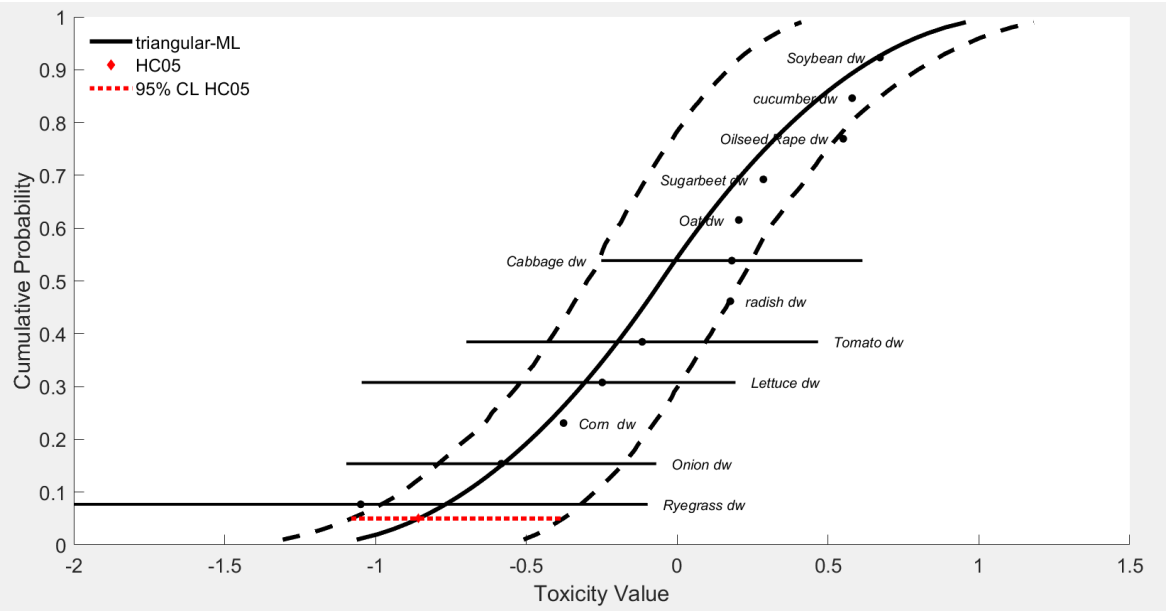
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | weibull | 42.2189 | 0 | 0.3572 | 0.1238 | 0.0931 |
| 2 | triangular | 43.5300 | 1.3111 | 0.1855 | 0.1390 | 0.0477 |
| 3 | normal | 43.7498 | 1.5310 | 0.1661 | 0.1623 | 0.0818 |
| 4 | logistic | 44.1825 | 1.9636 | 0.1338 | 0.1658 | 0.0977 |
| 5 | burr | 44.2811 | 2.0622 | 0.1274 | 0 | NaN |
| 6 | gumbel | 47.1742 | 4.9553 | 0.0300 | 0.1518 | 0.0580 |

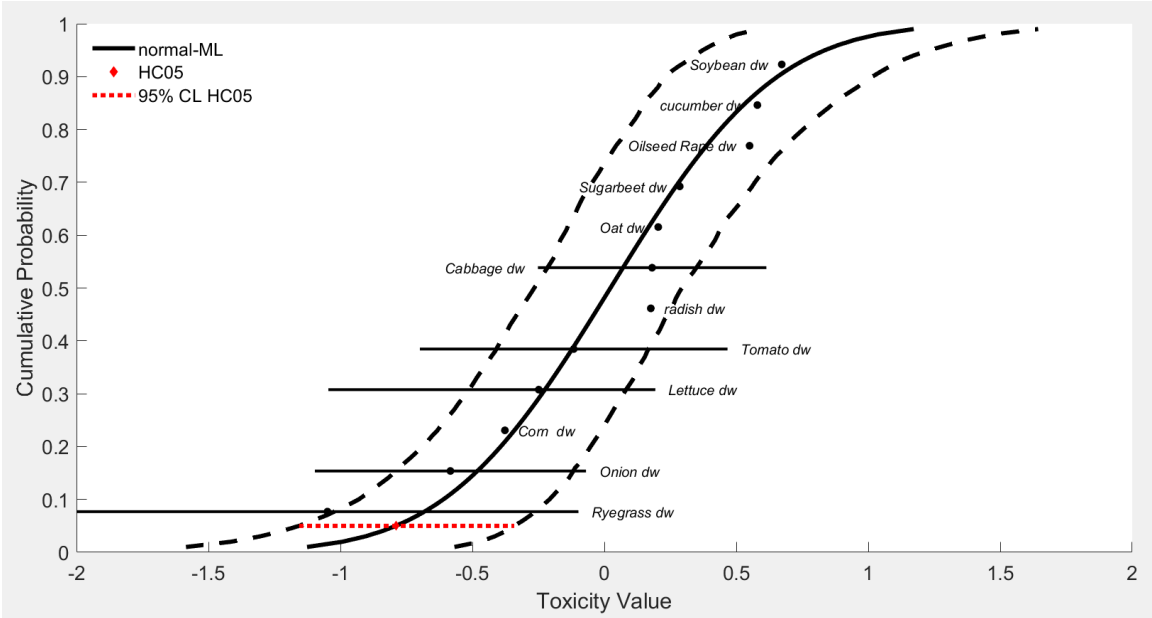
Based on the goodness of fit, EPA moved forward with Weibull, triangular, and normal distributions, and ultimately selected the Weibull distribution for the dry weight data from the seedling emergence toxicity tests.




**Weibull (selected distribution)**




Triangular




Normal

## *Vegetative Vigor Dry Weight Data*

Goodness of fit:

Results:

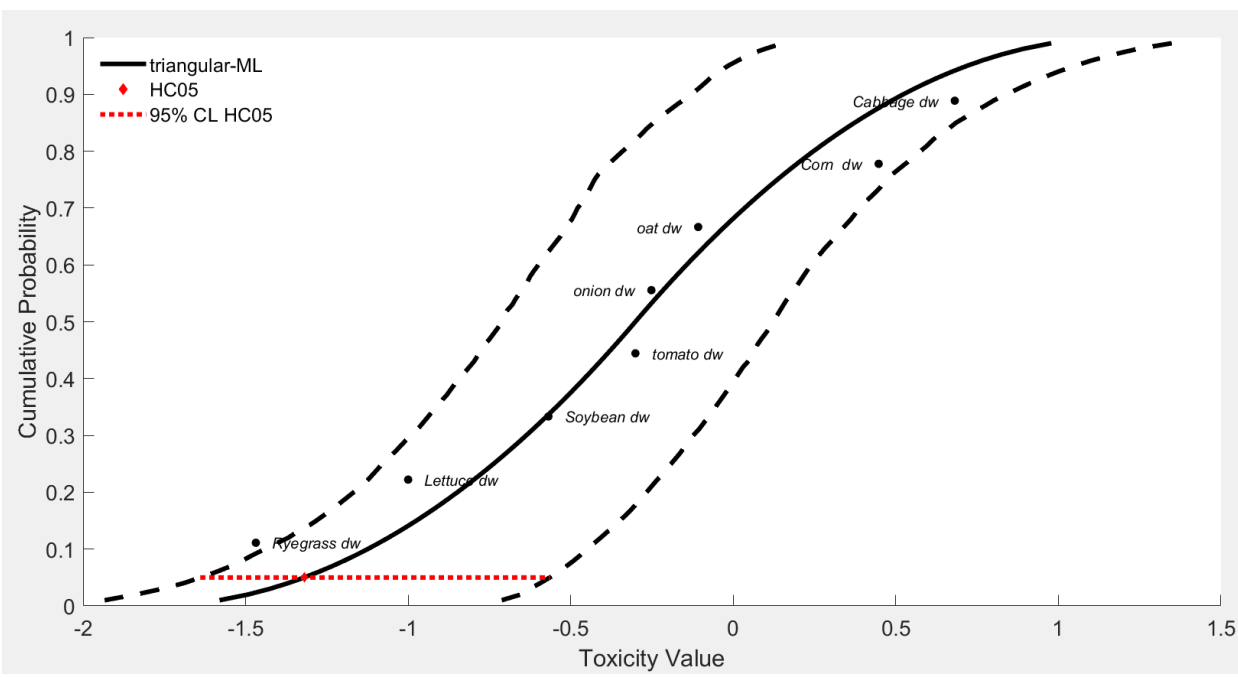
| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.0392 | 0.9031 |
| 2 | logistic | ML | 0.0356 | 0.8162 |
| 3 | triangular | ML | 0.0479 | 0.9441 |
| 4 | gumbel | ML | 0.0442 | 0.7702 |
| 5 | weibull | ML | 0.0178 | 0.7572 |
| 6 | burr | ML | 0.0331 | 0.8142 |

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.038397 |
| Model-averaged SE of HCp: | 0.029326 |
| CV of HCp: | 0.76376 |

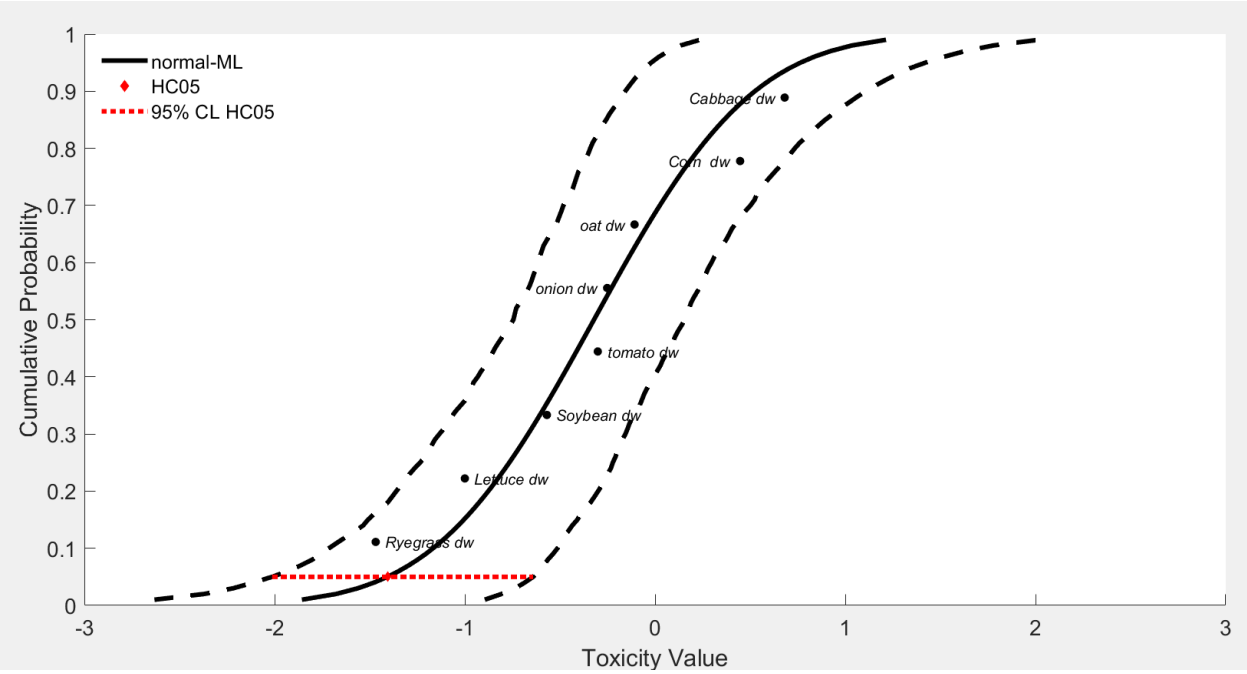
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 22.9079 | 0 | 0.3409 | 0.0479 | 0.0219 |
| 2 | normal | 23.9652 | 1.0573 | 0.2009 | 0.0392 | 0.0323 |
| 3 | weibull | 24.2605 | 1.3526 | 0.1733 | 0.0178 | 0.0241 |
| 4 | logistic | 24.4105 | 1.5026 | 0.1608 | 0.0356 | 0.0339 |
| 5 | gumbel | 25.0935 | 2.1856 | 0.1143 | 0.0442 | 0.0253 |
| 6 | burr | 30.0025 | 7.0946 | 0.0098 | 0.0331 | 0.0444 |

Based on the goodness of fit, EPA moved forward with triangular and normal distributions, and ultimately selected the normal distribution for the dry weight data from the vegetative vigor toxicity tests.




Triangular




**Normal (selected distribution)**

## 14.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 14-24. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | Not permitted on labels | | | 0 * | 0 * | 0 * | 0 * |
| **Application Rate of 4.0 lb a.i./A (maximum application rate for multiple uses and an example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * | 0 * |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 5.2 µg a.i./L for green algae, *Selenastrum capricornutum* (MRID 42372205). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For pendimethalin, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less 1.0. This is explained further in **Section 14.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 14-25. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 6.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 76.9 | 76.9 | 76.9 | 162.3 | 156.8 | 155.8 | 155.1 | 73.3 |
| 10 | 51.8 | 46.5 | 42.7 | 40.4 | 14.4 | 7.1 | 4.3 | 35.5 |
| 20 | 38.5 | 30.8 | 26.4 | 20.4 | 6.8 | 3.8 | 2.3 | 20.0 |
| 25 | 32.9 | 25.0 | 20.7 | 15.0 | 5.1 | 3.0 | 1.8 | 14.4 |
| 50 | 25.8 | 16.6 | 11.0 | 7.3 | 2.6 | 1.8 | 1.1 | 5.2 |
| 75 | 18.1 | 11.2 | 7.2 | 4.8 | 1.8 | 1.3 | 0.8 | 2.5 |
| 100 | 15.3 | 8.9 | 5.7 | 3.9 | 1.5 | 1.1 | 0.7 | 1.6 |
| 125 | 11.4 | 6.6 | 4.2 | 3.0 | 1.2 | 0.9 | 0.6 | 1.0 |
| 150 | 9.6 | 5.3 | 3.3 | 2.5 | 1.0 | 0.8 | 0.5 | 0.7 |
| 175 | 8.0 | 4.4 | 2.7 | 2.1 | 0.9 | 0.7 | 0.4 | 0.5 |
| 200 | 7.1 | 3.8 | 2.3 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 |
| 225 | 6.5 | 3.3 | 1.9 | 1.6 | 0.7 | 0.6 | 0.4 | 0.3 |
| 250 | 5.7 | 2.8 | 1.7 | 1.4 | 0.6 | 0.5 | 0.3 | 0.2 |
| 275 | 5.1 | 2.5 | 1.5 | 1.3 | 0.6 | 0.5 | 0.3 | 0.2 |
| 300 | 4.7 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 | 0.1 |
| 325 | 4.3 | 2.0 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 350 | 4.0 | 1.9 | 1.2 | 1.0 | 0.5 | 0.4 | 0.3 | 0.1 |
| 375 | 3.7 | 1.7 | 1.1 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 400 | 3.5 | 1.6 | 1.0 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 500 | 2.9 | 1.3 | 0.8 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 2.5 | 1.2 | 0.7 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 2.2 | 1.0 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 800 | 2.1 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.9 | 0.9 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.8 | 0.8 | 0.5 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.039 lb a.i./A

[2] Although aerial application is not permitted on the pendimethalin labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 14.3.3.1** and **14.4.1** the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-26. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 6.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application[2] | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 17.6 | 17.6 | 17.6 | 37.2 | 36.0 | 35.7 | 35.6 | 16.8 |
| 10 | 11.9 | 10.7 | 9.8 | 9.3 | 3.3 | 1.6 | 1.0 | 8.1 |
| 20 | 8.8 | 7.1 | 6.1 | 4.7 | 1.6 | 0.9 | 0.5 | 4.6 |
| 25 | 7.5 | 5.7 | 4.8 | 3.4 | 1.2 | 0.7 | 0.4 | 3.3 |
| 50 | 5.9 | 3.8 | 2.5 | 1.7 | 0.6 | 0.4 | 0.3 | 1.2 |
| 75 | 4.2 | 2.6 | 1.7 | 1.1 | 0.4 | 0.3 | 0.2 | 0.6 |
| 100 | 3.5 | 2.1 | 1.3 | 0.9 | 0.3 | 0.2 | 0.2 | 0.4 |
| 125 | 2.6 | 1.5 | 1.0 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 150 | 2.2 | 1.2 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 175 | 1.8 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 200 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 1.5 | 0.8 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.9 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.17 lb a.i./A

[2] Although aerial application is not permitted on the pendimethalin labels for this application rate, the results are retained in this appendix to show the full set of calculations and results. Within **Sections 14.3.3.1** and **14.4.1** the aerial results are not considered.

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-27. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 51.3 | 51.3 | 51.3 | 108.2 | 104.5 | 103.9 | 103.4 | 48.8 |
| 10 | 34.5 | 31.0 | 28.4 | 26.9 | 9.6 | 4.8 | 2.9 | 23.6 |
| 20 | 25.6 | 20.6 | 17.6 | 13.6 | 4.5 | 2.6 | 1.5 | 13.3 |
| 25 | 21.9 | 16.7 | 13.8 | 10.0 | 3.4 | 2.0 | 1.2 | 9.6 |
| 50 | 17.2 | 11.1 | 7.3 | 4.9 | 1.7 | 1.2 | 0.7 | 3.5 |
| 75 | 12.1 | 7.5 | 4.8 | 3.2 | 1.2 | 0.9 | 0.5 | 1.7 |
| 100 | 10.2 | 6.0 | 3.8 | 2.6 | 1.0 | 0.7 | 0.5 | 1.1 |
| 125 | 7.6 | 4.4 | 2.8 | 2.0 | 0.8 | 0.6 | 0.4 | 0.7 |
| 150 | 6.4 | 3.5 | 2.2 | 1.7 | 0.7 | 0.5 | 0.3 | 0.4 |
| 175 | 5.3 | 2.9 | 1.8 | 1.4 | 0.6 | 0.5 | 0.3 | 0.3 |
| 200 | 4.7 | 2.6 | 1.5 | 1.3 | 0.5 | 0.4 | 0.3 | 0.2 |
| 225 | 4.3 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.2 | 0.2 |
| 250 | 3.8 | 1.9 | 1.1 | 1.0 | 0.4 | 0.3 | 0.2 | 0.1 |
| 275 | 3.4 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| 300 | 3.1 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| 325 | 2.9 | 1.3 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 | 0.1 |
| 350 | 2.7 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 375 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 |
| 400 | 2.3 | 1.1 | 0.7 | 0.5 | 0.3 | 0.2 | 0.2 | <0.1 |
| 500 | 1.9 | 0.9 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 600 | 1.7 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 700 | 1.5 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 800 | 1.4 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 900 | 1.3 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 1.2 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.039 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-28. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 11.8 | 11.8 | 11.8 | 24.8 | 24.0 | 23.8 | 23.7 | 11.2 |
| 10 | 7.9 | 7.1 | 6.5 | 6.2 | 2.2 | 1.1 | 0.7 | 5.4 |
| 20 | 5.9 | 4.7 | 4.0 | 3.1 | 1.0 | 0.6 | 0.4 | 3.1 |
| 25 | 5.0 | 3.8 | 3.2 | 2.3 | 0.8 | 0.5 | 0.3 | 2.2 |
| 50 | 3.9 | 2.5 | 1.7 | 1.1 | 0.4 | 0.3 | 0.2 | 0.8 |
| 75 | 2.8 | 1.7 | 1.1 | 0.7 | 0.3 | 0.2 | 0.1 | 0.4 |
| 100 | 2.3 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.2 |
| 125 | 1.7 | 1.0 | 0.6 | 0.5 | 0.2 | 0.1 | 0.1 | 0.2 |
| 150 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 175 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 225 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 250 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 350 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.17 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-29. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 25.6 | 25.6 | 25.6 | 54.1 | 52.3 | 51.9 | 51.7 | 24.4 |
| 10 | 17.3 | 15.5 | 14.2 | 13.5 | 4.8 | 2.4 | 1.4 | 11.8 |
| 20 | 12.8 | 10.3 | 8.8 | 6.8 | 2.3 | 1.3 | 0.8 | 6.7 |
| 25 | 11.0 | 8.3 | 6.9 | 5.0 | 1.7 | 1.0 | 0.6 | 4.8 |
| 50 | 8.6 | 5.5 | 3.7 | 2.4 | 0.9 | 0.6 | 0.4 | 1.7 |
| 75 | 6.0 | 3.7 | 2.4 | 1.6 | 0.6 | 0.4 | 0.3 | 0.8 |
| 100 | 5.1 | 3.0 | 1.9 | 1.3 | 0.5 | 0.4 | 0.2 | 0.5 |
| 125 | 3.8 | 2.2 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 | 0.3 |
| 150 | 3.2 | 1.8 | 1.1 | 0.8 | 0.3 | 0.3 | 0.2 | 0.2 |
| 175 | 2.7 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 200 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 225 | 2.2 | 1.1 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 275 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 |
| 300 | 1.6 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.2 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 1.0 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.039 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-30. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 5.9 | 5.9 | 5.9 | 12.4 | 12.0 | 11.9 | 11.9 | 5.6 |
| 10 | 4.0 | 3.6 | 3.3 | 3.1 | 1.1 | 0.5 | 0.3 | 2.7 |
| 20 | 2.9 | 2.4 | 2.0 | 1.6 | 0.5 | 0.3 | 0.2 | 1.5 |
| 25 | 2.5 | 1.9 | 1.6 | 1.1 | 0.4 | 0.2 | 0.1 | 1.1 |
| 50 | 2.0 | 1.3 | 0.8 | 0.6 | 0.2 | 0.1 | 0.1 | 0.4 |
| 75 | 1.4 | 0.9 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | 0.2 |
| 100 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 125 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 150 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 175 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 200 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.17 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-31. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.73 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 22.2 | 22.2 | 22.2 | 46.8 | 45.2 | 44.9 | 44.7 | 21.1 |
| 10 | 14.9 | 13.4 | 12.3 | 11.6 | 4.1 | 2.1 | 1.2 | 10.2 |
| 20 | 11.1 | 8.9 | 7.6 | 5.9 | 2.0 | 1.1 | 0.7 | 5.8 |
| 25 | 9.5 | 7.2 | 6.0 | 4.3 | 1.5 | 0.9 | 0.5 | 4.2 |
| 50 | 7.4 | 4.8 | 3.2 | 2.1 | 0.7 | 0.5 | 0.3 | 1.5 |
| 75 | 5.2 | 3.2 | 2.1 | 1.4 | 0.5 | 0.4 | 0.2 | 0.7 |
| 100 | 4.4 | 2.6 | 1.6 | 1.1 | 0.4 | 0.3 | 0.2 | 0.5 |
| 125 | 3.3 | 1.9 | 1.2 | 0.9 | 0.3 | 0.3 | 0.2 | 0.3 |
| 150 | 2.8 | 1.5 | 1.0 | 0.7 | 0.3 | 0.2 | 0.1 | 0.2 |
| 175 | 2.3 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 |
| 200 | 2.1 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 225 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| 250 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 350 | 1.2 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.039 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-32. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.73 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 5.1 | 5.1 | 5.1 | 10.7 | 10.4 | 10.3 | 10.3 | 4.8 |
| 10 | 3.4 | 3.1 | 2.8 | 2.7 | 1.0 | 0.5 | 0.3 | 2.3 |
| 20 | 2.5 | 2.0 | 1.7 | 1.3 | 0.5 | 0.3 | 0.2 | 1.3 |
| 25 | 2.2 | 1.7 | 1.4 | 1.0 | 0.3 | 0.2 | 0.1 | 1.0 |
| 50 | 1.7 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 | 0.3 |
| 75 | 1.2 | 0.7 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | 0.2 |
| 100 | 1.0 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.1 |
| 125 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | 0.1 |
| 150 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 175 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.17 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-33. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Terrestrial Plant Toxicity Endpoint for an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 12.8 | 12.8 | 12.8 | 27.1 | 26.1 | 26.0 | 25.8 | 12.2 |
| 10 | 8.6 | 7.7 | 7.1 | 6.7 | 2.4 | 1.2 | 0.7 | 5.9 |
| 20 | 6.4 | 5.1 | 4.4 | 3.4 | 1.1 | 0.6 | 0.4 | 3.3 |
| 25 | 5.5 | 4.2 | 3.5 | 2.5 | 0.8 | 0.5 | 0.3 | 2.4 |
| 50 | 4.3 | 2.8 | 1.8 | 1.2 | 0.4 | 0.3 | 0.2 | 0.9 |
| 75 | 3.0 | 1.9 | 1.2 | 0.8 | 0.3 | 0.2 | 0.1 | 0.4 |
| 100 | 2.6 | 1.5 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 | 0.3 |
| 125 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 | 0.2 |
| 150 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 |
| 175 | 1.3 | 0.7 | 0.4 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 |
| 200 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| 225 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 |
| 250 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 0.9 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 300 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 350 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 500 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 5th Percentile of SSD = 0.039 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 14-34. Ratios of the Spray Drift Deposition EEC to the Terrestrial Plant Toxicity Endpoint Relevant for Generalist Animals for an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | | Airblast (Sparse Canopy) |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom | |
| 0 | 2.9 | 2.9 | 2.9 | 6.2 | 6.0 | 6.0 | 5.9 | 2.8 |
| 10 | 2.0 | 1.8 | 1.6 | 1.5 | 0.6 | 0.3 | 0.2 | 1.4 |
| 20 | 1.5 | 1.2 | 1.0 | 0.8 | 0.3 | 0.1 | 0.1 | 0.8 |
| 25 | 1.3 | 1.0 | 0.8 | 0.6 | 0.2 | 0.1 | 0.1 | 0.6 |
| 50 | 1.0 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | 0.2 |
| 75 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | 0.1 |
| 100 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | 0.1 |
| 125 | 0.4 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the 25th Percentile of SSD = 0.17 lb a.i./A

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 15 Propanil Case Study Example (PC Code 028201)

## 15.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 15.2 Use Information

Propanil is a selective amide herbicide utilized for targeted post-emergence use to control broadleaf plants and grasses, particularly barnyard grass, during rice production. The mechanism of action is not well understood but propanil is believed to be effective by interfering with electron transport in photosystem II of photosynthesis. The maximum single application rate is 6.0 lb a.i./A for both aerial and ground applications.

Propanil is moderately mobile in soil and rapidly absorbed by foliage but there is limited evidence of translocation from treated foliage to other areas of the plant. Aerobic and anaerobic metabolism are the major routes of propanil degradation in the environment. Propanil is only registered for use on rice and can be applied during the post-emergence phase (March through May). The active ingredient requires ≥ 70 °F temperatures to be most effective.

**Table 15-1** includes the use information from the 2019 Draft Risk Assessment for Registration Review (DRA; DP449993) for Registration Review. As this is an illustrative example of how the draft Herbicide Strategy would be implemented for propanil, changes to the registered labels and use since this DRA (*e.g.,* changes outlined in the Interim Decision in December 2020) are not considered at this time but would be considered when EPA conducts assessments for propanil for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2019 assessment. **Table 15-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 15.6**. The UDLs are spatial representations of potential pesticide use sites. The UDL for use on rice is the Rice UDL. Information about the UDL assignments can be found in **Section 5**.

EPA used the modeling for estimating environmental exposure based on application to rice fields, the only registered use of propanil, using the Pesticides in Flooded Applications Model (PFAM; v.2.0). EPA extracted the estimated environmental concentrations (EECs) directly from the 2019 DRA for Registration Review (DP449993). EPA focused on estimated environmental concentrations (EECs) for liquid spray formulations of propanil as this application method represents the greatest source of potential offsite movement. Although granular formulations of propanil are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff/erosion exposure from granular applications is unknown but the modeling provided in the 2019 assessment is expected to be representative of broadcast applications of granules given the similarity of the application methods and rates. The document is an illustrative example of the draft Herbicide Strategy framework; this case study is not intended to be an ESA effects determination for propanil.

**Table 15-1. Summary of the Labeled Use Patterns for Propanil (2019 Draft Risk Assessment for Registration Review, DP449993)[1]**

| Use Site/ Location (Use Data Layer) | App Target | App Type | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Seasonal Rate (lb ai/A/season) | MRI (d) | Comments (*e.g.* geographic/ application timing restrictions, pollinator specific language) |
|---|---|---|---|---|---|---|---|---|---|
| Rice (Rice UDL) | Flooded Field | Broadcast | A, G | Post-emergence, Spring/Fall | 4.0 – 6.0 | NS (2) | 8.0 | NS | 7-day rice paddy water holding (discharge) interval for the Mississippi Delta and California. Do not apply to fields where catfish farming is practiced. Do not apply via irrigation system. |

App=application; equip=equipment; MRI=Minimum retreatment interval; UDL=Use Data Layer; A=aerial; G=ground; ai=active ingredient; d=day; NS=not specified on the label

Values in parentheses are the values that EPA assumed in the modeling conducted in the 2019 Draft Risk Assessment for Registration Review (DP449993).

[1] The use information presented in this table is identical to the agricultural uses included in the 2019 Draft Risk Assessment for Registration Review (DP449993).

## 15.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of propanil (**Section 15.3.1**), reported incidents (**Section 15.3.2**), and the EECs to calculate magnitude of difference values (**Section 15.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 15.3.1 Toxicity Information

**Table 15-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for propanil. The terrestrial and aquatic plant toxicity data sets (monocot and dicot terrestrial plants; vascular and nonvascular aquatic plants) were not robust enough to support generating Species Sensitivity Distributions (SSDs); however, all terrestrial and aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[215] are available to evaluate potential impacts of propanil on listed species. EPA used the most sensitive monocot and dicot vegetative vigor $IC_{25}$ endpoints for calculating magnitude of difference values for monocot and dicot terrestrial and wetland plants. For aquatic plants, EPA used the most sensitive $IC_{50}$ for vascular and nonvascular plants for comparing EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[216].

**Table 15-2. Summary of the Most Sensitive Toxicity Endpoints for Propanil (As Summarized in the 2019 Draft Risk Assessment for Registration Review (DP449993))**

| Toxicity Test | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Onion (*Allium cepa*) | NOAEC = 0.61 lb a.i./A<br>$IC_{25}$ = 1.4 lb a.i./A | 47144702<br>Acceptable | Test with TGAI; based on reduction in shoot length. |
| | Dicot: Lettuce (*Lactuca sativa*) | NOAEC = 0.11 lb a.i./A<br>$IC_{25}$ = 0.54 lb a.i./A | 47144702<br>Acceptable | Test with TGAI; based on effects on fresh weight |
| Vegetative Vigor | Monocot: Onion (*Allium cepa*) | NOAEC = 0.03 lb a.i./A<br>**$IC_{25}$ = 0.13 lb a.i./A** | 43069901<br>Acceptable | Test with TEP; based on effects on fresh weight |
| | Dicot: Cabbage (*Brassica oleracea*) | NOAEC = 0.03 lb a.i./A<br>**$IC_{25}$ = 0.09 lb a.i./A** | 43069901<br>Acceptable | Test with TEP; based on effects on fresh weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | NOAEC = 20 µg a.i./L<br>**$IC_{50}$ = 110 µg a.i./L** | 41777201<br>Acceptable | Most sensitive endpoint based on reduction in number of fronds. |

[215] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[216] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

| Toxicity Test | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| | | | | |
| Aquatic Nonvascular Plant | Freshwater Diatom (*Navicula pelliculosa*) | NOAEC = 6.3 µg a.i./L **$IC_{50}$ = 16 µg a.i./L** | 41777501 Acceptable | Based on cell density reduction at the LOAEC. |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}$/$IC_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; TEP=typical end-use product

**Bolded** endpoints indicate the most sensitive endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed plants and animals that depend on plants.

Overall, the magnitude of difference between the endpoint and EEC is calculated considering the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

For listed terrestrial plants and animals that depend on terrestrial plants, only spray drift exposure was modeled (*i.e.,* EPA did not consider exposure via runoff/erosion to be relevant for this case study example). For listed plants and animals that obligately depend on monocots/dicots, EPA compared the spray drift exposure estimates to the most sensitive monocot and dicot endpoints (**Table 15-2** and **Table 15-3)** as explained further in **Section 15.3.3.1**. For listed animals that generally rely on terrestrial plants and for terrestrial designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for dicot growth (Table 6-2 and **Table 15-3**).

For listed wetland plants and animals that obligately depend on wetland plants, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive vegetative vigor monocot and dicot $IC_{25}$ endpoints. An SSD was not possible given the limited number of species with definitive $IC_{25}$ endpoints. Therefore, EPA used the most sensitive toxicity endpoints (**Table 15-2**) were used to calculate the magnitude of difference. To determine the magnitude of difference for wetland plants, EPA first converted the most sensitive terrestrial plant endpoints (**Table 15-2**) to micrograms of active ingredient per liter (µg a.i./L), allowing for comparison to the PFAM EECs to model wetland erosion zone exposure (see Appendix 1: Conversion of Terrestrial Plant Toxicity Endpoints (in lb a.i./A) to Wetland Relevant Endpoints (in µg a.i./L); **Table 15-3**). In this conversion, EPA assumed the volume of water was equivalent to a full Plant Assessment Tool wetland.

For listed animals that generally rely on wetland plants and for designated critical habitats in wetlands and small waterbodies[217], EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive terrestrial plant $IC_{25}$ converted to µg a.i./L, which is the $IC_{25}$ for dicot growth (**Table 15-2** and **Table 15-3**).

For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ values for vascular and nonvascular plants (**Table 15-2** and **Table 15-3**).

**Table 15-3. Toxicity Endpoints used to Calculate the Magnitude of Difference for Propanil[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | Monocots: 0.13 lb a.i./A<br>Dicots: 0.09 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | Monocots: 97.1 µg a.i./L<br>Dicots: 67.3 µg a.i./L |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | Vascular: 110 µg a.i./L<br>Nonvascular: 16 µg a.i./L |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | Monocots: 0.13 lb a.i./A<br>Dicots: 0.09 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants | Wetlands, Small Waterbodies[5] | Monocots: 97.1 µg a.i./L<br>Dicots: 67.3 µg a.i./L |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[7] | Terrestrial | 0.09 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[8] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 67.3 µg a.i./L |
| | | Based on aquatic plant endpoints: 110 µg a.i./L (Vascular) 16 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[9] | EPA Standard Pond and Larger Waterbodies[10] | 110 µg a.i./L (Vascular)<br>16 µg a.i./L (Nonvascular) |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated. In this case study for propanil, EPA calculated five sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for use of propanil on flooded rice fields.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1** of the **Case Study Summary and Process** document). For small waterbodies, EPA compares the PFAM EECs to the terrestrial plant toxicity endpoints (converted to µg a.i./L).

[217] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.

[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for use of propanil on flooded rice fields.
[7] Inclusive of species that rely on monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for propanil. EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for dicot growth.
[8] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the PFAM EECs to the terrestrial plant toxicity endpoint (converted to µg a.i./L) and to the aquatic plant toxicity endpoints. For the comparison to the terrestrial plant toxicity endpoint, EPA selected the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for dicot growth.
[9] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[10] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**). For larger waterbodies, EPA compares the PFAM EECs to the aquatic plant toxicity endpoints.

### 15.3.2 Incidents

The incident information from the 2019 Draft Risk Assessment for Registration Review (DP449993) for propanil is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[218] (as discussed in **Section 15.3.3.3**), which informs the potential population-level impacts (**Section 15.6**), and to identify the proposed level of mitigation (see **Section 15.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 15.3.3.3**).[219] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

[218] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2 of the Strategy Framework document for further details on magnitude of effect**.
[219] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA. EPA searched the database May 16, 2019, in support of the assessment for Registration Review. There were four reported ecological incidents associated with the use of propanil on rice. Two incidents were related to rice crop damage following direct treatment of the agricultural field and one incident was due to spray drift from application to an adjacent rice field, which resulted in no leaf growth on exposed trees.

Because the plant incidents are few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for propanil. In other words, the propanil incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 15.3.3.3**) are unaltered by the available propanil incident data.

### 15.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants. However, as discussed above in **Section 15.3.1**, this is not applicable for propanil because EPA did not generate an SSD for propanil.

#### *15.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 15-4** and **Table 15-5** demonstrate the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoints to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of propanil (0.09 lb a.i./A for dicots (**Table 15-4**); 0.13 lb a.i./A for monocots (**Table 15-5**)). To estimate potential diet/habitat effects to generalist animals, EPA selected the most sensitive endpoint applicable for generalists (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots; **Table 15-2**) while considering the different toxicity endpoints available for propanil. Therefore, EPA based the spray drift distances for generalist animals on the dicot $IC_{25}$ (0.09 lb a.i./A) and grouped generalist animals with listed dicots (**Table 15-4**).

Within **Table 15-4** and **Table 15-5**, the modeled application rates are representative of the maximum single application rate currently registered for propanil (6.0 lb a.i./A) and reduced rates (4.0 and 2.0 a.i./A) that could be applied. **Table 15-4** and **Table 15-5** give the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint for dicots (**Table 15-4**) and monocots (**Table 15-5**) and also the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size, as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 15.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances (than the spray drift distances estimated for terrestrial/wetland plants (**Section 15.7**). This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 15-4. Spray Drift Distances to the Population-Level Impacts Endpoint for Listed Dicots, Animals that Obligately Rely on Dicots, and Generalist Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 700 | 300 | 200 | 175 | 75 | 50 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **2.0** [300] | **1.0** [300] | **1.0** [200] | 0.8 [200] | 0.6 [100] | 0.5 [100] | 0.3 [100] |
| **Application Rate of 4.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 400 | 225 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.3** [300] | 0.6 [300] | 0.7 [200] | 0.5 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 2.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 200 | 125 | 75 | 75 | 20 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.7 [300] | 0.3 [300] | 0.3 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon the most sensitive $IC_{25}$ value for dicots are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.

[2] For propanil, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 15.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to the medium MOE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 15.8** contains the full output of results.

### Table 15-5. Spray Drift Distances to the Population-Level Impacts Endpoint for Listed Monocots and Animals that Obligately Rely on Monocots, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 400 | 225 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.4** [300] | 0.7 [300] | 0.7 [200] | 0.6 [200] | 0.4 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 4.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 275 | 175 | 125 | 75 | 25 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.9 [300] | 0.4 [300] | 0.5 [200] | 0.4 [200] | 0.3 [100] | 0.2 [100] | 0.1 [100] |
| **Application Rate of 2.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 150 | 100 | 75 | 50 | 20 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.5 [300] | 0.2 [300] | 0.2 [200] | 0.2 [200] | 0.1 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon the most sensitive $IC_{25}$ value for monocots are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For propanil, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 15.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to the medium MOE is >25ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 15.8** contains the full output of results.

#### *15.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PFAM compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PFAM see **Section 3.1**.

**Table 15-6** and **Table 15-7** below present the magnitude of difference values for each use considering the habitat (aquatic or wetland) and the toxicity endpoint (aquatic plant $IC_{50}$, monocot $IC_{25}$, dicot $IC_{25}$). As explained in **Section 3.1.3**, EPA did not calculate runoff/erosion magnitude of difference values for terrestrial plants use on flooded rice because the overland sheet-flow runoff is not expected to occur in fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops[220] ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. In future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

**Table 15-6. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitat in Waterbodies Equivalent in Size to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Flooded Rice (without levees/berms) | 2900 – 8400 | 26 – 76 | 180 – 520 |

[1] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water, which for this example is assumed to be representative of larger waterbodies (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for propanil, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* different application rates) as well as different PFAM scenarios (based on PFAM version 2.0).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[220] https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/rice/ArkansasFurrowIrrigatedRiceHandbook.pdf

**Table 15-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (µg a.i./L)[2] | Wetland Dicots[3] | Wetland Monocots[4] | Aquatic Vascular Plants[5] | Aquatic Nonvascular Plants[5] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] |
| Flooded Rice (without levees/berms) | 2900 – 8400 | 42 – 130 | 29 – 86 | 26 – 76 | 180 – 520 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, EPA compared the EECs for the wetland (calculated in PFAM; in µg a.i./L) to the terrestrial plant toxicity endpoints (converted to µg a.i./L; see **Section 15.7** and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* different application rates) as well as different PFAM scenarios (based on PFAM version 2.0).

[3] The magnitude of difference values in this column are relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. Additionally, this column is relevant for listed generalist animals and designated critical habitats in wetlands and small waterbodies. Because EPA could not generate a reliable Species Sensitivity Distribution for propanil (as explained in **Section 15.3.1**), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots) in wetlands and small waterbodies. Therefore, the magnitude of difference for generalist animals and for designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive dicot $IC_{25}$.

[4] The magnitude of difference values in this column are only relevant for listed monocots in wetlands and animals that obligately rely on wetland dicots. See footnote 3 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.

[5] Because a Species Sensitivity Distribution is not appropriate for aquatic plants for propanil, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitude of difference values.

[5] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *15.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 15-8.** These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 15.3.3.1** and **15.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 15.4**) and conducting a population-level impact analysis (**Section 15.6**).

For propanil, given the limited plant toxicity data and the lack of SSDs[221], EPA would assign a low magnitude of effect to groups of listed species and CHs[222] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned a medium magnitude of effect in **Table 15-8** when the magnitude of difference is from 1 up to 10. EPA assigned a high or very high magnitude of effect to groups of species and CHs based on a magnitude of difference of 10 up to 100 or greater than 100, respectively.

**Table 15-8. Use-Based Magnitude of Effect for Propanil.[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|
| | Monocots, Animals Obligately Depending on Monocots | Dicots, Animals Obligately Depending on Dicots, Generalist Animals[4], and CHs[4] | Monocots, Animals Obligately Depending on Monocots | Dicots, Animals Obligately Depending on Dicots, Generalist Animals[4], and CHs[4] | Plants[6], Obligate & Generalist Animals[7], CHs |
| Flooded Rice | High[5] | High[5] | High | Very High | Very High |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 15.4**) and to conduct the population-level impacts analysis (**Section 15.6**). If the magnitude of effect is medium or higher for propanil, EPA determined that there is a potential for population-level impacts.

[2] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] For animals that generally rely upon terrestrial/wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* $IC_{25}$ for monocots, $IC_{25}$ for dicots, and $IC_{50}$ for aquatic plants (applicable for wetlands and small waterbodies only)). The magnitude of effect in this table reflects the highest magnitude of difference calculated for generalists for each use, which is based on the dicot $IC_{25}$ (see **Table 15-4** and **Table 15-7**); therefore, generalist animals and CHs are grouped with dicots.

[5] Reflects only a spray drift pathway of exposure for terrestrial plants.

[6] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[7] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies.

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[221] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[222] Species and CH groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

## 15.4 Framework Step 2: Identify Mitigation Measures

**Section 15.4** outlines the mitigation measures identified for propanil for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 15.4.1**), runoff/erosion (**Section 15.4.2**), and flooded field with levees/berms (**Section 15.4.3**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 15.4.1 Spray Drift Mitigation Measures Identified

**Table 15-13** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants, listed animals that obligately or generally depend on these plants, and designated critical habitats. Although EPA calculated spray drift buffer distances for listed monocots and animals obligately depending on monocots in **Table 15-5**, the spray drift buffer distances for listed monocots and animals obligately depending on monocots are shorter than the distances for listed dicots, animals depending on dicots, and generalist animals. This is because EPA used the most sensitive dicot $IC_{25}$ to calculate the buffer distances for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the dicot $IC_{25}$, EPA identified farther spray drift buffer distances for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the extent of the spray drift buffers, EPA grouped listed monocots and animals that obligately rely on monocots with listed dicots, animals obligately relying on dicots, and generalist animals, and EPA relied upon the results based on the dicot $IC_{25}$ to determine the spray drift buffer distances. As explained in **Section 6.1** of the **Strategy Framework**, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeedsError! Reference source not found..

**Table 15-9. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants, Listed Animals that Obligately Depend on Plants, and Listed Animals that Generally Rely on Terrestrial/Wetland Plants as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1,2]**

| Single Maximum Application Rate (lb ai/A)[3] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium -Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 6.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 175[e,f,g] | 75[f,g] | 50[f,g] | 20[h] |
| 4.0 | 300[a,b,c] | 225[a,b] | 150[b,d] | 125[e,f,g] | 50[f,g] | 25[h] | 20[h] |
| 2.0 | 200[a,b] | 125[b,d] | 75[b,d] | 75[f,g] | 20[h] | 10[h] | None[4] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[5] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] EPA identified the spray drift buffer distances in this table (based on the most sensitive dicot $IC_{25}$) for all listed plants and all listed animals that rely on plants for diet/habitat. This is due to the lack of an SSD for propanil, resulting in EPA using the dicot toxicity endpoint, which is more sensitive than the available monocot toxicity endpoints. The resulting propanil spray drift distances modeled for monocots are shorter than for generalist animals (due to the toxicity to dicots driving the spray drift distances for generalists; see **Table 15-4** and **Table 15-5)**.
[3] Single maximum label rates reflect the range of uses represented in **Table 15-1.**
[4] EPA did not identify a spray drift buffer as a mitigation measure because the magnitude of difference is ≤0.5 at 10 ft off the treated field.
[5] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 15.4.2 Runoff/Erosion Mitigation Measures Identified for Row Rice

EPA's identification of the proposed runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed monocots (lowest monocot $IC_{25}$)). Runoff/erosion mitigation measures in this section are only applicable to flooded rice, which is grown in fields without dikes around the field. These mitigation measures are not applicable to fields with berms or

levees around the field. Additionally, these mitigation measures are only applicable to wetland and aquatic habitats. EPA did not calculate runoff/erosion magnitude of difference values for terrestrial plants use on rice because the overland sheet-flow runoff is not expected to occur in fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. In future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

For propanil, see **Section 15.3.3.2** for more details on the magnitude of difference between EECs and toxicity endpoints for each plant and animal group. EPA assigns the mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in **Section 5.2** in the **Strategy Framework** document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of propanil is <1,000 L/kg-o.c. (mean $K_{OC}$ = 487 L/kg-o.c.), EPA identified more mitigation points for this runoff-prone herbicide (as compared to a different erosion-prone herbicide).

As described in the **Strategy Framework**, for the draft Strategy, EPA would identify mitigations for runoff/erosion for flooded rice[223] whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would apply, and if it is between 100 and 1,000, high mitigation would apply.

Overall for propanil, EPA identified proposed runoff/erosion mitigation measures for at least one wetland/aquatic taxon.

- For listed aquatic plants and animals that depend on aquatic plants[224] and designated Critical Habitats in waterbodies similar in size to the EPA farm pond or larger[225], the mitigation category is high[226] to reduce the likelihood of potential population-level impacts from use on rice[227] (**Table 15-10**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies.

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[223] Runoff/erosion mitigation practices are only applicable to flooded rice, which is grown in fields without dikes around the field. These runoff/erosion mitigation practices are not applicable to fields with berms or levees around the field.
[224] None of the listed aquatic animals have obligate relationships to plants.
[225] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[226] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios ≥1000), High (ratios ≥100 but <1000), Medium (ratios ≥10 but <100), Low (ratios ≥1 but <10), No Mitigation (ratios <1).
[227] This is not applicable for rice grown on fields with berms or levees around the field.

- For semi-aquatic/wetland dicots, animals that obligately[228] depend on wetland dicots, and animals that generally[229] rely on plants in wetlands or small waterbodies[230], the mitigation category is high for use on rice[227] (**Table 15-11)**. For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland plants and for animals that depend on wetland plants.
- For semi-aquatic/wetland monocots and animals that obligately depend on monocots in wetlands and small waterbodies[230], the mitigation category is medium for use on rice[227] (**Table 15-11)**.
- For aquatic plants in wetlands or small waterbodies[230] and for animals that depend on these plants (both obligately and generally), the mitigation category for use on rice[227] is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. Based on the aquatic vascular toxicity endpoint, EPA identified the mitigation category to be medium for use on rice[227] (**Table 15-11**). Based on the nonvascular aquatic plant toxicity endpoint, EPA identified high mitigation for use on rice[227] (**Table 15-11**). Therefore, the mitigation category for these listed species is high.

[228] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[229] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.
[230] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**).

**Table 15-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Flooded Rice (without levees/berms) | 2900 – 8400 | 26 – 76 | Medium | 180 – 520 | High |

[1] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for propanil, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* different application rates) as well as different PFAM scenarios (based on PFAM version 2).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 15-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (µg a.i./L)[2] | Wetland Dicots[3] | | Wetland Monocots[4] | | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] |
| Flooded Rice (without levees/berms) | 2900 – 8400 | 42 – 130 | High | 29 – 86 | Medium | 26 – 76 | Medium | 180 – 520 | High |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, EPA compared the EECs for the wetland (calculated in PFAM; in µg a.i./L) to the terrestrial plant toxicity endpoints (converted to µg a.i./L; see Appendix 1: Conversion of Terrestrial Plant Toxicity Endpoints (in lb a.i./A) to Wetland Relevant Endpoints (in µg a.i./L)) and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* different application rates) as well as different PFAM scenarios (based on PFAM version 2).

[3] The magnitude of difference values and mitigation categories in these two columns are relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. Additionally, this column is relevant for listed generalist animals and designated critical habitats in wetlands and small waterbodies. Because EPA could not generate a reliable Species Sensitivity Distribution for propanil (as explained in **Section 15.3.1**), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots) in wetlands and small waterbodies. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive dicot $IC_{25}$.

[4] The magnitude of difference values and mitigation categories in these columns are only relevant for listed monocots in wetlands and animals that obligately rely on wetland monocots. See footnote 3 for the magnitude of difference values and mitigation categories applicable for listed generalist animals and designated critical habitats.

[5] Because a Species Sensitivity Distribution is not appropriate for aquatic plants for propanil, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitude of difference values and mitigation categories.

[6] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[7] Mitigations were identified whenever the magnitude of difference is >1.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants **(Table 15-10** and **Table 15-11**) and wetland plants (**Table 15-11**). For propanil, the mitigation points for these aquatic (including wetland) habitats are equivalent regardless of whether the area is for protection of listed plants, obligate animals, or generalist animals, because of the available toxicity data where the most sensitive dicot $IC_{25}$ is applicable to plants, obligate animals, and generalist animals (as discussed below). Runoff/erosion mitigation points are not identified for terrestrial habitats, because propanil is only registered for use on rice and because the overland sheet-flow runoff is not expected to occur in rice fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. At this time, EPA has not considered runoff/erosion from row rice, but in future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

**Table 15-12** provides the runoff/erosion mitigation points identified for propanil. Although EPA calculated the magnitude of difference values and determined the runoff/erosion mitigation categories for listed monocots and listed animals that obligately rely on monocots, these values are not presented in **Table 15-12**. The mitigation categories and mitigation points identified for listed monocots and animals obligately depending on monocots are lower than the values for generalist animals. This is because EPA could not generate an SSD for propanil and instead used the most sensitive monocot $IC_{25}$ to calculate the magnitude of difference for listed monocots (and animals obligately relying on monocots) and used the most sensitive dicot $IC_{25}$ to calculate the magnitude of difference for listed dicots, animals obligately relying on dicots, and generalist animals. This is based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the dicot $IC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed monocots. However, listed monocots and animals obligately relying on monocots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the runoff/erosion mitigation levels for propanil, EPA grouped listed monocots and animals that obligately rely on monocots with listed dicots, listed animals obligately relying on dicots, and generalist animals.

**Table 15-12. Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic, Wetland, and Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | Aquatic and Wetland Habitats |
|---|---|---|
| | **Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points)** | **Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points)** |
| Flooded Rice (without levees/berms) | No runoff mitigation identified | High (9 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of terrestrial and aquatic (including wetland) habitats for listed species.

[2] The mitigation points identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants **(Table 15-10** and **Table 15-11**) and listed animals that obligately or generally depend on aquatic and wetland plants **(Table 15-10** and **Table 15-11**) . Runoff/erosion mitigation measures in this section are only applicable to flooded rice, which is grown in fields without dikes around the field, and EPA has not identified runoff/erosion mitigation measures for terrestrial habitats at this time.

### 15.4.3 Mitigation Measures Identified for Flooded Fields with Levees or Berms

In future assessments, EPA may also identify runoff/erosion mitigations for flooded rice fields that have levees or berms. EPA did not include mitigation measures for flooded fields in the **Technical Support for Mitigation** document; however, a recent proposal for an herbicide for use on flooded rice identified potential mitigations. These mitigation measures could be considered for chemicals with flooded rice uses (including propanil) in future regulatory (not illustrative) decisions using the final Herbicide Strategy. EPA identified the following potential mitigations to address population-level impacts to listed species from use of propanil on flooded rice fields with levees or berms:

- Berm/levee maintenance practices are important elements toward reducing exposure for non-target organisms and the label should direct the grower directly to a berm/levee management program. The reference for best management practices (BMPs) needs to be specific and indicate the pages that are relevant to the BMPs. The label must also include the following:
    - Propanil shall not be applied to rice fields exhibiting visible water seepage that moves offsite into drains that are considered California state waters.
    - Borders surrounding each rice field shall be compacted before water is allowed to fill the field; the degree of compaction shall be sufficient to prevent water from seeping through the border. This requirement applies to new or reworked existing borders for the current rice season.
    - A common border between two existing rice fields does not need to be compacted.
    - Overspray of berms/levees should be minimized to reduce the extent of spray drift exposure and the extent to which granules would be available for ingestion.

- Retaining the water in the rice paddy (*i.e.*, a holding period) for specific intervals provides an opportunity for compounds to dissipate and/or degrade. EPA could specify a propanil-specific holding period in future regulatory decisions.[231]

## 15.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for propanil are discussed in this section.

Based on the submitted toxicity data (see **Section 15.3.1**), propanil may be slightly more toxic to dicots than to monocots. EPA identified more restrictive mitigations for listed dicots, listed animals that obligately rely on dicots, and generalist animals than for other listed species such as listed monocots and listed animals that obligately rely on listed monocots. EPA used the most sensitive dicot $IC_{25}$ (instead of the most sensitive monocot $IC_{25}$) to calculate the magnitude of difference for generalist animals because generalist animals are assumed to rely on both monocots and dicots, depending on what is available in their habitat. By using the most sensitive dicot $IC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed monocots (as explained in **Sections 15.3.3.1**, **15.3.3.2**, **15.4.1**, and **15.4.2**). However, listed monocots and animals obligately relying on monocots occur in areas where listed generalist animals occur. Therefore, for identifying the extent of mitigation measures, EPA determined that differential mitigations for monocots and dicots are not appropriate for propanil. In other words, to cover the wide geographic range of listed generalist animals across the United States, and also to provide sufficient protection to listed dicot species, EPA would only generate one set of spray drift mitigation measures (**Table 15-9**) and one set of runoff/erosion mitigation measures (**Table 15-12**). The spray drift mitigation measures would apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). The runoff/erosion mitigation measures would only apply to wetland and aquatic habitats in areas where the rice fields do not have levees/berms. EPA would propose to put all of the mitigations on the general label without using use Bulletins because the mitigations do not differ for different geographic areas (*i.e.,* mitigations are equivalent across the lower 48 United States).

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[231] In future regulatory actions, the EPA could recommend a specific holding period (*e.g.,* 30 days) before release of the paddy water into downstream conveyances. Additionally, EPA could recommend that flood waters be released at a specified rate (*e.g.,* not more than 2 inches of water over a drain box weir for seven additional days after the 30-day holding period).

## 15.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 15.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with the Rice Use Data Layer (UDL), which represents the only registered use of propanil. EPA's overlap analysis was based on the offsite transport area where spray drift of propanil may lead to exposures for listed terrestrial species and where runoff/erosion of propanil may lead to exposures for listed wetland and aquatic species. This offsite transport area is represented by extending the on-field portion of the Rice UDL to include areas of potential offsite exposure. For wetland and aquatic species, this area is represented by a 300 m (1000 ft) extension around the Rice UDL (see **Appendix B** of **Strategy Framework** document for more information).

As outlined in **Section 15.3.3.1** and **Section 15.4.1**, the offsite drift distance for terrestrial species depends on the application method (aerial vs. ground) and the endpoint relevant for the taxonomic group (monocot $IC_{25}$ or dicot $IC_{25}$). Specifically in the population-level impacts analysis for propanil, EPA used the following offsite drift distances:

- Listed Monocots and Animals that Obligately Depend on Monocots: EPA used an aerial application drift distance of 120 m and a ground application drift distance of 60 m.
- Listed Dicots, Animals that Obligately Depend on Dicots, Generalist Animals, and Designated Critical Habitats: EPA used 210 m and 60 m for aerial and ground applications, respectively.

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with the Rice UDL at the specified offsite distance (considering the taxonomic group, habitat, and relationship to plants) and if the use-specific magnitude of effect was medium or high (**Section 15.3.3.3**). **Table 15-13** summarizes the number of species and CHs with potential population-level impacts for the Rice UDL. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

In general, as discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. As mentioned above (**Section 15.5**), based on this illustrative example, EPA would not propose use of the four PULAs for propanil at this time because mitigation measures for listed generalist animals cover the entire lower 48 United States and are equivalent to the mitigation measures for listed plants and obligate animals included in the PULAs. However, if additional toxicity data are submitted and EPA is able generate robust SSDs for propanil in the future, EPA could

identify differential mitigations for groups of species (including generalist animals), allowing EPA to use the PULAs in regulatory actions for propanil.

**Table 15-13. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Propanil Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.[1]**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[2] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Rice | 469 / 142 | 12 | 5 |
| **Listed Animal Generalists** | | | |
| Rice | 534 / 316 | 28 | 8 |

CH=designated critical habitat

[1] For propanil, EPA has only considered drift exposure for listed terrestrial species at this time, whereas EPA considered both drift and runoff/erosion exposure for wetland and aquatic species. EPA used different drift distances for monocots and dicots (and animals that depend on these plants) in the analysis of population-level impacts. See the preceding text for a description of the specific offsite distances.

[2] These values are based on EPA's analyses for example purposes for propanil. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

## 15.7 Appendix 1: Conversion of Terrestrial Plant Toxicity Endpoints (in lb a.i./A) to Wetland Relevant Endpoints (in µg a.i./L)

| Step | Conversion Step and Units | Direct Impacts Endpoint: Dicot ($IC_{25}$) | Direct Impacts Endpoint: Monocot ($IC_{25}$) | Comments |
|---|---|---|---|---|
| 1 | lb a.e./A | **0.09** | **0.13** | **USER ENTRY FROM STUDIES[1]** |
| 2 | Conversion factor: lb to µg | 4.54E+08 | 4.54E+08 | |
| 3 | µg/A<br>(Step 1 multiplied by Step 2) | 4.08E+07 | 5.90E+07 | |
| 4 | Conversion factor: A to $m^2$ | 4046.86 | 4046.86 | |
| 5 | µg/$m^2$<br>(Step 3 divided by Step 4) | 1.01E+04 | 1.46E+04 | |
| 6 | µg/$m^3$ assuming depth of 0.15 m<br>(Step 5 divided by 0.15) | 6.73E+04 | 9.71E+04 | |
| 7 | Conversion to µg/L for wetland<br>(Step 6 times 0.001) | 67.3 | 97.1 | Concentration to exceed endpoint if concentration was in a full wetland (WPEZ) |
| 8 | Propanil discharge EECs (µg/L) after required 7-day hold | 2850 – 8390 | 2850 –8390 | From 2019 DRA (DP449993) |
| 9 | Magnitude of Difference Estimate for Wetland Plants<br>(Step 8 divided by Step 7) | 42 – 130 | 29 – 86 | |

DRA=Draft Risk Assessment for Registration Review

[1] The most sensitive terrestrial plant toxicity endpoints are **bolded** in **Table 15-2**.

## 15.8 Appendix 2: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 15-14. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 6.0 lb a.i./A (maximum application rate for use on rice)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 75 | 50 | 20 | 20 | 5 | <5 | 0* |
| **Application Rate of 4.0 lb a.i./A (an example of a reduced rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 20 | 20 | 20 | 10 | <5 | 0* | 0* |
| **Application Rate of 2.0 lb a.i./A (an example of a reduced rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 0* | 0* | 0* | <5 | 0* | 0* | 0* |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 16 µg a.i./L for freshwater diatom, *Navicula pelliculosa* (MRID 41777501). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document

[2] For propanil, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 15.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 15-15. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots, Listed Animals that Obligately Depend on Dicots, and Listed Generalist Animals at an Application Rate of 6.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 33.3 | 33.3 | 33.3 | 70.3 | 68.0 | 67.5 | 67.2 |
| 10 | 22.4 | 20.1 | 18.5 | 17.5 | 6.2 | 3.1 | 1.9 |
| 20 | 16.7 | 13.4 | 11.5 | 8.8 | 3.0 | 1.7 | 1.0 |
| 25 | 14.3 | 10.8 | 9.0 | 6.5 | 2.2 | 1.3 | 0.8 |
| 50 | 11.2 | 7.2 | 4.8 | 3.2 | 1.1 | 0.8 | 0.5 |
| 75 | 7.9 | 4.9 | 3.1 | 2.1 | 0.8 | 0.6 | 0.4 |
| 100 | 6.6 | 3.9 | 2.5 | 1.7 | 0.6 | 0.5 | 0.3 |
| 125 | 5.0 | 2.9 | 1.8 | 1.3 | 0.5 | 0.4 | 0.3 |
| 150 | 4.2 | 2.3 | 1.4 | 1.1 | 0.4 | 0.3 | 0.2 |
| 175 | 3.5 | 1.9 | 1.2 | 0.9 | 0.4 | 0.3 | 0.2 |
| 200 | 3.1 | 1.7 | 1.0 | 0.8 | 0.3 | 0.3 | 0.2 |
| 225 | 2.8 | 1.4 | 0.8 | 0.7 | 0.3 | 0.2 | 0.2 |
| 250 | 2.5 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 |
| 275 | 2.2 | 1.1 | 0.6 | 0.6 | 0.3 | 0.2 | 0.1 |
| 300 | 2.0 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 325 | 1.9 | 0.9 | 0.5 | 0.5 | 0.2 | 0.2 | 0.1 |
| 350 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| 375 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| 400 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 500 | 1.2 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 600 | 1.1 | 0.5 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 |
| 700 | 1.0 | 0.4 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.09 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 15-16. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots and Listed Animals that Obligately Depend on Monocots at an Application Rate of 6.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 23.1 | 23.1 | 23.1 | 48.7 | 47.0 | 46.7 | 46.5 |
| 10 | 15.5 | 13.9 | 12.8 | 12.1 | 4.3 | 2.1 | 1.3 |
| 20 | 11.5 | 9.3 | 7.9 | 6.1 | 2.0 | 1.2 | 0.7 |
| 25 | 9.9 | 7.5 | 6.2 | 4.5 | 1.5 | 0.9 | 0.6 |
| 50 | 7.7 | 5.0 | 3.3 | 2.2 | 0.8 | 0.5 | 0.3 |
| 75 | 5.4 | 3.4 | 2.2 | 1.5 | 0.5 | 0.4 | 0.2 |
| 100 | 4.6 | 2.7 | 1.7 | 1.2 | 0.4 | 0.3 | 0.2 |
| 125 | 3.4 | 2.0 | 1.3 | 0.9 | 0.4 | 0.3 | 0.2 |
| 150 | 2.9 | 1.6 | 1.0 | 0.8 | 0.3 | 0.2 | 0.2 |
| 175 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 |
| 200 | 2.1 | 1.2 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 |
| 225 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 250 | 1.7 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| 275 | 1.5 | 0.8 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 300 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 325 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 350 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 375 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 400 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 500 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.13 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 15-17. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots, Listed Animals that Obligately Depend on Dicots, and Listed Generalist Animals at an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 22.2 | 22.2 | 22.2 | 46.9 | 45.3 | 45.0 | 44.8 |
| 10 | 15.0 | 13.4 | 12.3 | 11.7 | 4.2 | 2.1 | 1.2 |
| 20 | 11.1 | 8.9 | 7.6 | 5.9 | 2.0 | 1.1 | 0.7 |
| 25 | 9.5 | 7.2 | 6.0 | 4.3 | 1.5 | 0.9 | 0.5 |
| 50 | 7.5 | 4.8 | 3.2 | 2.1 | 0.7 | 0.5 | 0.3 |
| 75 | 5.2 | 3.2 | 2.1 | 1.4 | 0.5 | 0.4 | 0.2 |
| 100 | 4.4 | 2.6 | 1.6 | 1.1 | 0.4 | 0.3 | 0.2 |
| 125 | 3.3 | 1.9 | 1.2 | 0.9 | 0.3 | 0.3 | 0.2 |
| 150 | 2.8 | 1.5 | 1.0 | 0.7 | 0.3 | 0.2 | 0.1 |
| 175 | 2.3 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 |
| 200 | 2.1 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 |
| 225 | 1.9 | 0.9 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 250 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 275 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 300 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 325 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 350 | 1.2 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 375 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 400 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 500 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.5 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.09 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 15-18. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots and Listed Animals that Obligately Depend on Monocots at an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 15.4 | 15.4 | 15.4 | 32.5 | 31.4 | 31.2 | 31.0 |
| 10 | 10.4 | 9.3 | 8.5 | 8.1 | 2.9 | 1.4 | 0.9 |
| 20 | 7.7 | 6.2 | 5.3 | 4.1 | 1.4 | 0.8 | 0.5 |
| 25 | 6.6 | 5.0 | 4.1 | 3.0 | 1.0 | 0.6 | 0.4 |
| 50 | 5.2 | 3.3 | 2.2 | 1.5 | 0.5 | 0.4 | 0.2 |
| 75 | 3.6 | 2.2 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 |
| 100 | 3.1 | 1.8 | 1.1 | 0.8 | 0.3 | 0.2 | 0.1 |
| 125 | 2.3 | 1.3 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 |
| 150 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.2 | 0.1 |
| 175 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 200 | 1.4 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 225 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 250 | 1.1 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 275 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 300 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 325 | 0.9 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| 350 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| 375 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 400 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 500 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.13 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 15-19. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots, Listed Animals that Obligately Depend on Dicots, and Listed Generalist Animals at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 11.1 | 11.1 | 11.1 | 23.4 | 22.7 | 22.5 | 22.4 |
| 10 | 7.5 | 6.7 | 6.2 | 5.8 | 2.1 | 1.0 | 0.6 |
| 20 | 5.6 | 4.5 | 3.8 | 2.9 | 1.0 | 0.6 | 0.3 |
| 25 | 4.8 | 3.6 | 3.0 | 2.2 | 0.7 | 0.4 | 0.3 |
| 50 | 3.7 | 2.4 | 1.6 | 1.1 | 0.4 | 0.3 | 0.2 |
| 75 | 2.6 | 1.6 | 1.0 | 0.7 | 0.3 | 0.2 | 0.1 |
| 100 | 2.2 | 1.3 | 0.8 | 0.6 | 0.2 | 0.2 | 0.1 |
| 125 | 1.7 | 1.0 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 |
| 150 | 1.4 | 0.8 | 0.5 | 0.4 | 0.1 | 0.1 | 0.1 |
| 175 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 200 | 1.0 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 225 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 250 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 275 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 375 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.09 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 15-20. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots and Listed Animals that Obligately Depend on Monocots at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 7.7 | 7.7 | 7.7 | 16.2 | 15.7 | 15.6 | 15.5 |
| 10 | 5.2 | 4.6 | 4.3 | 4.0 | 1.4 | 0.7 | 0.4 |
| 20 | 3.8 | 3.1 | 2.6 | 2.0 | 0.7 | 0.4 | 0.2 |
| 25 | 3.3 | 2.5 | 2.1 | 1.5 | 0.5 | 0.3 | 0.2 |
| 50 | 2.6 | 1.7 | 1.1 | 0.7 | 0.3 | 0.2 | 0.1 |
| 75 | 1.8 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 100 | 1.5 | 0.9 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 |
| 125 | 1.1 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 150 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 175 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 200 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 225 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 250 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 275 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 300 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 325 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.13 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 16 Thiobencarb Case Study Example (PC Code 108401)

## 16.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Herbicide Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Herbicide Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 16.2 Use Information

Thiobencarb is a systemic thiocarbamate herbicide used to control grasses and broadleaf weeds during rice production. The mechanism of action is inhibition of cell growth via lipid synthesis inhibition. The maximum single application rate is 4.0 lb a.i./A for both spray and granular applications. The granular formations do not specify whether to use aerial or ground application methods. For rice grown in the Gulf Coast and Mississippi River Valley, thiobencarb is usually applied as a liquid (emulsifiable concentrate formulation) to non-flooded fields. In California, thiobencarb is almost always applied as a granule to water in flooded fields. Thiobencarb is slightly mobile soil and is a systemic herbicide that is readily absorbed by seeds and roots. Following root absorption, the active ingredient is translocated throughout the plant. When applied to leaves, however, the rates of absorption and translocation within plants are reduced. Thiobencarb degrades in aerobic soil with half-lives ranging from 23 to 272 days. However, it is stable in aerobic and anaerobic aquatic systems (half-life = 2,097 and 2,678, respectively).

**Table 16-1** includes the use information from the 2018 Draft Risk Assessment for Registration Review (DRA; DP439283). As this is an illustrative example of how the draft Strategy would be implemented for thiobencarb, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Interim Decision in December 2019) are not considered at this time but would be considered when EPA conducts assessments for thiobencarb for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2019 assessment. **Table 16-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 16.6**. The UDLs are spatial representations of potential pesticide use sites. The UDL for use on rice is the Rice UDL. Information about the UDL assignments can be found in **Section 5.**

EPA used the modeling for estimating environmental exposure based on application to rice fields, the only registered use of thiobencarb, using the Pesticides in Flooded Applications Model (PFAM; v.2.0). EPA extracted the estimated environmental concentrations (EECs) directly from the 2018 DRA for Registration Review (DP439283). EPA focused on estimated environmental concentrations (EECs) for liquid spray formulations of thiobencarb as this application method represents the greatest source of potential offsite movement. Although granular formulations of thiobencarb are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff/erosion exposure from granular applications is unknown but the modeling provided in the 2018 assessment is expected to be representative of broadcast applications of granules given the similarity of the application methods and rates. The document is an illustrative example of the draft Strategy framework; this case study is not intended to be an ESA effects determination for thiobencarb.

**Table 16-1. Summary of the Labeled Use Patterns for Thiobencarb (2018 Draft Risk Assessment for Registration Review, DP439283)[1]**

| Use Site/ Location (Use Data Layer) | App Target | App Type | App Equip | App Time | Max Single Rate (lb ai/A) | Max # App/yr | Max Seasonal Rate (lb ai/A/season) | MRI (d) | Comments (*e.g.* geographic/ application timing restrictions, pollinator specific language) |
|---|---|---|---|---|---|---|---|---|---|
| Rice (Rice UDL) | Flooded Field[2]; Dry-seeded and wet-seeded rice | Broadcast | A, G | Pre-emergence, Post-emergence | 4.0 | NS (1) | 4.0 | NS | CA only: Do not discharge rice field tailwater for 6 to 30 days after application. |

App=application; equip=equipment; MRI = Minimum retreatment interval; UDL=Use Data Layer; A=aerial; G=ground; ai=active ingredient; d=day; NS=not specified on the label

Values in parentheses are the values that EPA assumed in the modeling conducted in the 2018 Draft Risk Assessment for Registration Review (DP439283).

[1] The use information presented in this table is identical to the agricultural uses included in the 2018 Draft Risk Assessment for Registration Review (DP439283).

[2] Granular formulations are only used when applied to flooded rice fields.

## 16.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of thiobencarb (**Section 16.3.1**), reported incidents (**Section 16.3.2**), and the EECs to calculate magnitude of difference values (**Section 16.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 16.3.1 Toxicity Information

**Table 16-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for thiobencarb. The terrestrial and aquatic plant toxicity data sets (monocot and dicot terrestrial plants; vascular and nonvascular aquatic plants) were not robust enough to support generating Species Sensitivity Distributions (SSDs); however, all terrestrial and aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[232] are available to evaluate potential impacts of thiobencarb on listed species. EPA used the most sensitive monocot and dicot seedling emergence $IC_{25}$ endpoints for calculating magnitude of difference values for monocot and dicot terrestrial and wetland plants. For aquatic plants, EPA used the most sensitive $IC_{50}$ for vascular and nonvascular plants for comparing EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for listed plants and animals in larger water bodies[233].

**Table 16-2. Summary of the Most Sensitive Toxicity Endpoints for Thiobencarb (As Summarized in the 2018 Draft Risk Assessment for Registration Review, DP439283)**

| Toxicity Test | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Ryegrass (*Lolium perenne*) | **$IC_{25}$ = 0.019 lb a.i./A**<br>NOAEC = 0.0051 lb a.i./A | 41690902<br>Acceptable | Test with TGAI; based on reduction in shoot length |
| | Dicot: Cabbage (*Brassica oleracea*) | **$IC_{25}$ = 0.082 lb a.i./A**<br>NOAEC = 0.071 lb a.i./A | 41690902<br>Acceptable | Test with TGAI; based on reduction in shoot length |
| Vegetative Vigor | Monocot: Ryegrass (*Lolium perenne*) | $IC_{25}$ = 0.073 lb a.i./A<br>NOAEC = 0.020 lb a.i./A | 41690902<br>Acceptable | Test with TGAI; based on reduction in shoot length |
| | Dicot: Soybean (*Glycine max*) | $IC_{25}$ = 1.2 lb a.i./A<br>NOAEC < 0.12 lb a.i./A | 41690902<br>Acceptable | Test with TGAI; based on reduction in shoot weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | **$IC_{50}$ = 770 µg a.i./L**<br>NOAEC = 140 µg a.i./L | 41690901<br>Acceptable | Most sensitive endpoint based on decreased frond production |

[232] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

[233] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.

| Toxicity Test | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Aquatic Nonvascular Plant | Green algae (*Selenastrum capricornutum*) | **$IC_{50}$ = 17 µg a.i./L**<br>NOAEC = 13 µg a.i./L | 41690901<br>Acceptable | Based on cell density reduction at the LOAEC |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $IC_{25}$/$IC_{50}$=Concentration resulting in a 25 or 50% inhibition in growth; a.i.=active ingredient; TGAI=technical grade active ingredient; LOAEC=Lowest Observed Adverse Effect Concentration

**Bolded** endpoints indicate the most sensitive endpoints EPA used to calculate the magnitude of difference between the EEC and toxicity endpoint for listed plants and animals that depend on plants.

Overall, the magnitude of difference between the endpoint and EEC is calculated considering the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

For listed terrestrial plants and animals that depend on terrestrial plants, only spray drift exposure was modeled (*i.e.,* EPA did not consider exposure via runoff/erosion to be relevant for this case study example). For listed plants and animals that obligately depend on monocots/dicots, EPA compared the spray drift exposure estimates to the most sensitive monocot and dicot endpoints (**Table 16-2** and **Table 16-3**) as explained further in **Section 16.3.3.1**. For listed animals that generally rely on terrestrial plants and for terrestrial designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for monocot growth (**Table 16-2** and **Table 16-3**).

For listed wetland plants and animals that obligately depend on wetland plants, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive seedling emergence monocot and dicot $IC_{25}$ endpoints. An SSD was not possible given the limited number of species with definitive $IC_{25}$ endpoints. Therefore, EPA used the most sensitive toxicity endpoints (**Table 16-2**) were used to calculate the magnitude of difference. To determine the magnitude of difference for wetland plants, EPA first converted the most sensitive terrestrial plant endpoints (Table 6-2) to micrograms of active ingredient per liter (µg a.i./L), allowing for comparison to the PFAM EECs to model wetland erosion zone exposure (see **Section 16.7**; **Table 16-3**). In this conversion, EPA assumed the volume of water was equivalent to a full Plant Assessment Tool wetland.

For listed animals that generally rely on wetland plants and for designated critical habitats in wetlands and small waterbodies[234], EPA calculated the magnitude of difference as the ratio of

[234] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). See **Section 3.1.1** in the **Case Study Summary and Process** document for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.

the EEC to the most sensitive terrestrial plant $IC_{25}$ converted to µg a.i./L, which is the $IC_{25}$ for monocot growth (Table 6-2 and **Table 16-3**).

For animals that rely on aquatic plants (vascular or nonvascular), EPA calculated the magnitude of difference using the most sensitive $IC_{50}$ values for vascular and nonvascular plants (Table 6-2 and **Table 16-3**).

**Table 16-3. Toxicity Endpoints used to Calculate the Magnitude of Difference for Thiobencarb[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | Monocots: 0.019 lb a.i./A<br>Dicots: 0.082 lb a.i./A |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | Monocots: 14.2 µg a.i./L<br>Dicots: 54.5 µg a.i./L |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | Vascular: 770 µg a.i./L<br>Nonvascular: 17 µg a.i./L |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | Monocots: 0.019 lb a.i./A<br>Dicots: 0.082 lb a.i./A |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants | Wetlands, Small Waterbodies[5] | Monocots: 14.2 µg a.i./L<br>Dicots: 54.5 µg a.i./L |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[7] | Terrestrial | 0.019 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[8] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint: 14.2 µg a.i./L |
| | | Based on aquatic plant endpoints:<br>Vascular: 770 µg a.i./L<br>Nonvascular: 17 µg a.i./L |
| Aquatic Animals that Generally Rely on Aquatic Plants[9] | EPA Standard Pond and Larger Waterbodies[10] | Vascular: 770 µg a.i./L<br>Nonvascular: 17 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated. In this case study for thiobencarb, EPA calculated five sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for use of thiobencarb on flooded rice fields.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the PFAM EECs to the terrestrial plant toxicity endpoints (converted to µg a.i./L).
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for use of thiobencarb on flooded rice fields.
[7] Inclusive of species that rely on monocots, dicots, and non-flowering plants. EPA only used these endpoints in spray drift exposure modeling because runoff exposure is not relevant for terrestrial plants for thiobencarb. EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for monocot growth.

[8] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the PFAM EECs to the terrestrial plant toxicity endpoint (converted to µg a.i./L) and to the aquatic plant toxicity endpoints. For the comparison to the terrestrial plant toxicity endpoint, EPA selected the most sensitive terrestrial plant $IC_{25}$, which is the $IC_{25}$ for monocot growth.
[9] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.
[10] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**). For larger waterbodies, EPA compares the PFAM EECs to the aquatic plant toxicity endpoints.

### 16.3.2 Incidents

The incident information from the 2018 Draft Risk Assessment for Registration Review (DP439283) is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[235] (as discussed in **Section 16.3.3.3**), which informs the potential population-level impacts (**Section 16.6**), and to identify the proposed level of mitigation (see **Section 16.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 16.3.3.3**).[236] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA. EPA searched the database on November 16, 2017, in support of the assessment for Registration Review. The database contained seven reported ecological incidents associated with the use of thiobencarb on rice, all of which involved plants. A "highly probable" incident (I004940-003) occurred in an agricultural area of CA on 1/27/97 and that reportedly stunted plant growth. The report did not include neither the affected species nor the magnitude of the incident. The other six incidents (I006793-007, -008, -009, I007467-025, I007467-026 and I007776-008) also occurred in CA. The

[235] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2 of the Strategy Framework document for further details on magnitude of effect**.
[236] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

reports described plant damage and reduced rice yield of an unknown magnitude from direct treatment to the crop. These incidents are classified as “possible” to “probable”.

Because the plant incidents are few, the incidents alone do not provide evidence that the magnitude of effect categories should be shifted for thiobencarb. In other words, the thiobencarb incidents do not indicate an unexpected pathway of off-field exposure nor an unexpected toxicity response compared to the available toxicity data. Therefore, the magnitude of effect categories (**Section 16.3.3.3**) are unaltered by the available thiobencarb incident data.

### 16.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants. However, as discussed above in **Section 16.3.1**, this is not applicable for thiobencarb because EPA did not generate an SSD for thiobencarb.

#### *16.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 16-4** (dicots) and **Table 16-5** (monocots) demonstrate the impact of each of these variables on drift exposure when compared to the terrestrial plant toxicity endpoints to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of thiobencarb (dicot $IC_{25}$ = 0.082 lb a.i./A (**Table 16-4**); monocot $IC_{25}$ = 0.019 lb a.i./A (**Table 16-5**)). To estimate potential diet/habitat effects to generalist animals, EPA selected the most sensitive endpoint applicable for generalists (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots; Table 6-2) while considering the different toxicity endpoints available for thiobencarb. Therefore, EPA based the spray drift distances for generalist animals on the monocot $IC_{25}$ (0.019 lb a.i./A) and grouped generalist animals with listed monocots (**Table 16-5**).

Within **Table 16-4** and **Table 16-5**, the modeled application rates are representative of the maximum single application rate currently registered for thiobencarb (4.0 lb a.i./A) and reduced rates (2.0 and 1.0 lb a.i./A) that could be applied. **Table 16-4** and **Table 16-5** provide the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity

endpoint for dicots (**Table 16-4**) and monocots (**Table 16-5**) and also the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 16.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 16.8**). This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 16-4. Spray Drift Distances to the Population-Level Impacts Endpoint for Listed Dicots and Animals that Obligately Rely on Dicots, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 4.0 lb a.i./A (maximum application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 450 | 225 | 150 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.5** [300] | 0.7 [300] | 0.7 [200] | 0.6 [200] | 0.5 [100] | 0.3 [100] | 0.2 [100] |
| **Application Rate of 2.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 225 | 125 | 100 | 75 | 25 | 20 | 10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.7 [300] | 0.4 [300] | 0.4 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |
| **Application Rate of 1.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 125 | 75 | 50 | 50 | 15 | 10 | <10 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.4 [300] | 0.2 [300] | 0.2 [200] | 0.1 [200] | 0.1 [100] | 0.1 [100] | 0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon the most sensitive $IC_{25}$ value for dicots are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For thiobencarb, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 16.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

[3] If the distance to medium MoE is >25 ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 16.8** contains the full output of results.

**Table 16-5. Spray Drift Distances to the Population-Level Impacts Endpoint for Listed Monocots, Animals that Obligately Rely on Monocots, and Generalist Animals, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 4.0 lb a.i./A (maximum application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | >1000 | 550 | 450 | 225 | 175 | 100 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **6.4** [300] | **3.1** [300] | **3.2** [200] | **2.6** [200] | **2.0** [100] | **1.5** [100] | 0.9 [100] |
| **Application Rate of 2.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | >1000 | 450 | 275 | 250 | 100 | 75 | 50 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **3.2** [300] | **1.5** [300] | **1.6** [200] | **1.3** [200] | **1.0** [100] | 0.7 [100] | 0.5 [100] |
| **Application Rate of 1.0 lb a.i./A (example of a reduced application rate)** | | | | | | | |
| Distance to Medium MoE[2,3] (ft) | 500 | 250 | 175 | 125 | 50 | 25 | 20 |
| Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.6** [300] | 0.8 [300] | 0.8 [200] | 0.6 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect
**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.
Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.
[1] Spray drift distances based upon the most sensitive $IC_{25}$ value for monocots are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For thiobencarb, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 16.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25 ft, the distance represented in this table is rounded to the nearest 25 ft for summarization purposes. **Section 16.8** contains the full output of results.

#### *16.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PFAM compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PFAM see **Section 3.1**.

**Table 16-6** and **Table 16-7** below present the magnitude of difference values for each use considering the habitat (aquatic or wetland) and the toxicity endpoint (aquatic plant $IC_{50}$,

monocot $IC_{25}$, dicot $IC_{25}$). As explained in **Section 3.1.3**, EPA did not calculate runoff/erosion magnitude of difference values for terrestrial plants use on flooded rice because the overland sheet-flow runoff is not expected to occur in fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops[237] ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. In future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

**Table 16-6. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Critical Habitats in Waterbodies Equivalent in Size to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Range of Magnitude of Difference[3] |
| Flooded Rice (without levees/berms) | 360 - 540 | 0.47 – 0.70 | 21 – 32 |

[1] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water, which for this example is assumed to be representative of larger waterbodies (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for thiobencarb, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling with different PFAM scenarios (based on PFAM version 2.0).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[237] https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/rice/ArkansasFurrowIrrigatedRiceHandbook.pdf

**Table 16-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (µg a.i./L)[2] | Wetland Dicots[3] | Wetland Monocots[4] | Aquatic Vascular Plants[5] | Aquatic Nonvascular Plants[5] |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] |
| Flooded Rice (without levees/berms) | 360 - 540 | 6.7 – 9.8 | 26 – 38 | 0.47 – 0.70 | 21 – 32 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, EPA compared the EECs for the wetland (calculated in PFAM; in µg a.i./L) to the terrestrial plant toxicity endpoints (converted to µg a.i./L; see **Section 16.7** and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling with different PFAM scenarios (based on PFAM version 2.0).

[3] The magnitude of difference values in this column are only relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. See footnote 4 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.

[4] The magnitude of difference values in this column are relevant for listed monocots in wetlands and animals that obligately rely on wetland monocots. Additionally, this column is relevant for listed generalist animals and designated critical habitats in wetlands and small waterbodies. Because EPA could not generate a reliable Species Sensitivity Distribution for thiobencarb (as explained in **Section 16.3.1**), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots) in wetlands and small waterbodies. Therefore, the magnitude of difference for generalist animals and for designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive monocot $IC_{25}$.

#### *16.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 16-8.** These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 15.3.3.1** and **16.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 16.4**) and conducting a population-level impact analysis (**Section 16.6**).

For thiobencarb, given the limited plant toxicity data and the lack of SSDs[238], EPA would assign a low magnitude of effect to groups of listed species and CHs[239] when the magnitude of difference is less than 1. For low magnitude of effect, population-level impacts are not expected. EPA assigned a medium magnitude of effect in **Table 16-8** when the magnitude of difference is from 1 up to 10. EPA assigned a high or very high magnitude of effect to groups of species and CHs based on a magnitude of difference of 10 up to 100 or greater than 100, respectively.

**Table 16-8. Use-Based Magnitude of Effect Determinations for Thiobencarb[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|
| | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Plants[6], Obligate & Generalist Animals[7], CHs |
| Flooded Rice | High[5] | High[5] | High | Medium | High |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 16.4**) and to conduct the population-level impacts analysis (**Section 16.6**). If the magnitude of effect is medium or higher for thiobencarb, EPA determined that there is a potential for population-level impacts.

[2] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

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[238] See **Section 3.3.2** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.

[239] Species and CH groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

[4] For animals that generally rely upon terrestrial/wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* $IC_{25}$ for monocots, $IC_{25}$ for dicots, and $IC_{50}$ for aquatic plants (applicable for wetlands and small waterbodies only)). The magnitude of effect in this table reflects the highest magnitude of difference calculated for generalists for each use, which is based on the monocot $IC_{25}$ (see **Table 16-5** and **Table 16-7**); therefore, generalist animals and CHs are grouped with dicots.
[5] Reflects only a spray drift pathway of exposure for terrestrial plants.
[6] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.
[7] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies.

## 16.4 Framework Step 2: Identify Mitigation Measures

**Section 16.4** outlines the mitigation measures identified for thiobencarb for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 16.4.1**), runoff/erosion (**Section 16.4.2**), and flooded field with levees/berms (**Section 16.4.3**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts and/or take of listed species. Overall, for the draft Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 16.4.1 Spray Drift Mitigation Measures Identified

**Table 16-9** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants, listed animals that obligately or generally depend on these plants, and designated critical habitats. Although EPA calculated spray drift buffer distances for listed dicots and animals obligately depending on dicots in **Table 16-4**, the spray drift buffer distances for listed dicots and animals obligately depending on dicots are shorter than the distances for listed monocots, animals depending on monocots, and generalist animals. This is because EPA used the most sensitive monocot $IC_{25}$ to calculate the buffer distances for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the monocot $IC_{25}$, EPA identified farther spray drift buffer distances for generalist animals than for listed dicots. However, listed dicots and animals obligately relying on dicots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the extent of the spray drift buffers, EPA grouped listed dicots and animals that obligately rely on dicots with listed monocots, animals obligately relying on monocots, and generalist animals, and EPA relied upon the results based on the monocot $IC_{25}$ to determine the spray drift buffer distances. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can

elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeeds**.**

**Table 16-9. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants, Listed Animals that Obligately Depend on Plants, and Listed Animals that Generally Rely on Terrestrial/Wetland Plants as Related to Single Maximum Application Rate, Application Method and Droplet Size[1,2]**

| Single Maximum Application Rate (lb ai/A)[3] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium -Coarse | Coarse-Very Coarse | Very Fine-Fine High Boom | Very Fine-Fine Low Boom | Fine-Medium/ Coarse High Boom | Fine-Medium/ Coarse Low Boom |
| 4.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 100[e,g,h] | 100[e,f,g,h] |
| 2.0 | 300[a,b,c] | 300[a,b,c] | 200[a,b] | 200[e,g,h] | 100[e,g,h] | 75[g,h] | 50[g,h] |
| 1.0 | 300[a,b,c] | 250[a,b,c] | 175[a,b,d] | 125[e,g,h] | 50[g,h] | 25[i] | 20[i] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft can be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Fine-Medium/Coarse-Low Boom buffers ≥75 ft could be reduced by 25 ft with coarse or coarser droplets<br>[g] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[h] Hooded Sprayers reduce buffer distance by half<br>[i] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] EPA identified the spray drift buffer distances in this table (based on the most sensitive monocot $IC_{25}$) for all listed plants and all listed animals that rely on plants for diet/habitat. This is due to the lack of an SSD for thiobencarb, resulting in EPA using the monocot toxicity endpoint, which is more sensitive than the available dicot toxicity endpoints. The resulting thiobencarb spray drift distances modeled for dicots are shorter than for generalist animals (due to the toxicity to monocots driving the spray drift distances for generalists; see **Table 16-4** and **Table 16-5).**.
[3] Single maximum label rates reflect the range of uses represented in **Table 16-1.**
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 16.4.2 Runoff/Erosion Mitigation Measures Identified for Row Rice

EPA's identification of the proposed runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts is dependent upon the toxicity endpoint used and the representative species (*e.g.,* listed monocots (lowest monocot $IC_{25}$)). Runoff/erosion mitigation measures in this section are only applicable to flooded rice, which is grown in fields without dikes around the field. These mitigation measures are not applicable to fields with berms or levees around the field. Additionally, these mitigation measures are only applicable to wetland and aquatic habitats. EPA did not calculate runoff/erosion magnitude of difference values for terrestrial plants use on rice because the overland sheet-flow runoff is not expected to occur in fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. In future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

For thiobencarb, see **Section 16.3.3.2** for more details on the magnitude of difference between EECs and toxicity endpoints for each plant and animal group. EPA assigns the mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in Section 5.2 in the Strategy Framework document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of thiobencarb is >1,000 L/kg-o.c. (mean $K_{OC}$ = 1,322 L/kg-o.c.), EPA identified fewer mitigation points for this erosion-prone herbicide (as compared to a different runoff-prone herbicide).

As described in the **Strategy Framework**, for the draft Strategy, EPA would identify mitigations for runoff/erosion for flooded rice[240] whenever the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference is between 1 and 10, low mitigation would apply. If the magnitude of difference is between 10 and 100, medium mitigation would apply, and if it is between 100 and 1,000, high mitigation would apply.

Overall for thiobencarb, EPA identified proposed runoff/erosion mitigation measures for at least one wetland/aquatic taxon.

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[240] Runoff/erosion mitigation practices are only applicable to flooded rice, which is grown in fields without dikes around the field. These runoff/erosion mitigation practices are not applicable to fields with berms or levees around the field.

- For listed aquatic plants and animals that depend on aquatic plants[241] and designated Critical Habitats in waterbodies similar in size to the EPA farm pond or larger[242], the mitigation category is medium[243] to reduce the likelihood of potential population-level impacts from use on rice[244] (**Table 16-10**). For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for aquatic plants and for animals that depend on aquatic plants in larger water bodies.
- For semi-aquatic/wetland dicots and animals that obligately[245] depend on dicots in wetlands or small waterbodies[246], the mitigation category is low for use on rice[244] (**Table 16-11)**.
- For the reasons explained in **Section 3.2**, these mitigation categories are also relevant for all designated Critical Habitats for wetland plants and for animals that depend on wetland plants.
- For semi-aquatic/wetland monocots, animals that obligately[245] depend on monocots, animals that generally[247] rely on plants in wetlands and small waterbodies[246], the mitigation category is medium for use on rice[244] (**Table 16-11**).
- For aquatic plants in wetlands or small waterbodies[246] and for animals that depend on these plants (both obligately and generally), the mitigation category for use on rice[244] is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. Based on the aquatic vascular toxicity endpoint, EPA set the mitigation category as no mitigation for use on rice[244] (**Table 16-11**). Based on the nonvascular aquatic plant toxicity endpoint, EPA identified medium mitigation for use on rice[244] (**Table 16-11**). Therefore, the mitigation category for these listed species is medium.

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[241] None of the listed aquatic animals have obligate relationships to plants.
[242] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[243] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).
[244] This is not applicable for rice grown on fields with berms or levees around the field.
[245] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[246] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**).
[247] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.

**Table 16-10. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Critical Habitats in Waterbodies Equivalent in Size to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[4] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Flooded Rice (without levees/berms) | 360 - 540 | 0.47 – 0.70 | No mitigation | 21 – 32 | Medium |

[1] Modeling for flooded rice relied upon PFAM and EECs represent the concentrations in released flood water and for this example is assumed to be representative of larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for thiobencarb, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.
[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling with different PFAM scenarios (based on PFAM version 2.0).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 16-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (µg a.i./L)[2] | Wetland Dicots[3] | | Wetland Monocots[4] | | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] | Range of Magnitude of Difference[6] | Mitigation Category[7] |
| Flooded Rice (without levees/berms) | 360 - 540 | 6.7 – 9.8 | Low | 26 – 38 | Medium | 0.47 – 0.70 | No mitigation | 21 – 32 | Medium |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, EPA compared the EECs for the wetland (calculated in PFAM; in µg a.i./L) to the terrestrial plant toxicity endpoints (converted to µg a.i./L; see **Section 16.7** and the aquatic plant toxicity endpoints as discussed in **Section 16.3.1**.

[2] The ranges of EECs and the magnitude of difference between the EEC and toxicity endpoints reflect modeling different potential applications (*e.g.,* different application rates) as well as different PFAM scenarios (based on PFAM version 2).

[3] The magnitude of difference values and mitigation categories in these two columns are only relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. See footnote 4 for the magnitude of difference values and mitigation categories applicable for listed generalist animals and designated critical habitats.

[4] The magnitude of difference values and mitigation categories in these columns are relevant for listed monocots in wetlands and animals that obligately rely on wetland monocots. Additionally, this column is relevant for listed generalist animals and designated critical habitats in wetlands and small waterbodies. Because EPA could not generate a reliable Species Sensitivity Distribution for thiobencarb (as explained in **Section 16.3.1**), EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $IC_{25}$ for monocots or $IC_{25}$ for dicots) in wetlands and small waterbodies. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive monocot $IC_{25}$.

[5] Because a Species Sensitivity Distribution is not appropriate for aquatic plants for thiobencarb, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitude of difference values and mitigation categories.

[6] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[7] Mitigations were identified whenever the magnitude of difference is >1.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 16-10** and **Table 16-11**) and wetland plants (**Table 16-11**). For thiobencarb, the mitigation points for these aquatic (including wetland) habitats are equivalent regardless of whether the area is for protection of listed plants, obligate animals, or generalist animals, because of the available toxicity data where the most sensitive monocot $IC_{25}$ is applicable to plants, obligate animals, and generalist animals (as discussed below). Runoff/erosion mitigation points are not identified for terrestrial habitats, because thiobencarb is only registered for use on rice and because the overland sheet-flow runoff is not expected to occur in rice fields with levees around the fields and in situations where water movement off of the field is controlled with a weir or berm. Rice grown in the mid-South is sometimes grown similar to row crops ("furrow irrigated rice" or "row rice"), and traditional runoff/erosion models are appropriate for evaluating this exposure pathway. At this time, EPA has not considered runoff/erosion from row rice, but in future evaluations, EPA plans to utilize the Plant Assessment Tool to evaluate the potential for runoff/erosion exposure for terrestrial and wetland plants for row rice in the mid-South.

**Table 16-12** provides the runoff/erosion mitigation points identified for thiobencarb. Although EPA calculated the magnitude of difference values and determined the runoff/erosion mitigation categories for listed dicots and listed animals that obligately rely on dicots, these values are not presented in **Table 16-12**. The mitigation categories and mitigation points identified for listed dicots and animals obligately depending on dicots are lower than the values for generalist animals. This is because EPA could not generate an SSD for thiobencarb and instead used the most sensitive monocot $IC_{25}$ to calculate the magnitude of difference for listed monocots animals obligately relying on monocots, and generalist animals, and used the most sensitive dicot $IC_{25}$ to calculate the magnitude of difference for listed dicots (and animals obligately relying on dicots). This is based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the monocot $IC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed dicots. However, listed dicots and animals obligately relying on dicots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the runoff/erosion mitigation levels for thiobencarb, EPA grouped listed dicots and animals that obligately rely on dicots with listed monocots, listed animals obligately relying on monocots, and generalist animals.

**Table 16-12. Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic, Wetland, and Terrestrial Habitats.[1,2]**

| Use | Terrestrial Habitats | Aquatic and Wetland Habitats |
|---|---|---|
| | **Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points)** | **Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points)** |
| Flooded Rice (without levees/berms) | No runoff mitigation identified | Medium (5 pts) |

CH=designated critical habitat

[1] See **Section 5.3** of the **Strategy Framework** document for discussion of terrestrial and aquatic (including wetland) habitats for listed species.

[2] The mitigation points identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 16-10** and **Table 16-11**) and listed animals that obligately or generally depend on aquatic and wetland plants (**Table 16-10** and **Table 16-11).** Runoff/erosion mitigation measures in this section are only applicable to flooded rice, which is grown in fields without dikes around the field, and EPA has not identified runoff/erosion mitigation measures for terrestrial habitats at this time.

### 16.4.3 Mitigation Measures Identified for Flooded Fields with Levees or Berms

In future assessments, EPA may also identify runoff/erosion mitigations for flooded rice fields that have levees or berms. EPA did not include mitigation measures for flooded fields in the **Technical Support for Mitigation** document; however, a recent proposal for an herbicide use on flooded rice identified potential mitigations. These mitigation measures could be considered for chemicals with flooded rice uses (including thiobencarb) in future regulatory (not illustrative) decisions using the final Herbicide Strategy. EPA identified the following potential mitigations to address population-level impacts to listed species from use of thiobencarb on flooded rice fields with levees or berms:

- Berm/levee maintenance practices are important elements toward reducing exposure for non-target organisms and the label should direct the grower directly to a berm/levee management program. The reference for best management practices (BMPs) needs to be specific and indicate the pages that are relevant to the BMPs. The label must also include the following:
    - Thiobencarb shall not be applied to rice fields exhibiting visible water seepage that moves offsite into drains that are considered California state waters.
    - Borders surrounding each rice field shall be compacted before water is allowed to fill the field; the degree of compaction shall be sufficient to prevent water from seeping through the border. This requirement applies to new or reworked existing borders for the current rice season.
    - A common border between two existing rice fields does not need to be compacted.
    - Overspray of berms/levees should be minimized to reduce the extent of spray drift exposure and the extent to which granules would be available for ingestion.

- Retaining the water in the rice paddy (*i.e.*, a holding period) for specific intervals provides an opportunity for compounds to dissipate and/or degrade. EPA could specify a thiobencarb-specific holding period in future regulatory decisions.[248]

## 16.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for thiobencarb are discussed in this section.

Based on the submitted toxicity data (see **Section 16.3.1**), thiobencarb may be slightly more toxic to monocots than to dicots. EPA identified more restrictive mitigations for listed monocots, listed animals that obligately rely on monocots, and generalist animals than for other listed species such as listed dicots and listed animals that obligately rely on listed dicots. EPA used the most sensitive monocot $IC_{25}$ (instead of the most sensitive dicot $IC_{25}$) to calculate the magnitude of difference for generalist animals because generalist animals are assumed to rely on both monocots and dicots, depending on what is available in their habitat. By using the most sensitive monocot $IC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed dicots (as explained in **Sections 16.3.3.1**, **16.3.3.2**, **16.4.1**, and **16.4.2**). However, listed dicots and animals obligately relying on dicots occur in areas where listed generalist animals occur. Therefore, for identifying the extent of mitigation measures, EPA determined that differential mitigations for monocots and dicots are not appropriate for thiobencarb. In other words, to cover the wide geographic range of listed generalist animals across the United States, and also to provide sufficient protection to listed monocot species, EPA would only generate one set of spray drift mitigation measures (**Table 16-9**) and one set of runoff/erosion mitigation measures (**Table 16-12**). The spray drift mitigation measures would apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic). The runoff/erosion mitigation measures would only apply to wetland and aquatic habitats in areas where the rice fields do not have levees/berms. EPA would propose to put all of the mitigations on the general label without using use Bulletins because the mitigations do not differ for different geographic areas (*i.e.,* mitigations are equivalent across the lower 48 United States).

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[248] In future regulatory actions, the EPA could recommend a specific holding period (*e.g.,* 30 days) before release of the paddy water into downstream conveyances. Additionally, EPA could recommend that flood waters be released at a specified rate (*e.g.,* not more than 2 inches of water over a drain box weir for seven additional days after the 30-day holding period).

## 16.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in the **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 16.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with the Rice Use Data Layer (UDL), which represents the only registered use of thiobencarb. EPA's overlap analysis was based on the offsite transport area where spray drift of thiobencarb may lead to exposures for listed terrestrial species and where runoff/erosion of thiobencarb may lead to exposures for listed wetland and aquatic species. This offsite transport area is represented by extending the on-field portion of the Rice UDL to include areas of potential offsite exposure. For wetland and aquatic species, this area is represented by a 300 m (1000 ft) extension around the Rice UDL (see **Appendix B** of **Strategy Framework** document for more information).

As outlined in **Section 16.3.3.1** and **Section 16.4.1**, the offsite drift distance for terrestrial species depends on the application method (aerial vs. ground) and the endpoint relevant for the taxonomic group (monocot $IC_{25}$ or dicot $IC_{25}$). Specifically in the population-level impacts analysis for thiobencarb, EPA used the following offsite drift distances:

- Listed Monocots, Animals that Obligately Depend on Monocots, Generalist Animals, and Designated Critical Habitats: EPA used an aerial application drift distance of 300 m and a ground application drift distance of 150 m.
- Listed Dicots and Animals that Obligately Depend on Dicots: EPA used 150 m and 60 m for aerial and ground applications, respectively.

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with the Rice UDL at the specified offsite distance (considering the taxonomic group, habitat, and relationship to plants) and if the use-specific magnitude of effect was medium or high (**Section 16.3.3.3**). **Table 16-13** summarizes the number of species and CHs with potential population-level impacts for the Rice UDL. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

In general, as discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. As mentioned above (**Section 16.5**), based on this illustrative example, EPA would not propose use of the four PULAs for thiobencarb at this time because mitigation measures for listed generalist animals cover the entire lower 48 United States and are equivalent to the mitigation measures for listed plants and obligate animals included in the PULAs. However, if additional toxicity data are submitted and EPA is able generate robust SSDs for thiobencarb in the future, EPA could

identify differential mitigations for groups of species (including generalist animals), allowing EPA to use the PULAs in regulatory actions for thiobencarb.

**Table 16-13. The Number of Listed Species and Designated Critical Habitats Identified where there are Potential for Population-Level Impacts in CONUS for Thiobencarb Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigations.[1]**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[2] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Rice | 469 / 142 | 12 | 8 |
| **Listed Animal Generalists** | | | |
| Rice | 534 / 316 | 28 | 8 |

CH=designated critical habitat

[1] For thiobencarb, EPA has only considered drift exposure for listed terrestrial species at this time, whereas EPA considered both drift and runoff/erosion exposure for wetland and aquatic species. EPA used different drift distances for monocots and dicots (and animals that depend on these plants) in the analysis of population-level impacts. See the preceding text for a description of the specific offsite distances.

[2] These values are based on EPA's analyses for example purposes for thiobencarb. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

## 16.7 Appendix 1: Conversion of Terrestrial Plant Toxicity Endpoints (in lb a.i./A) to Wetland Relevant Endpoints (in µg a.i./L)

| Step | Conversion Step and Units | Direct Impacts Endpoint: Dicot ($IC_{25}$) | Direct Impacts Endpoint: Monocot ($IC_{25}$) | Comments |
|---|---|---|---|---|
| 1 | lb a.e./A | **0.082** | **0.019** | **USER ENTRY FROM STUDIES[1]** |
| 2 | Conversion factor: lb to µg | 4.54E+08 | 4.54E+08 | |
| 3 | µg/A<br>(Step 1 multiplied by Step 2) | 3.72E+07 | 8.62E+06 | |
| 4 | Conversion factor: A to $m^2$ | 4046.86 | 4046.86 | |
| 5 | µg/$m^2$<br>(Step 3 divided by Step 4) | 9.19E+03 | 2.13E+03 | |
| 6 | µg/$m^3$ assuming depth of 0.15 m<br>(Step 5 divided by 0.15) | 6.13E+04 | 1.42E+04 | |
| **7** | Conversion to µg/L for wetland<br>(Step 6 times 0.001) | 54.5 | 14.2 | Concentration to exceed endpoint if concentration was in a full wetland (WPEZ) |
| **8** | Thiobencarb discharge EECs (µg/L) after 14-day hold as modeled in the 2018 DRA (DP439283) | 364 – 536 | 364 – 536 | From 2018 DRA (DP439283) |
| **11** | Magnitude of Difference Estimate for Wetland Plants<br>(Step 8 divided by Step 7) | 6.7 – 9.8 | 26 – 38 | |

DRA=Draft Risk Assessment for Registration Review

[1] The most sensitive terrestrial plant toxicity endpoints are **bolded** in **Table 16-2**

## 16.8 Appendix 2: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 16-14. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 4.0 lb a.i./A (maximum application rate for use on rice)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | 0* | 0* | 0* | 0* | 0* | 0* | 0* |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=magnitude of effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 17 µg a.i./L for green algae, *Selenastrum capricornutum* (MRID 41690901). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For thiobencarb, the magnitude of effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 16.3.3.3.** The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 16-15. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals that Obligately Depend on Dicots at an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 24.4 | 24.4 | 24.4 | 51.5 | 49.7 | 49.4 | 49.2 |
| 10 | 16.4 | 14.7 | 13.5 | 12.8 | 4.6 | 2.3 | 1.4 |
| 20 | 12.2 | 9.8 | 8.4 | 6.5 | 2.2 | 1.2 | 0.7 |
| 25 | 10.4 | 7.9 | 6.6 | 4.8 | 1.6 | 1.0 | 0.6 |
| 50 | 8.2 | 5.3 | 3.5 | 2.3 | 0.8 | 0.6 | 0.3 |
| 75 | 5.7 | 3.6 | 2.3 | 1.5 | 0.6 | 0.4 | 0.3 |
| 100 | 4.9 | 2.8 | 1.8 | 1.2 | 0.5 | 0.3 | 0.2 |
| 125 | 3.6 | 2.1 | 1.3 | 1.0 | 0.4 | 0.3 | 0.2 |
| 150 | 3.0 | 1.7 | 1.0 | 0.8 | 0.3 | 0.2 | 0.2 |
| 175 | 2.5 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 |
| 200 | 2.3 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.1 |
| 225 | 2.0 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 250 | 1.8 | 0.9 | 0.5 | 0.5 | 0.2 | 0.2 | 0.1 |
| 275 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 300 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 325 | 1.4 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 350 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 375 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 400 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 500 | 0.9 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.082 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 16-16. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 4.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 105.3 | 105.2 | 105.2 | 222.1 | 214.6 | 213.2 | 212.2 |
| 10 | 70.8 | 63.6 | 58.4 | 55.3 | 19.7 | 9.8 | 5.9 |
| 20 | 52.6 | 42.2 | 36.2 | 27.9 | 9.3 | 5.3 | 3.2 |
| 25 | 45.0 | 34.2 | 28.4 | 20.5 | 6.9 | 4.2 | 2.5 |
| 50 | 35.3 | 22.8 | 15.0 | 10.0 | 3.5 | 2.4 | 1.5 |
| 75 | 24.8 | 15.4 | 9.9 | 6.6 | 2.5 | 1.8 | 1.1 |
| 100 | 20.9 | 12.2 | 7.8 | 5.3 | 2.0 | 1.5 | 0.9 |
| 125 | 15.6 | 9.0 | 5.8 | 4.2 | 1.6 | 1.2 | 0.8 |
| 150 | 13.1 | 7.2 | 4.5 | 3.4 | 1.4 | 1.1 | 0.7 |
| 175 | 10.9 | 6.0 | 3.7 | 2.9 | 1.2 | 0.9 | 0.6 |
| 200 | 9.7 | 5.3 | 3.2 | 2.6 | 1.1 | 0.9 | 0.6 |
| 225 | 8.8 | 4.5 | 2.7 | 2.2 | 1.0 | 0.8 | 0.5 |
| 250 | 7.7 | 3.9 | 2.3 | 2.0 | 0.9 | 0.7 | 0.5 |
| 275 | 7.0 | 3.4 | 2.0 | 1.8 | 0.8 | 0.6 | 0.4 |
| 300 | 6.4 | 3.1 | 1.8 | 1.6 | 0.7 | 0.6 | 0.4 |
| 325 | 5.9 | 2.8 | 1.7 | 1.4 | 0.7 | 0.5 | 0.4 |
| 350 | 5.5 | 2.6 | 1.6 | 1.3 | 0.6 | 0.5 | 0.4 |
| 375 | 5.1 | 2.4 | 1.5 | 1.2 | 0.6 | 0.5 | 0.3 |
| 400 | 4.8 | 2.2 | 1.4 | 1.1 | 0.6 | 0.4 | 0.3 |
| 500 | 3.9 | 1.8 | 1.1 | 0.6 | 0.2 | 0.2 | 0.1 |
| 600 | 3.4 | 1.6 | 0.9 | 0.4 | 0.2 | 0.2 | 0.1 |
| 700 | 3.1 | 1.4 | 0.8 | 0.3 | 0.2 | 0.1 | 0.1 |
| 800 | 2.8 | 1.3 | 0.8 | 0.3 | 0.1 | 0.1 | 0.1 |
| 900 | 2.6 | 1.2 | 0.7 | 0.2 | 0.1 | 0.1 | 0.1 |
| 1000 | 2.5 | 1.1 | 0.7 | 0.2 | 0.1 | 0.1 | 0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.019 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 16-17. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals that Obligately Depend on Dicots at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 12.2 | 12.2 | 12.2 | 25.7 | 24.9 | 24.7 | 24.6 |
| 10 | 8.2 | 7.4 | 6.8 | 6.4 | 2.3 | 1.1 | 0.7 |
| 20 | 6.1 | 4.9 | 4.2 | 3.2 | 1.1 | 0.6 | 0.4 |
| 25 | 5.2 | 4.0 | 3.3 | 2.4 | 0.8 | 0.5 | 0.3 |
| 50 | 4.1 | 2.6 | 1.7 | 1.2 | 0.4 | 0.3 | 0.2 |
| 75 | 2.9 | 1.8 | 1.1 | 0.8 | 0.3 | 0.2 | 0.1 |
| 100 | 2.4 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 |
| 125 | 1.8 | 1.0 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 150 | 1.5 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 175 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 200 | 1.1 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 225 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 250 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.082 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 16-18. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 52.6 | 52.6 | 52.6 | 111.1 | 107.3 | 106.6 | 106.1 |
| 10 | 35.4 | 31.8 | 29.2 | 27.6 | 9.8 | 4.9 | 2.9 |
| 20 | 26.3 | 21.1 | 18.1 | 13.9 | 4.7 | 2.6 | 1.6 |
| 25 | 22.5 | 17.1 | 14.2 | 10.3 | 3.5 | 2.1 | 1.3 |
| 50 | 17.7 | 11.4 | 7.5 | 5.0 | 1.8 | 1.2 | 0.7 |
| 75 | 12.4 | 7.7 | 5.0 | 3.3 | 1.2 | 0.9 | 0.6 |
| 100 | 10.5 | 6.1 | 3.9 | 2.7 | 1.0 | 0.7 | 0.5 |
| 125 | 7.8 | 4.5 | 2.9 | 2.1 | 0.8 | 0.6 | 0.4 |
| 150 | 6.6 | 3.6 | 2.3 | 1.7 | 0.7 | 0.5 | 0.3 |
| 175 | 5.5 | 3.0 | 1.8 | 1.4 | 0.6 | 0.5 | 0.3 |
| 200 | 4.9 | 2.6 | 1.6 | 1.3 | 0.5 | 0.4 | 0.3 |
| 225 | 4.4 | 2.2 | 1.3 | 1.1 | 0.5 | 0.4 | 0.3 |
| 250 | 3.9 | 1.9 | 1.2 | 1.0 | 0.4 | 0.3 | 0.2 |
| 275 | 3.5 | 1.7 | 1.0 | 0.9 | 0.4 | 0.3 | 0.2 |
| 300 | 3.2 | 1.5 | 0.9 | 0.8 | 0.4 | 0.3 | 0.2 |
| 325 | 2.9 | 1.4 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 |
| 350 | 2.7 | 1.3 | 0.8 | 0.7 | 0.3 | 0.3 | 0.2 |
| 375 | 2.6 | 1.2 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 |
| 400 | 2.4 | 1.1 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 |
| 500 | 2.0 | 0.9 | 0.6 | 0.3 | 0.1 | 0.1 | 0.1 |
| 600 | 1.7 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 |
| 700 | 1.5 | 0.7 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 800 | 1.4 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 | <0.1 |
| 900 | 1.3 | 0.6 | 0.4 | 0.1 | 0.1 | <0.1 | <0.1 |
| 1000 | 1.2 | 0.6 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.019 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 16-19. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals that Obligately Depend on Dicots at an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 6.1 | 6.1 | 6.1 | 12.9 | 12.4 | 12.4 | 12.3 |
| 10 | 4.1 | 3.7 | 3.4 | 3.2 | 1.1 | 0.6 | 0.3 |
| 20 | 3.0 | 2.4 | 2.1 | 1.6 | 0.5 | 0.3 | 0.2 |
| 25 | 2.6 | 2.0 | 1.6 | 1.2 | 0.4 | 0.2 | 0.1 |
| 50 | 2.0 | 1.3 | 0.9 | 0.6 | 0.2 | 0.1 | 0.1 |
| 75 | 1.4 | 0.9 | 0.6 | 0.4 | 0.1 | 0.1 | 0.1 |
| 100 | 1.2 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 125 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 150 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 175 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 200 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 225 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 250 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 275 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.082 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 16-20. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 26.3 | 26.3 | 26.3 | 55.5 | 53.6 | 53.3 | 53.0 |
| 10 | 17.7 | 15.9 | 14.6 | 13.8 | 4.9 | 2.4 | 1.5 |
| 20 | 13.2 | 10.6 | 9.0 | 7.0 | 2.3 | 1.3 | 0.8 |
| 25 | 11.3 | 8.6 | 7.1 | 5.1 | 1.7 | 1.0 | 0.6 |
| 50 | 8.8 | 5.7 | 3.8 | 2.5 | 0.9 | 0.6 | 0.4 |
| 75 | 6.2 | 3.8 | 2.5 | 1.7 | 0.6 | 0.4 | 0.3 |
| 100 | 5.2 | 3.1 | 1.9 | 1.3 | 0.5 | 0.4 | 0.2 |
| 125 | 3.9 | 2.3 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 |
| 150 | 3.3 | 1.8 | 1.1 | 0.9 | 0.3 | 0.3 | 0.2 |
| 175 | 2.7 | 1.5 | 0.9 | 0.7 | 0.3 | 0.2 | 0.2 |
| 200 | 2.4 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 |
| 225 | 2.2 | 1.1 | 0.7 | 0.6 | 0.2 | 0.2 | 0.1 |
| 250 | 1.9 | 1.0 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 275 | 1.8 | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| 300 | 1.6 | 0.8 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 325 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 350 | 1.4 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 375 | 1.3 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 400 | 1.2 | 0.6 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 500 | 1.0 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 |
| 600 | 0.9 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.019 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

# 17 Trifluralin Case Study Example (PC Code 036101)

## 17.1 Introduction

This case study is based on a currently registered pesticide active ingredient and includes a description of how EPA used modeling and plant toxicity data to demonstrate the development of the draft Strategy (Strategy) process. However, some of the pesticide-specific information, including labeled use information, may have been simplified here to concisely demonstrate the methods and the framework as part of the draft Strategy. This case study is not intended to support a regulatory action for the chemical. The current analyses in this case study do not consider mitigations implemented after the finalization of the most recent ecological risk assessment. Mitigations identified in this case study are not intended for regulatory purposes and do not replace existing mitigations implemented on the labels.

There are two supporting documents that this case study relies upon—both of which have been posted to the docket along with this case study. First is the **Strategy Framework** document ("Draft Herbicide Strategy Framework to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides"), which describes the overarching processes and considerations for the draft Strategy. Second is the **Technical Support for Mitigation** document ("Draft Technical Support for Runoff, Erosion, and Spray Drift Mitigation Practices to Protect Non-Target Plants and Wildlife"), which provides the evaluation of spray drift and runoff/erosion mitigation measures and their efficacy. **Sections 1-5** above describe the methods that were considered in the generation of the information provided in this case study. The case study, as presented below, is not a complete process description, and does not provide details on the methods applied. For more information on these details please review the three supporting documents discussed above.

## 17.2 Use Information

Trifluralin is a pre-emergent synthetic fluorinated dinitroaniline herbicide that enters plants through developing roots preventing the alignment and separation of chromosomes during mitosis (*i.e.,* trifluralin is a mitosis disruptor). Trifluralin binds to the major microtubule protein tubulin leading to microtubule loss and the absence of the spindle apparatus preventing alignment and separation of chromosomes during mitosis. Dinitroaniline-induced microtubule loss typically results in the swelling of root tips as cells in this region fail to divide or elongate.

Trifluralin is used to control annual grasses[249] and broadleaf weeds in the early stages of plant development on a variety of food crops and non-food use sites. This herbicide is formulated as

[249] Trifluralin's mode of action is notable because it targets annual grasses, which are monocotyledonous flowering plants (or monocots). Based on the submitted toxicity data (discussed in **Section 17.3.1**, trifluralin may be more toxic to monocots than dicots.

an emulsifiable concentrate, soluble liquid, and granular products. Trifluralin is applied dormant, semi-dormant, pre-plant, pre-transplant, post-plant, pre-emergence, post-emergence, lay-by, or postharvest. Trifluralin can be applied by aerial spray, ground spray, chemigation or by granular spreaders. Some labels require soil incorporation, while others do not. Per the 2018 Draft Risk Assessment (DP438977) for Registration Review, many labels require the incorporation of soil applied and granule products at 2 inches depth within 24 hours of application.

**Table 17-1** includes the use information from the 2018 Draft Risk Assessment (DRA; DP438977) for Registration Review. EPA only included the agricultural uses which were evaluated in this DRA in the draft Strategy. As this is an illustrative example of how the draft Strategy would be implemented for trifluralin, changes to the registered labels and uses since this DRA (*e.g.,* changes outlined in the Interim Decision in November 2019) are not considered at this time but would be considered when EPA conducts assessments for trifluralin for regulatory decisions using the final Herbicide Strategy. Therefore, the current analyses in this case study do not consider mitigations put in place after the finalization of the 2018 assessment. **Table 17-1** also identifies the Use Data Layer (UDL) that EPA assigned to each use for the purposes of conducting GIS analyses such as those discussed in **Section 17.5**. The UDLs are spatial representations of potential pesticide use sites; for example, the UDL for use on field corn is the Corn UDL and the UDL for use on sorghum is the Other Grains UDL. Information about the UDL assignments can be found in **Section 5**.

EPA estimated exposures using the selected[250] uses and application information provided in **Table 17-1**. The selected uses do not represent all registered uses of trifluralin and instead include large acreage use sites (*e.g.,* corn) and the agricultural use sites where trifluralin usage is most common. These selected uses are examples to illustrate the draft Strategy framework; however, this case study is not intended to be an ESA effects determination that would assess all use patterns. For the draft Strategy, EPA focused on calculating estimated environmental concentrations (EECs) for liquid spray formulations of trifluralin as this application method represents the greatest source of potential offsite movement. Although granular formulations of trifluralin are registered, spray drift exposure (and thereby drift mitigation measures) would be negligible; the extent of runoff/erosion exposure from granular applications is unknown but the modeling provided here is expected to be representative of broadcast applications of granules given the similarity of the application methods and rates. EPA used the Pesticide in Water Calculator (PWC, v.2.001) and the Plant Assessment Tool (PAT, v.2.8) to generate the estimates.

[250] The uses evaluated as part of the proposed Herbicide Strategy are consistent with the agricultural uses that were evaluated in the 2018 Draft Risk Assessment (DP438977) for Registration Review of trifluralin. Any uses not evaluated in the 2018 assessment and any new uses since this assessment are not included in this example case study for the proposed Herbicide Strategy.

**Table 17-1. Summary of the Selected Agricultural Use Patterns Labeled for Trifluralin (2018 Draft Risk Assessment for Registration Review, DP438977)[1]**

| Use Site | Maximum Single App. Rate (lb a.i./A) | Maximum # App. per year | Maximum App. Rate per Year (lb a.i./acre/yr) | Minimum Retreatment Interval (days) |
|---|---|---|---|---|
| **Other Grains Use Data Layer** | | | | |
| Canola/Rape; Barley; Sorghum | 1.0 | Not Specified | | |
| Safflower | 1.25 | | | |
| Sugarcane[2] | 2.0 | Not Specified | | |
| **Other Crops Use Data Layer** | | | | |
| Castor Bean, Flax, Flax Seed, Mustard Seed | 1.0 | Not Specified | | |
| Kenaf | 0.75 | Not specified | | |
| **Other Row Crops Use Data Layer** | | | | |
| Sunflower; Sunflower Seed | 1.0 | Not Specified | | |
| Hops | 0.9 | Not Specified | | |
| Peanuts; Sugar Beet | 0.75 | Not Specified | | |
| **Vegetables and Ground Fruit Use Data Layer** | | | | |
| Dried Beans/Peas; Beans (Lima, Snap, Bush, Pole, String, Mung); Cowpea/Blackeye Pea; Peas (Field, Southern, Dried-Type, Succulent, Unspecified); Carrot (including tops); Celery; Broccoli; Brussel Sprouts; Cabbage; Cauliflower; Collards; Crambe; Cantaloupe; Cucumber; Pumpkin; Squash; Watermelon; Eggplant; Pepper; Pepper (Chili Type); Tomato; Guar; Kale; Marigold; Mustard; Okra; Potatoes; Turnip (Greens); Vegetables (Unspecified) | 1.0 | Not Specified | | |
| Asparagus | 2.0 | Not Specified | | |
| Broccoli Raab; Chinese Cabbage; Kohlrabi; Mint/Peppermint/Spearmint; Radish | 0.75 | Not Specified | | |
| Chicory; Endive (Escarole) | 1.25 | Not Specified | | |
| Onions | 0.63 | Not Specified | | |
| **Alfalfa Use Data Layer** | | | | |
| Alfalfa | 2.0 | 2 | 4.0 | 60 |
| **Citrus Use Data Layer** | | | | |
| Grapefruit, Oranges | 2.0 | Not Specified | | |
| **Corn Use Data Layer** | | | | |
| Corn (Field) | 1.0 | Not Specified | | |
| **Cotton Use Data Layer** | | | | |
| Cotton | 2.0 | Not Specified | | |
| **Wheat Use Data Layer** | | | | |
| Wheat | 1.0 | Not Specified | | |
| **Other Orchards Use Data Layer** | | | | |
| Almonds, Apricot, Nectarine, Peaches, Pecans, Walnuts | 2.0 | Not Specified | | |
| **Soybeans Use Data Layer** | | | | |
| Soybeans | 2.0 | Not Specified | | |

| Use Site | Maximum Single App. Rate (lb a.i./A) | Maximum # App. per year | Maximum App. Rate per Year (lb a.i./acre/yr) | Minimum Retreatment Interval (days) |
|---|---|---|---|---|
| **Grapes Use Data Layer** | | | | |
| Grapes/Wine Grapes | 2.0 | Not Specified | | |

App=application; a.i.=active ingredient;
[1] The use information presented in this table is identical to the agricultural uses included in the 2018 Draft Risk Assessment for Registration Review (DP438977).
[2] Sugarcane has a maximum single application rate of 4.0 lb a.i./A for use in Hawaii; however, because the draft Herbicide Strategy is focused on the conterminous United States, this rate is not represented in this table.

## 17.3 Framework Step 1: Identify Potential Population-Level Impacts

This section identifies the potential population-level impacts based on the toxicity of trifluralin (**Section 17.3.1**), reported incidents (**Section 17.3.2**), and the EECs to calculate magnitude of difference values (**Section 17.3.3**). The toxicity profile, reported incidents, and magnitude of difference values are the basis for determining the lines of evidence as to whether population-level impacts are indicated on a use-specific basis.

### 17.3.1 Toxicity Information

**Table 17-2** summarizes the most sensitive toxicity endpoints from submitted terrestrial and aquatic plant toxicity studies for trifluralin.

**Table 17-2. Summary of the Most Sensitive Toxicity Endpoints for Trifluralin (As Summarized in the 2018 Draft Risk Assessment for Registration Review, DP438977)**

| Toxicity Test[1] | Test Species | Endpoint | MRID / Classification | Comments |
|---|---|---|---|---|
| Seedling Emergence | Monocot: Ryegrass (*Lolium perenne*) | **$EC_{25}$ = 0.0399 lb a.i./A**<br>$IC_{05}$ = 0.0137 lb a.i./A | 49177202 Supplemental (qualitative use)[a] | Based on effects to survival[b,c] |
| | Dicot: Cucumber (*Cucumis sativus*) | **$IC_{25}$ = 0.19 lb a.i./A**<br>NOAEC = 0.13 lb a.i./A | 43984401 Acceptable | Based on effects on shoot fresh weight |
| Vegetative Vigor | Monocot: Oat (*Avena sativa*) | $IC_{25}$ = 0.841 lb a.i./A<br>NOAEC = 0.50 lb a.i./A | 49616103 Acceptable | Based on effects to height |
| | Dicot: Cucumber (*Cucumis sativus*) | $IC_{25}$ = 0.796 lb a.i./A<br>NOAEC = 0.25 lb a.i./A | 41934503 Acceptable | Based on effects to fresh weight |
| Aquatic Vascular Plant | Duckweed (*Lemna gibba*) | **$IC_{50}$ = 49.7 µg a.i./L**<br>NOAEC < 2.53 µg a.i./L | 42834104 Supplemental | Based on effects to growth inhibition |
| Aquatic Nonvascular Plant | Marine Diatom (*Skeletonema costatum*) | **$IC_{50}$ = 21.9 µg a.i./L**<br>NOAEC = 14.0 µg a.i./L | 42834101 Acceptable | Based on effects to cell count |

MRID= Master Record Identifiers (a tracking number assigned to information submitted to the EPA Office of Pesticide Programs); NOAEC=No Observed Adverse Effect Concentration; $EC_{25}$=Concentration resulting in a 25% effect in survival; $IC_{05/25/50}$=Concentration resulting in a 5, 25, or 50% inhibition in growth; a.i.=active ingredient. **Bolded** endpoints indicate the most sensitive endpoints, which EPA used to calculate the magnitude of difference between the EEC and toxicity endpoints.
[a] Although the Data Evaluation Record for MRID 49177202 indicates that the study was classified as supplemental for qualitative use, the 2018 DRA (DP438977) used the most sensitive monocot endpoint quantitatively to estimate risk to non-listed monocots. EPA did not re-evaluate these data as part of this case study for the draft Herbicide Strategy and instead assumed that the data are suitable for quantitative use.
[b] Terrestrial plant toxicity studies are designed to capture sub-lethal effects; therefore survival is not expected to be the most sensitive endpoint. There is a strong effect of emergence and survivorship on oat, ryegrass, and wheat in this study. The lack of emergence and low survival of these species may have confounded growth effects.
[c] Oat, ryegrass and wheat survival endpoints were only slightly lower than their respective emergence endpoints, and significant inhibitions in emergence in these species measured up to 64, 80 and 100% at the higher treatment levels.

As explained below, EPA calculated a Species Sensitivity Distributions (SSD) for the seedling emergence plant weight endpoints with monocot and dicot weight data combined. Because there were few definitive toxicity endpoints[251] available for the height data from the seedling emergence and for both growth endpoints from the vegetative vigor studies, robust SSDs for these data could not be generated. Typically, EPA would use the most sensitive 5$^{th}$ and 25$^{th}$ percentile $IC_{25}$ values from the SSD (**Table 17-3**; **Figure 17-1**) to calculate the magnitude of difference between the EEC and toxicity endpoints for terrestrial plants.

**Table 17-3. Summary of Species Sensitivity Distribution (SSD) Results for Monocots and Dicots for Trifluralin[1]**

| Percentile (x) | Seedling Emergence Test |
|---|---|
| | **Weight: x Percentile $IC_{25}$ from SSD (C.I.), lb a.i./A** |
| 5 | 0.066 (0.013 – 0.29) |
| 25 | 0.30 (0.12 – 0.69) |
| 50 | 0.66 (0.33 – 1.2) |

[1] No toxicity endpoints in this table are bolded because these SSD endpoints were not used to calculate the magnitude of difference ratios for trifluralin. See the preceding text for a full explanation.

[251] Definitive endpoints are endpoints where a concentration causing 25% inhibition is estimated. Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 2 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

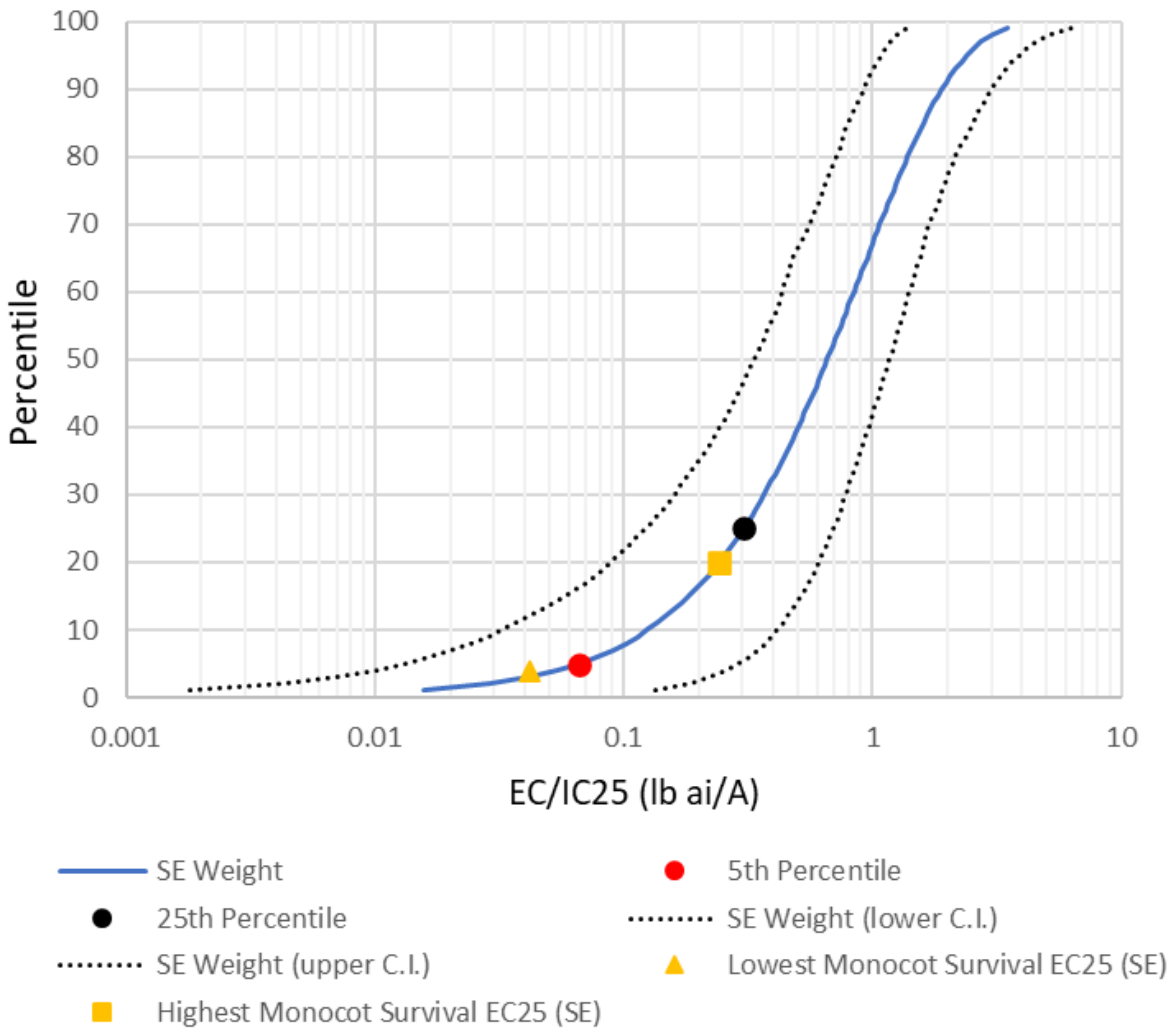


**Figure 17-1. Seedling Emergence (SE) Study Species Sensitivity Distribution representing the Distribution of the Plant Weight $IC_{25}$ Values for Trifluralin. The Upper and Lower Confidence Intervals (C.I.) are plotted for the SE Plant Weight SSD. Also shown is where the most and least sensitive monocot SE survival $EC_{25}$ values are located on the SSD.**

Overall, the magnitude of difference between the endpoint and EEC is calculated considering the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship[252]).

Although EPA generated the SSD for the plant weight data, EPA determined that use of the SSD values generated from combining monocot and dicot data was not appropriate for trifluralin because survival was the most sensitive endpoint for monocots in one of the seedling emergence studies (MRID 49177202; **Table 17-2**). The available, definitive $EC_{25}$ values for monocot survival in this seedling emergence study range from 0.04 to 0.25 lb a.i./A, whereas the monocot weight $IC_{25}$ values range from 0.064 to 0.74 lb a.i./A with only half of the weight $IC_{25}$ values below the highest survival $EC_{25}$. This indicates that monocot survival is affected at lower concentrations than growth for many test species. At the 5$^{th}$ percentile of the SSD based on the weight data (0.066 lb a.i./A), there was more than a 25% effect on survival for two of the tested monocot species and nearly a 25% effect for a third monocot species in this seedling emergence study. Therefore, for trifluralin, EPA calculated the magnitude of difference values (see **Section 17.3.3**) separately= for monocots and dicots. Because the data are too few to generate separate monocot and dicot SSDs, EPA used the most sensitive toxicity endpoints presented in **Table 17-2** to calculate the magnitude of difference ratios this case study example (**Table 17-4**).

For listed wetland and terrestrial plants and animals that obligately depend on wetland/terrestrial plants, EPA calculated the magnitude of difference as a ratio of the EEC to the $EC/IC_{25}$ for seedling emergence survival (monocots) or plant weight (dicots) (**Table 17-4**). For animals that generally rely on wetland/terrestrial plants and for critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive $EC/IC_{25}$, which is the $EC_{25}$ for monocot survival.

There were insufficient data to generate reliable SSDs for the aquatic plant toxicity data (vascular and nonvascular plants); however, all aquatic plant toxicity studies required in the Code of Federal Regulations at 40 CFR Part 158[253] are available to evaluate potential impacts of trifluralin on listed species. EPA used the most sensitive $IC_{50}$ for aquatic vascular plants and the most sensitive $IC_{50}$ value for aquatic nonvascular plants (**Table 17-2** and **Table 17-4**) to compare EECs to toxicity endpoints to determine the magnitude of difference, which is applicable for

[252] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend. Generalist animals are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat. Obligate and generalist animals can only be distinguished when endpoints from an SSD are used. This is not applicable for trifluralin.
[253] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-E/part-158

listed plants and animals in larger water bodies[254], as well as listed animals in wetlands and smaller water bodies[255] that generally rely on aquatic plants.

**Table 17-4. Toxicity Endpoints used to Calculate the Magnitude of Difference for Trifluralin[1]**

| Taxon | Habitat | Endpoint Used for Magnitude of Difference Calculation[2] |
|---|---|---|
| **Direct Impacts to Plants** | | |
| Listed Terrestrial Plants[3] | Terrestrial Plant Exposure Zone | 0.0399 lb a.i./A (Monocots)<br>0.19 lb a.i./A (Dicots) |
| Listed Wetland Plants[4] | Wetland Plant Exposure Zone | 0.0399 lb a.i./A (Monocots)<br>0.19 lb a.i./A (Dicots) |
| Listed Aquatic Plants | Wetland Plant Exposure Zone, Small Waterbodies[5] | 0.0399 lb a.i./A (Monocots)<br>0.19 lb a.i./A (Dicots) |
| **Prey/Habitat Impacts to Animals** | | |
| Terrestrial Animals that Obligately Rely on Terrestrial Plants[6] | Terrestrial | 0.0399 lb a.i./A (Monocots)<br>0.19 lb a.i./A (Dicots) |
| Wetland Animals that Obligately Rely on Wetland or Aquatic Plants[6] | Wetlands, Small Waterbodies[5] | 0.0399 lb a.i./A (Monocots)<br>0.19 lb a.i./A (Dicots) |
| Terrestrial Animals that Generally Rely on Terrestrial Plants[6] | Terrestrial | 0.0399 lb a.i./A |
| Wetland Animals that Generally Rely on Wetland or Aquatic Plants[7] | Wetlands, Small Waterbodies | Based on terrestrial plant endpoint:<br>0.0399 lb a.i./A |
| | | Based on aquatic plant endpoints:<br>49.7 µg a.i./L (Vascular)<br>21.9 µg a.i./L (Nonvascular) |
| Aquatic Animals that Generally Rely on Aquatic Plants[8] | EPA Farm Pond and Larger Waterbodies[6] | Vascular: 49.7 µg a.i./L<br>Nonvascular: 21.9 µg a.i./L |

[1] See **Section 5.1** of the **Strategy Framework** document (specifically **Table 5-1**) for details on all possible magnitude of difference values that can be calculated. In this case study for trifluralin, EPA calculated six sets of magnitude of difference values (instead of all 10 possible sets of values) because the same toxicity endpoint is used to represent multiple taxa.
[2] The magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[3] Inclusive of listed monocots, dicots, and non-flowering plants.
[4] Inclusive of listed monocots, dicots, non-flowering plants, and lichens.
[5] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints as discussed in **Section 3.2**.
[6] Inclusive of species that rely on monocots, dicots, and non-flowering plants.
[7] For animals in wetlands or small waterbodies that generally rely on wetland/aquatic plants, EPA compares the EECs for the wetland (in lb a.i./A) to the terrestrial plant toxicity endpoints and the EECs for the wetland (in µg a.i./L) to the aquatic plant toxicity endpoints (as discussed in **Section 3.2**).
[8] All currently listed aquatic animals have a generalist relationship to plants so a separate analysis and different toxicity endpoint has not been identified for obligate aquatic animals.

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[254] Larger waterbodies are those that are the EPA farm pond or greater in size (*i.e.,* bins 3, 4, 6, 7, 9, 10). See **Section 3.1**.
[255] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. See **Section 3.1**.

[9] Larger waterbodies are those that are the EPA farm pond or greater (*i.e.,* bins 3, 4, 6, 7, 9, 10) (as discussed in **Section 3.1**).

### 17.3.2 Incidents

The incident information from the 2018 Draft Risk Assessment for Registration Review (DP438977) for trifluralin is included below. EPA uses incident information as part of the Weight of Evidence to determine the magnitude of effect[256] (as discussed in **Section 17.3.3.3**), which informs the potential population-level impacts (**Section 17.6**), and to identify the proposed level of mitigation (see **Section 17.4**). Incident data are one line of evidence that may indicate that the magnitude of effect categories should be shifted to lower magnitude of difference levels to indicate that there is potential for population-level impacts and therefore a higher level of mitigation may be applicable for an herbicide (see discussion **Section 17.3.3.3**).[257] Generally, incident data are most informative when they identify unexpected results for a given use condition, such as a toxicity response from a taxon thought to be insensitive to the specific herbicide based on the available toxicity data. Incident data are particularly informative for chemicals where the medium magnitude of effect category corresponds to magnitude of difference values from 10 up to 100 based on the available toxicity data. In these cases, incident data may inform the need to lower the medium magnitude of effect category to correspond to magnitude of difference values between 1 and 10, thereby increasing the proposed level of mitigation.

The Incident Data System (IDS) provides information on the available ecological pesticide incidents, including those that have been aggregately reported to the EPA. EPA searched the IDS on April 4, 2018, in support of the assessment for Registration Review. There were 94 incidents involving trifluralin in the IDS database, 86 of which involved effects to terrestrial plants. Of the 94 incidents reported, one was categorized as 'highly probable' and 58 were categorized as 'probable'. Regarding the legal status, 'registered use' represents the largest legality category with 73% of the incidents reported. Approximately 10% of the reports consist of 'misuse' or 'misuse accidental' and 15% were undetermined uses.

Additionally, incidents have been reported to the Agency in an aggregated format. Pesticide registrants report certain types of incidents to the Agency as aggregate counts of incidents occurring per product per quarter. Ecological incidents reported in aggregate reports include

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[256] The magnitude of effect is determined based on the magnitude of difference (ratio of exposure estimate to toxicity endpoint) along with lines of evidence including consideration of the empirical toxicity data (*e.g.,* effects on survival), the nature of the SSDs (*e.g.,* slope of the curve), and incidents. See **Section 5.2** of the **Strategy Framework** document for further details on magnitude of effect.

[257] The lack of reported incidents is not used to reduce the proposed magnitude of effect category nor the proposed amount of mitigation identified for a use as indicated by the standard approaches (*i.e.,* based on the magnitude of difference) because of inherent uncertainty in the incident data and assumption that incidents are likely underreported.

those categorized as 'minor plant' incidents. There were 179 minor aggregate incident reports for plants.

For trifluralin, the plant damage incidents include damage to a wide variety of terrestrial plants (*e.g.,* alfalfa, barley, bean, birch, blue spruce, corn, cotton, dry bean, ornamentals, peanut, pinto bean, potato, raspberry, rose, soybean, soybean seed, spreading yew, sudan grass, sugarcane, sunflower, tomato and wheat (spring and other varieties)), particularly from exposure to direct treatment or spray drift. Of the incidents involving terrestrial plants, all are classified as 'highly probable' or 'probable' in the context of trifluralin use. Other reported incident included impacts such as stunted growth, discoloration, reduced yield, incapacitation, and mortality, and incident exposures included spills, runoff, and carryover.

The high number of incidents of direct impacts to plants off the treated field is one line of evidence that the magnitude of effect categories should be shifted to a lower magnitude of difference threshold for trifluralin (**Section 17.3.3.3**). In other words, the trifluralin incidents indicate that plant effects resulting from off-field exposure occur, and EPA considered this potential off-field exposure within this case study.

### 17.3.3 Characterization of the Spray Drift and Runoff/Erosion Magnitude of Difference Values

This section discusses the magnitude of difference calculated for spray drift and runoff/erosion exposure. The magnitude of difference is the ratio of the EEC to the relevant toxicity endpoint, where the relevant toxicity endpoint varies depending on whether EPA is estimating the magnitude of difference for listed plants and listed animals that obligately rely on plants for diet/habitat or for listed animals that generally rely on plants. When data are sufficient for generating an SSD for an herbicide, EPA estimates the magnitude of difference for listed plants and obligate animals using a lower, more sensitive endpoint than the endpoint used for estimating the magnitude of difference for animals with a generalist relationship to plants. However, as discussed above in **Section 17.3.1**, this is not applicable for trifluralin because EPA did not use the SSD results given the impact on monocot survival.

#### *17.3.3.1 Spray Drift Distance Estimation*

The magnitude of difference for spray drift from liquid spray formulations varies based on application rate, application method, droplet size distribution, distance to the habitat, and the plant toxicity endpoint. **Table 17-5** demonstrates the impact of each of these variables on drift exposure when compared with the terrestrial plant toxicity endpoints to estimate the magnitude of difference for listed terrestrial and wetland plants and diet/habitat impacts to listed obligate animals from use of trifluralin (0.0399 lb a.i./A for monocots; 0.19 lb a.i./A for dicots). To estimate potential diet/habitat effects to generalist animals, EPA selected the most sensitive endpoint applicable for generalists (*i.e.,* $EC_{25}$ for monocots or $IC_{25}$ for dicots) while considering the differential toxicity of trifluralin to monocots and dicots. Therefore, in **Table**

**17-5**, EPA based the spray drift distances for generalist animals on the monocot $EC_{25}$ (0.0399 lb a.i./A).

Within **Table 17-5**, the modeled application rates are representative of the maximum single application rate currently registered for trifluralin (2.0 lb a.i./A) and reduced rates (1.0 and 0.75 a.i./A) representative of maximum single application rates for other uses (**Table 17-1**). **Table 17-5** gives the distance at which the spray drift deposition equals the most sensitive terrestrial plant toxicity endpoint for monocots and dicots and also the magnitude of difference at the maximum spray drift buffer distance. The maximum spray drift buffer distances vary by application method and droplet size, as explained in the **Technical Support for Mitigation** document. EPA uses these spray drift distances and magnitude of difference values at the maximum buffer distance to identify spray drift mitigations (discussed in **Section 17.4.1**).

Spray drift exposure to aquatic habitats results in shorter off-field distances than the spray drift distances estimated for terrestrial/wetland plants (**Section 0**). This difference is due primarily to the inherent dilution of the spray drift exposure in the receiving waterbody, resulting in lower magnitude of difference estimates for aquatic plants (as compared to terrestrial/wetland plants). Because the spray drift distances are shorter for aquatic habitats, estimates for exposures in terrestrial and wetland habitats are considered protective of aquatic habitats.

**Table 17-5. Spray Drift Distances to the Population-Level Impacts Endpoints for Listed Terrestrial and Wetland Plants and Listed Animals that Depend on Plants, and the Magnitude of Difference at the Maximum Spray Buffer Distance[1]**

| Application Rate (lb a.i./A) | | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|---|
| | | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals** | | | | | | | | |
| 2.0 | Distance to Medium MoE[2,3] (ft) | 450 | 250 | 175 | 125 | 50 | 25 | 20 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | **1.5** [300] | 0.7 [300] | 0.8 [200] | 0.6 [200] | 0.5 [100] | 0.4 [100] | 0.2 [100] |
| 1.0 | Distance to Medium MoE[2,3] (ft) | 250 | 150 | 100 | 75 | 25 | 20 | 10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.8 [300] | 0.4 [300] | 0.4 [200] | 0.3 [200] | 0.2 [100] | 0.2 [100] | 0.1 [100] |
| 0.75 | Distance to Medium MoE[2,3] (ft) | 175 | 125 | 75 | 50 | 20 | 10 | 10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.6 [300] | 0.3 [300] | 0.3 [200] | 0.2 [200] | 0.2 [100] | 0.1 [100] | 0.1 [100] |
| **Listed Dicots and Listed Animals that Obligately Depend on Dicots** | | | | | | | | |
| 2.0 | Distance to Medium MoE[2,3] (ft) | 100 | 75 | 50 | 25 | 10 | 10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.3 [300] | 0.2 [300] | 0.2 [200] | 0.1 [200] | 0.1 [100] | 0.1 [100] | <0.1 [100] |
| 1.0 | Distance to Medium MoE[2,3] (ft) | 50 | 25 | 20 | 20 | 10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.2 [300] | 0.1 [300] | 0.1 [200] | 0.1 [200] | 0.1 [100] | <0.1 [100] | <0.1 [100] |
| 0.75 | Distance to Medium MoE[2,3] (ft) | 20 | 20 | 20 | 10 | <10 | <10 | <10 |
| | Magnitude of Difference at Maximum Buffer Distance [Maximum Buffer Distance (ft)] | 0.1 [300] | 0.1 [300] | 0.1 [200] | <0.1 [200] | <0.1 [100] | <0.1 [100] | <0.1 [100] |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse; MoE=magnitude of effect

**Bolded** values indicate that the ratio of the EEC to the endpoint exceeds 1.0 at the maximum spray drift buffer distance, indicating that additional mitigation should be considered.

Highlighted cells indicate that the distance to reach a low MoE (where population-level impacts are not expected) is farther than the maximum buffer distance.

[1] Spray drift distances based upon the seedling emergence endpoints for monocots (0.0399 lb a.i./A) and dicots (0.19 lb a.i./A) are considered protective and equivalent to the distances identified to protect sensitive wetland and aquatic areas. Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] For trifluralin, the Magnitude of Effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 17.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1. When the MoE is medium or greater and the magnitude of difference at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.
[3] If the distance to medium MoE is >25 ft, the distances represented in this table are rounded to the nearest 25 ft for summarization purposes. **Section 0** contains the full output of results.

#### *17.3.3.2 Runoff/Erosion Magnitude of Difference*

For runoff/erosion exposure, EPA calculates the magnitude of difference using the EECs generated by PWC and PAT compared to the appropriate toxicity endpoint. For more information on modeling runoff/erosion in PWC and PAT see **Section 3.1**.

**Table 17-6** through **Table 17-8** below present the magnitude of difference values for each use considering the habitat (aquatic, wetland, terrestrial) and the toxicity endpoint (aquatic plant $IC_{50}$, monocot $EC_{25}$, dicot $IC_{25}$).

**Table 17-6. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | Aquatic Nonvascular Plants |
|---|---|---|---|
| | | Range of magnitude of difference[3] | Range of magnitude of difference[3] |
| Alfalfa | 6.0 - 13 | 0.12 - 0.26 | 0.28 - 0.58 |
| Almond | 6.1 - 12 | 0.12 - 0.25 | 0.28 - 0.56 |
| Asparagus | 5.9 - 12 | 0.12 - 0.24 | 0.27 - 0.55 |
| Carrot | 2.9 - 5.9 | 0.06 - 0.12 | 0.13 - 0.27 |
| Citrus | 5.9 - 12 | 0.12 - 0.25 | 0.27 - 0.56 |
| Cole Crops | 2.9 - 6.1 | 0.06 - 0.12 | 0.13 - 0.28 |
| Corn | 3.0 - 6.7 | 0.06 - 0.14 | 0.14 - 0.31 |
| Cotton | 5.9 - 12 | 0.12 - 0.24 | 0.27 - 0.55 |
| Grape | 6.0 - 12 | 0.12 - 0.25 | 0.28 - 0.56 |
| Legumes | 3.0 - 6.1 | 0.06 - 0.12 | 0.14 - 0.28 |
| Melon | 3.0 - 6.1 | 0.06 - 0.12 | 0.14 - 0.28 |
| Oilseed Crops | 3.0 - 6.1 | 0.06 - 0.12 | 0.14 - 0.28 |
| Peaches | 6.0 - 12 | 0.12 - 0.24 | 0.28 - 0.55 |
| Peanuts | 2.2 - 4.5 | 0.05 - 0.09 | 0.10 - 0.21 |
| Pecans | 7.6 - 12 | 0.15 - 0.24 | 0.35 - 0.55 |
| Potato | 3.0 - 6.1 | 0.06 - 0.12 | 0.14 - 0.28 |
| Sorghum | 3.2 - 6.1 | 0.06 - 0.12 | 0.15 - 0.28 |
| Soybean | 6.0 - 12 | 0.12 - 0.24 | 0.28 - 0.55 |
| Sugarcane | 7.7 - 13 | 0.15 - 0.26 | 0.35 - 0.60 |
| Vegetables (unspecified) | 2.9 - 6.1 | 0.06 - 0.12 | 0.13 - 0.28 |
| Wheat | 3.0 - 6.1 | 0.06 - 0.12 | 0.14 - 0.28 |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for trifluralin, alternative endpoints (*i.e.,* 25th percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 17-7. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Monocots[3] | Wetland Dicots[4] | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[5] | Aquatic Nonvascular Plants[5] |
|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] | | Range of Magnitude of Difference[6] | Range of Magnitude of Difference[6] |
| Alfalfa | 0.09 - 0.20 | 2.7 - 5.9 | 0.47 - 1.1 | 27 - 60 | 0.55 - 1.2 | 1.2 - 2.7 |
| Almond | 0.10 - 0.21 | 2.9 - 6.2 | 0.53 - 1.1 | 29 - 59 | 0.59 - 1.2 | 1.3 - 2.7 |
| Asparagus | 0.09 - 0.19 | 2.7 - 5.6 | 0.47 – 1.0 | 28 - 56 | 0.56 - 1.1 | 1.3 - 2.5 |
| Carrot | 0.04 - 0.09 | 1.2 - 2.7 | 0.21 - 0.47 | 12 - 24 | 0.24 - 0.49 | 0.55 - 1.1 |
| Citrus | 0.10 - 0.20 | 2.9 - 5.9 | 0.53 - 1.1 | 27 - 62 | 0.54 - 1.3 | 1.2 - 2.8 |
| Cole Crops | 0.04 - 0.10 | 1.2 - 2.9 | 0.21 - 0.53 | 13 - 30 | 0.25 - 0.60 | 0.58 - 1.4 |
| Corn | 0.04 - 0.25 | 1.2 - 7.4 | 0.21 - 1.3 | 12 - 30 | 0.25 - 0.6 | 0.56 - 1.4 |
| Cotton | 0.08 - 0.55 | 2.4 - 16 | 0.42 - 2.9 | 26 - 55 | 0.52 - 1.1 | 1.2 - 2.5 |
| Grape | 0.09 - 0.32 | 2.7 - 9.4 | 0.47 - 1.7 | 29 - 62 | 0.58 - 1.2 | 1.3 - 2.8 |
| Legumes | 0.04 - 0.10 | 1.2 - 2.9 | 0.21 - 0.53 | 0.25 - 30 | 0.01 - 0.60 | 0.01 - 1.4 |
| Melon | 0.04 - 0.10 | 1.2 - 2.9 | 0.21 - 0.53 | 0.89 - 29 | 0.02 - 0.59 | 0.04 - 1.3 |
| Oilseed Crops | 0.05 - 0.10 | 1.5 - 2.9 | 0.26 - 0.53 | 15 - 31 | 0.31 - 0.61 | 0.69 - 1.4 |
| Peaches | 0.09 - 0.18 | 2.7 - 5.3 | 0.47 - 0.95 | 29 - 57 | 0.57 - 1.2 | 1.3 - 2.6 |
| Peanuts | 0.04 - 0.07 | 1.2 - 2.1 | 0.21 - 0.37 | 10 - 21 | 0.21 - 0.42 | 0.47 - 0.95 |
| Pecans | 0.25 - 0.26 | 7.4 - 7.7 | 1.3 - 1.4 | 28 - 57 | 0.56 - 1.1 | 1.3 - 2.6 |
| Potato | 0.04 - 0.14 | 1.2 - 4.1 | 0.21 - 0.74 | 14 - 30 | 0.28 - 0.60 | 0.63 - 1.4 |
| Sorghum | 0.12 - 0.22 | 3.5 - 6.5 | 0.63 - 1.2 | 13 - 27 | 0.26 - 0.55 | 0.60 - 1.2 |
| Soybean | 0.09 - 0.19 | 2.7 - 5.6 | 0.47 – 1.0 | 28 - 60 | 0.57 - 1.2 | 1.3 - 2.7 |
| Sugarcane | 0.24 - 0.34 | 7.1 - 10 | 1.3 - 1.8 | 27 - 58 | 0.54 - 1.2 | 1.2 - 2.7 |
| Vegetables (unspecified) | 0.04 - 0.09 | 1.2 - 2.7 | 0.21 - 0.47 | 12 - 30 | 0.25 - 0.60 | 0.56 - 1.4 |
| Wheat | 0.05 - 0.09 | 1.5 - 2.7 | 0.26 - 0.47 | 15 - 30 | 0.30 - 0.61 | 0.68 - 1.4 |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] EPA did not use the results from the Species Sensitivity Distribution for trifluralin (as explained in **Section 17.3.1**). For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats in wetlands and small waterbodies, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $EC_{25}$ for monocots or $IC_{25}$ for dicots) while considering the differential toxicity of trifluralin to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive monocot $EC_{25}$.

[4] The magnitude of difference values in this column are only relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. See footnote 3 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.

[5] Because a Species Sensitivity Distribution is not appropriate for aquatic plants for trifluralin, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed aquatic plants, animals obligately depending on

aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitude of difference values.
[6] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

**Table 17-8. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) for Runoff/Erosion Exposure for Terrestrial Plants, Animals that Rely on Terrestrial Plants, and Designated Critical Habitats in Terrestrial Environments[1]**

| Use | Range of EECs (lb a.i./A)[2] | Terrestrial Monocots[3] | Terrestrial Dicots[4] |
|---|---|---|---|
| | | Range of Magnitude of Difference[5] | Range of Magnitude of Difference[5] |
| Alfalfa | 0.24 - 1.5 | 7.1 - 45 | 1.3 – 8.0 |
| Almond | 0.18 - 0.72 | 5.3 - 21 | 0.95 - 3.8 |
| Asparagus | 0.20 - 0.71 | 5.9 - 21 | 1.1 - 3.7 |
| Carrot | 0.09 - 0.32 | 2.7 - 9.4 | 0.47 - 1.7 |
| Citrus | 0.13 - 0.97 | 3.8 - 29 | 0.68 - 5.1 |
| Cole Crops | 0.06 - 0.35 | 1.8 - 10 | 0.32 - 1.8 |
| Corn | 0.06 - 0.87 | 1.8 - 26 | 0.32 - 4.6 |
| Cotton | 0.23 - 2.1 | 6.8 - 62 | 1.2 – 11 |
| Grape | 0.14 - 1.9 | 4.1 - 56 | 0.74 – 9.9 |
| Legumes | 0.05 - 0.38 | 1.5 - 11 | 0.26 - 2.0 |
| Melon | 0.06 - 0.42 | 1.8 - 12 | 0.32 - 2.2 |
| Oilseed Crops | 0.06 - 0.35 | 1.8 - 10 | 0.32 - 1.8 |
| Peaches | 0.25 - 0.74 | 7.4 - 22 | 1.3 - 3.9 |
| Peanuts | 0.08 - 0.27 | 2.4 – 8.0 | 0.42 - 1.4 |
| Pecans | 0.81 - 1.2 | 24 - 35 | 4.3 - 6.3 |
| Potato | 0.06 - 0.71 | 1.8 - 21 | 0.32 - 3.7 |
| Sorghum | 0.45 - 0.77 | 13 - 23 | 2.4 - 4.1 |
| Soybean | 0.13 - 0.72 | 3.8 - 21 | 0.68 - 3.8 |
| Sugarcane | 1.1 - 2.1 | 31 - 63 | 5.5 - 11 |
| Vegetables (unspecified) | 0.08 - 0.39 | 2.4 - 12 | 0.42 - 2.1 |
| Wheat | 0.06 - 0.34 | 1.8 - 10 | 0.32 - 1.8 |

[1] Because a Species Sensitivity Distribution is not appropriate for terrestrial nor aquatic plants for trifluralin, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{25}$ or $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed terrestrial plants, animals obligately depending on terrestrial plants, and animals generally relying on terrestrial plants all have equivalent magnitude of difference values.
[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[3] EPA did not use the results from the Species Sensitivity Distribution for trifluralin (as explained in **Section 17.3.1**). For animals that generally rely upon terrestrial plants for diet or habitat and for terrestrial designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $EC_{25}$ for monocots or $IC_{25}$ for dicots) while considering the differential toxicity of trifluralin to monocots and dicots. Therefore, the magnitude of difference for generalist animals and terrestrial designated critical habitats is the ratio of the EEC to the most sensitive monocot $EC_{25}$.
[4] The magnitude of difference values in this column are only relevant for listed terrestrial dicots and animals that obligately rely on terrestrial dicots. See footnote 3 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.
[5] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

#### *17.3.3.3 Magnitude of Effect*

EPA determined the magnitude of effect for each taxonomic group as outlined in **Table 17-9.** These magnitude of effect conclusions are based on the ranges of magnitudes of difference between EECs and toxicity endpoints that are presented **Sections 17.3.3.1** and **17.3.3.2**, as well as the weight of evidence (*e.g.,* incidents, the toxicity profile). The magnitude of effect categories are discussed in **Section 5.2** of the **Strategy Framework** document, and **Table 5-2** in that document links the magnitude of difference, magnitude of effect, potential population-level impacts, and the mitigation categories. The magnitude of effect categories are influential for identifying mitigation measures (**Section 17.4**) and conducting a population-level impact analysis (**Section 17.6**).

For trifluralin, given the toxicity profile[258] with effects on monocot survival and the relatively high number of plant incidents (see **Section 17.3.2**), EPA assigned a low magnitude of effect in **Table 17-9** on a use basis to groups of listed species and critical habitats (CHs)[259] when the magnitude of difference is less than 1. For low magnitude of effect (when the magnitude of difference is <1), population-level impacts are not expected. EPA assigned a medium or high magnitude of effect in **Table 17-9** when the magnitude of difference is from 1 to 10 or 10 up to 100, respectively.

**Table 17-9. Use-Based Magnitude of Effect for Trifluralin.[1]**

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|
| | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Plants[5], Obligate & Generalist Animals[6], CHs |
| Alfalfa | High | Medium | Medium | Medium | Low |
| Almond | High | Medium | Medium | Medium | Low |
| Asparagus | High | Medium | Medium | Low | Low |
| Carrot | Medium | Medium | Medium | Low | Low |
| Citrus | High | Medium | Medium | Medium | Low |
| Cole Crops | High | Medium | Medium | Low | Low |
| Corn | High | Medium | Medium | Low | Low |
| Cotton | High | Medium | High | Medium | Low |
| Grape | High | Medium | Medium | Medium | Low |

[258] See **Section 3.3.3** for an explanation of the lines of evidence that EPA uses to determine the magnitude of effect category when ratios of EECs to the toxicity endpoint are between 1 and 10.
[259] Species and critical habitat groups are differentiated by the taxon (plant or animal), plant group (monocot, dicot, non-flowering plant, or lichen), habitat (terrestrial, semi-aquatic/wetland, aquatic), and for animals, the nature of the relationships to plants (*i.e.,* obligate vs. generalist relationship).

| Use | Terrestrial | | Wetland and Small Waterbodies[2] | | Aquatic (Larger Waterbodies[3]) |
|---|---|---|---|---|---|
| | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Monocots, Animals Obligately Depending on Monocots, Generalist Animals[4], and CHs[4] | Dicots, Animals Obligately Depending on Dicots | Plants[5], Obligate & Generalist Animals[6], CHs |
| Legumes | High | Medium | Medium | Low | Low |
| Melon | High | Medium | Medium | Low | Low |
| Oilseed Crops | High | Medium | Medium | Low | Low |
| Peaches | High | Medium | Medium | Low | Low |
| Peanuts | Medium | Medium | Medium | Low | Low |
| Pecans | High | Medium | Medium | Medium | Low |
| Potato | High | Medium | Medium | Low | Low |
| Sorghum | High | Medium | Medium | Medium | Low |
| Soybean | High | Medium | Medium | Low | Low |
| Sugarcane | High | High | Medium | Medium | Low |
| Vegetables (unspecified) | High | Medium | Medium | Low | Low |
| Wheat | Medium | Medium | Medium | Low | Low |

CH=designated critical habitat

[1] EPA used these magnitude of effect categories to identify mitigation categories (**Section 17.4**) and to conduct the population-level impacts analysis (**Section 17.6**). If the magnitude of effect is medium or higher for trifluralin, EPA determined that there is a potential for population-level impacts.

[2] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.

[3] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, and 10).

[4] For animals that generally rely upon terrestrial/wetland plants for diet or habitat and for designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists (*i.e.,* $EC_{25}$ for monocots, $IC_{25}$ for dicots, and $IC_{50}$ for aquatic plants (applicable for wetlands and small waterbodies only)). The magnitude of effect in this table reflects the highest magnitude of difference calculated for generalists for each use, which is based on the monocot $EC_{25}$ (see **Table 17-6**, **Table 17-7**, and **Table 17-8**); therefore, generalist animals and CHs are grouped with monocots.

[5] All listed aquatic plants are found in wetlands or smaller waterbodies; therefore, these species are covered in the previous columns.

[6] Currently, there are no listed aquatic animals that are obligates to aquatic plants in larger waterbodies.

## 17.4 Framework Step 2: Identify Mitigation Measures

**Section 17.4** outlines the mitigation measures identified for trifluralin for example purposes (*i.e.,* not for a regulatory action). EPA identified proposed spray drift (**Section 17.4.1**) and runoff/erosion (**Section 17.4.2**) mitigation measures that are expected to reduce exposure to levels below the toxicity threshold that, if exceeded, could result in population-level impacts

and/or take of listed species. Overall, for the draft Herbicide Strategy, EPA identified proposed mitigation measures when the magnitude of difference exceeds 1.

Although mitigations may apply for a use, a pesticide applicator may be exempt from mitigations if certain conditions (such as the treated field being >1000 ft from the habitat) are met as outlined in **Section 6.2** of the **Strategy Framework** document.

### 17.4.1 Spray Drift Mitigation Measures Identified

**Table 17-10** presents the spray drift buffers identified to address potential population-level impacts to listed terrestrial and wetland plants, listed animals that obligately depend on these plants, and listed animals that generally rely on plants. Although EPA calculated spray drift buffer distances for listed dicots and animals obligately depending on dicots in **Table 17-5**, the spray drift buffer distances for listed dicots and animals obligately depending on dicots are shorter than the distances for listed monocots, animals depending on monocots, and generalist animals. This is because EPA used the most sensitive monocot $IC_{25}$ to calculate the buffer distances for generalist animals based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the monocot $IC_{25}$, EPA identified farther spray drift buffer distances for generalist animals than for listed dicots. However, listed dicots and animals obligately relying on dicots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the extent of the spray drift buffers, EPA grouped listed dicots and animals that obligately rely on dicots with listed monocots, animals obligately relying on monocots, and generalist animals, and EPA relied upon the results based on the monocot $IC_{25}$ to determine the spray drift buffer distances. As explained in Section 6.1 of the Strategy Framework document, the pesticide applicator can elect to reduce the spray drift buffer if they employ mitigation measures such as hooded sprayers, windbreaks, or reduced windspeeds**.**

**Table 17-10. Spray Drift Mitigation Measures Identified for Listed Terrestrial and Wetland Plants, Listed Animals that Obligately Depend on Plants, and Listed Animals that Generally Rely on Terrestrial/Wetland Plants as Related to Single Maximum Application Rate, Application Method and Droplet Size.[1,2]**

| Single Maximum Application Rate (lb ai/A)[3] | Identified Downwind Spray Drift Buffer Distances (ft) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | Fine-Medium | Medium-Coarse | Coarse-Very Coarse | Very Fine-Fine, High Boom | Very Fine-Fine, Low Boom | Fine-Medium/ Coarse, High Boom | Fine-Medium/ Coarse, Low Boom |
| 2.0 | 300[a,b,c] | 250[a,b,c] | 175[a,b,d] | 125[e,f,g] | 50[f,g] | 25[h] | 20[h] |
| 1.0 | 250[a,b,c] | 150[b,d] | 100[b,d] | 75[f,g] | 25[h] | 20[h] | 10[h] |
| 0.75 | 175[a,b,d] | 125[b,d] | 75[b,d] | 50[f,g] | 20[h] | 10[h] | 10[h] |
| Mitigation Measures the Pesticide Applicator can Elect to Reduce Buffer Distances[4] | [a] Buffers ≥175 ft could be reduced by 25 ft if crop height at application is ≥1 ft.<br>[b] Windbreak (release height below top of windbreak) reduces buffer distance by half.<br>[c] Buffers ≥250 ft could be reduced by 25 ft if relative humidity at application is >70%<br>[d] Buffers 75-175 ft could be reduced by 25 ft if windspeed at application is 3-7 miles per hour | | | [e] Buffers ≥100 ft could be reduced by 25 ft if relative humidity at application is >60%<br>[f] Windbreak/Hedgerow (release height below top of windbreak) reduces buffer distance by half<br>[g] Hooded Sprayers reduce buffer distance by half<br>[h] The applicator would achieve sufficient mitigation with a windbreak or hedgerow (release height below the top of the windbreak/hedgerow) or hooded sprayers alone without a buffer. | | | |

[1] Very fine to fine droplets are not included for aerial applications because this droplet size is not typically used when applying herbicides aerially.
[2] EPA proposes to use the spray drift buffer distances in this table (based on the most sensitive monocot $IC_{25}$) for all listed plants and all listed animals that rely on plants for diet/habitat. This is due to the differential sensitivity of monocots and dicots to trifluralin and the shorter spray drift distances modeled for dicots than for generalist animals (due to the toxicity to monocots driving the spray drift distances for generalists; see **Table 17-5**).
[3] Single maximum label rates reflect the range of uses represented in **Table 17-1.**
[4] See Section 6.1 in the Strategy Framework document for discussion of these mitigation measures.

### 17.4.2 Runoff/Erosion Mitigation Measures Identified

EPA's identification of the proposed runoff/erosion mitigation measures for this example of the proposed Strategy Framework reflects the magnitude of difference between the EEC and toxicity endpoint, the habitat (*e.g.,* terrestrial, wetland), and the species' relationships to plants (*e.g.,* plant, animal obligate to dicots). The level of mitigation that EPA identified to address potential population-level impacts differs across uses and, as shown in **Figure 17-2**, the level of mitigation is dependent upon the toxicity endpoint used and the representative species (e.g., listed monocots (lowest monocot survival $EC_{25}$)). **Figure 17-2** visually represents the targeted reduction in EECs through the implementation of runoff/erosion mitigations for trifluralin.

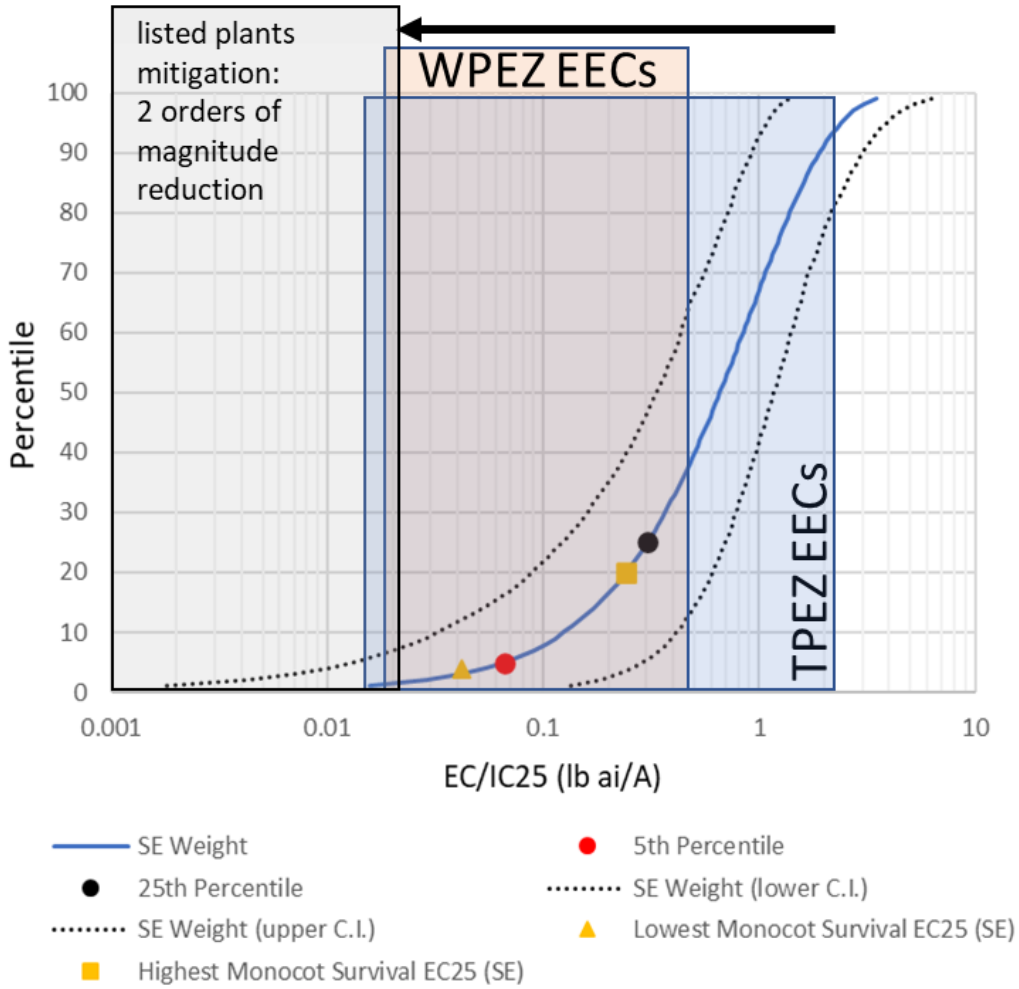


**Figure 17-2. Trifluralin Seedling Emergence (SE) Plant Weight Species Sensitivity Distribution (SSD) and the Most and Least Sensitive Monocot Survival Endpoints Compared to the Terrestrial (TPEZ, blue box) and Wetland (WPEZ, orange box) 1-in-10 year Estimated Environmental Concentrations (EECs) for all use patterns. In this case study, EPA did not use the SSD but instead selected the most sensitive monocot $EC_{25}$. Upper and lower confidence intervals are provided for the SE weight SSD.**

For trifluralin, see **Section 17.3.3.2** for more details on the magnitude of difference between EECs and toxicity endpoints for each use separated by plant and animal groups. EPA assigns the mitigation points for runoff/erosion exposure based on the magnitude of difference, as discussed in Section 5.2 in the Strategy Framework document. The number of points depends on the $K_{OC}$ of the herbicide; because the $K_{OC}$ of trifluralin is >1,000 L/kg-o.c. (mean $K_{fOC}$ = 8,758 L/kg-o.c.), EPA identified fewer mitigation points for this erosion-prone herbicide (as compared to a different runoff-prone herbicide).

As described in the **Strategy Framework**, for the draft Strategy, EPA would identify mitigations for runoff/erosion exposure whenever the magnitude of difference between the EEC and

toxicity endpoint is greater than 1.0. Generally, if the magnitude of difference (*i.e.,* ratio of EEC to toxicity endpoint) is between 1 and 10, EPA would identify low mitigation. If the magnitude of difference is between 10 and 100, medium mitigation would apply, and if it is between 100 and 1,000, high mitigation would apply. However, the proposed level of mitigation identified may deviate from these categories (low/medium/high) if the weight of evidence indicates that more or less mitigation would apply. For trifluralin, such exceptions are discussed in the text following the tables (where applicable) in this section.

Overall for trifluralin, EPA identified proposed runoff/erosion mitigation measures for at least one taxon for all registered uses considered in this document.

- For listed aquatic plants and animals that depend on aquatic plants[260] and designated Critical Habitats in waterbodies similar in size to the EPA farm pond or larger[261], no mitigations are identified to reduce the likelihood of potential population-level impacts (**Table 17-11**).
- For semi-aquatic/wetland monocots, animals that obligately depend on wetland monocots[262], animals that generally on wetland plants[263], and for designated critical habitats in wetlands and small waterbodies[264], the mitigation category is low[265] except for use on cotton, for which the mitigation category is medium (**Table 17-12).**
- For semi-aquatic/wetland dicots and animals that obligately depend on wetland dicots, the mitigation category depends on the specific use. For many uses (*e.g.,* alfalfa, almond etc.), the mitigation category is low, whereas EPA identified no mitigation for some uses (*e.g.,* carrots, cole crops, etc.) (**Table 17-12).**
- For aquatic plants in wetlands or small waterbodies[264] and for animals that depend on these plants (both obligately and generally), the mitigation category is based on the magnitude of difference that EPA estimated using the toxicity endpoints for aquatic vascular and nonvascular plants. Based on the aquatic vascular toxicity endpoint, EPA identified no mitigation for about half of the uses (*e.g.,* carrot, cole crops, corn, etc.) and low mitigation for all other uses (**Table 17-12**). Based on the nonvascular aquatic plant toxicity endpoint, EPA identified low mitigation for all uses except peanuts, for which EPA identified no mitigation (**Table 17-12**).
- For terrestrial monocots, animals that obligately depend on terrestrial monocots, animals that generally on terrestrial plants, and for terrestrial designated critical

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[260] None of the listed aquatic animals have obligate relationships to plants.
[261] This includes aquatic bins 3, 4, 6, 7, 9, and 10. See **Section 3.1** for details on the aquatic bins that EPA and the Services defined to match surface water EECs to aquatic habitat requirements for listed species.
[262] Obligate animal species are those that cannot survive and/or complete their lifecycle without the plant species on which they depend.
[263] Generalist animal species are non-obligate species that can survive and/or complete their lifecycle without a specific plant species but generally rely on plants for food or habitat.
[264] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8.
[265] Based on the magnitude of difference between the EEC and toxicity endpoint. Categories are: Very High (ratios $\geq$1000), High (ratios $\geq$100 but <1000), Medium (ratios $\geq$10 but <100), Low (ratios $\geq$1 but <10), No Mitigation (ratios <1).

habitats, the mitigation category is medium for all uses except for use on carrot, peanuts, and wheat, for which EPA identified low mitigation (**Table 17-13**).

- For terrestrial dicots and animals that obligately depend on terrestrial dicots, the mitigation category is low for all uses except for sugarcane, for which it is medium (**Table 17-13**).

**Table 17-11. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Waterbodies Equivalent to the EPA Pond or Larger[1,5]**

| Use | Range of Daily Mean EECs (µg a.i./L)[2] | Aquatic Vascular Plants | | Aquatic Nonvascular Plants | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[3] | Mitigation Category[3] | Range of Magnitude of Difference[3] | Mitigation Category[4] |
| Alfalfa | 6.0 - 13 | 0.12 - 0.26 | No mitigation | 0.28 - 0.58 | No mitigation |
| Almond | 6.1 - 12 | 0.12 - 0.25 | No mitigation | 0.28 - 0.56 | No mitigation |
| Asparagus | 5.9 - 12 | 0.12 - 0.24 | No mitigation | 0.27 - 0.55 | No mitigation |
| Carrot | 2.9 - 5.9 | 0.06 - 0.12 | No mitigation | 0.13 - 0.27 | No mitigation |
| Citrus | 5.9 - 12 | 0.12 - 0.25 | No mitigation | 0.27 - 0.56 | No mitigation |
| Cole Crops | 2.9 - 6.1 | 0.06 - 0.12 | No mitigation | 0.13 - 0.28 | No mitigation |
| Corn | 3.0 - 6.7 | 0.06 - 0.14 | No mitigation | 0.14 - 0.31 | No mitigation |
| Cotton | 5.9 - 12 | 0.12 - 0.24 | No mitigation | 0.27 - 0.55 | No mitigation |
| Grape | 6.0 - 12 | 0.12 - 0.25 | No mitigation | 0.28 - 0.56 | No mitigation |
| Legumes | 3.0 - 6.1 | 0.06 - 0.12 | No mitigation | 0.14 - 0.28 | No mitigation |
| Melon | 3.0 - 6.1 | 0.06 - 0.12 | No mitigation | 0.14 - 0.28 | No mitigation |
| Oilseed Crops | 3.0 - 6.1 | 0.06 - 0.12 | No mitigation | 0.14 - 0.28 | No mitigation |
| Peaches | 6.0 - 12 | 0.12 - 0.24 | No mitigation | 0.28 - 0.55 | No mitigation |
| Peanuts | 2.2 - 4.5 | 0.05 - 0.09 | No mitigation | 0.10 - 0.21 | No mitigation |
| Pecans | 7.6 - 12 | 0.15 - 0.24 | No mitigation | 0.35 - 0.55 | No mitigation |
| Potato | 3.0 - 6.1 | 0.06 - 0.12 | No mitigation | 0.14 - 0.28 | No mitigation |
| Sorghum | 3.2 - 6.1 | 0.06 - 0.12 | No mitigation | 0.15 - 0.28 | No mitigation |
| Soybean | 6.0 - 12 | 0.12 - 0.24 | No mitigation | 0.28 - 0.55 | No mitigation |
| Sugarcane | 7.7 - 13 | 0.15 - 0.26 | No mitigation | 0.35 - 0.60 | No mitigation |
| Vegetables (unspecified) | 2.9 - 6.1 | 0.06 - 0.12 | No mitigation | 0.13 - 0.28 | No mitigation |
| Wheat | 3.0 - 6.1 | 0.06 - 0.12 | No mitigation | 0.14 - 0.28 | No mitigation |

[1] Larger waterbodies are those that are similar in size to the EPA farm pond or are larger (*i.e.,* aquatic bins 3, 4, 6, 7, 9, 10). Because a Species Sensitivity Distribution is not available for aquatic plants for trifluralin, alternative endpoints (*i.e.,* 25$^{th}$ percentile $IC_{50}$ value) are not available for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants all have equivalent magnitude of difference values and equivalent mitigation categories.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[4] Mitigations were identified whenever the magnitude of difference is >1.

**Table 17-12. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Wetland and Aquatic Plants, Animals that Rely on Those Plants, and Designated Critical Habitats in Wetlands or Small Waterbodies[1]**

| Use | Range of EECs (lb a.i./A)[2] | Wetland Monocots[3] | | Wetland Dicots[4] | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Mitigation Category | Range of Magnitude of Difference[6] | Mitigation Category | | Range of Magnitude of Difference[6] | Mitigation Category | Range of Magnitude of Difference[6] | Mitigation Category |
| Alfalfa | 0.09 - 0.20 | 2.7 - 5.9 | Low | 0.47 - 1.1 | Low | 27 - 60 | 0.55 - 1.2 | Low | 1.2 - 2.7 | Low |
| Almond | 0.10 - 0.21 | 2.9 - 6.2 | Low | 0.53 - 1.1 | Low | 29 - 59 | 0.59 - 1.2 | Low | 1.3 - 2.7 | Low |
| Asparagus | 0.09 - 0.19 | 2.7 - 5.6 | Low | 0.47 – 1.0 | No mitigation[7] | 28 - 56 | 0.56 - 1.1 | Low | 1.3 - 2.5 | Low |
| Carrot | 0.04 - 0.09 | 1.2 - 2.7 | Low | 0.21 - 0.47 | No mitigation | 12 - 24 | 0.24 - 0.49 | No mitigation | 0.55 - 1.1 | Low |
| Citrus | 0.10 - 0.20 | 2.9 - 5.9 | Low | 0.53 - 1.1 | Low | 27 - 62 | 0.54 - 1.3 | Low | 1.2 - 2.8 | Low |
| Cole Crops | 0.04 - 0.10 | 1.2 - 2.9 | Low | 0.21 - 0.53 | No mitigation | 13 - 30 | 0.25 - 0.60 | No mitigation | 0.58 - 1.4 | Low |
| Corn | 0.04 - 0.25 | 1.2 - 7.4 | Low | 0.21 - 1.3 | No mitigation[7] | 12 - 30 | 0.25 - 0.6 | No mitigation | 0.56 - 1.4 | Low |
| Cotton | 0.08 - 0.55 | 2.36 - 16 | Medium | 0.42 - 2.9 | Low | 26 - 55 | 0.52 - 1.1 | Low | 1.2 - 2.5 | Low |
| Grape | 0.09 - 0.32 | 2.7 - 9.4 | Low | 0.47 - 1.7 | Low | 29 - 62 | 0.58 - 1.2 | Low | 1.3 - 2.8 | Low |
| Legumes | 0.04 - 0.10 | 1.2 - 2.9 | Low | 0.21 - 0.53 | No mitigation | 0.25 - 30 | 0.01 - 0.60 | No mitigation | 0.01 - 1.4 | Low |
| Melon | 0.04 - 0.10 | 1.2 - 2.9 | Low | 0.21 - 0.53 | No mitigation | 0.89 - 29 | 0.02 - 0.59 | No mitigation | 0.04 - 1.3 | Low |
| Oilseed Crops | 0.05 - 0.10 | 1.5 - 2.9 | Low | 0.26 - 0.53 | No mitigation | 15 - 31 | 0.31 - 0.61 | No mitigation | 0.69 - 1.4 | Low |
| Peaches | 0.09 - 0.18 | 2.7 - 5.3 | Low | 0.47 - 0.95 | No mitigation | 29 - 57 | 0.57 - 1.2 | Low | 1.3 - 2.6 | Low |
| Peanuts | 0.04 - 0.07 | 1.2 - 2.1 | Low | 0.21 - 0.37 | No mitigation | 10 - 21 | 0.21 - 0.42 | No mitigation | 0.47 - 0.95 | No mitigation |
| Pecans | 0.25 - 0.26 | 7.4 - 7.7 | Low | 1.3 - 1.4 | Low | 28 - 57 | 0.56 - 1.1 | Low | 1.3 - 2.6 | Low |
| Potato | 0.04 - 0.14 | 1.2 - 4.1 | Low | 0.21 - 0.74 | No mitigation | 14 - 30 | 0.28 - 0.60 | No mitigation | 0.63 - 1.4 | Low |

| Use | Range of EECs (lb a.i./A)[2] | Wetland Monocots[3] | | Wetland Dicots[4] | | Range of EECs (µg a.i./L)[2] | Aquatic Vascular Plants[5] | | Aquatic Nonvascular Plants[5] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[6] | Mitigation Category | Range of Magnitude of Difference[6] | Mitigation Category | | Range of Magnitude of Difference[6] | Mitigation Category | Range of Magnitude of Difference[6] | Mitigation Category |
| Sorghum | 0.12 - 0.22 | 3.5 - 6.5 | Low | 0.63 - 1.2 | Low | 13 - 27 | 0.26 - 0.55 | No mitigation | 0.60 - 1.2 | Low |
| Soybean | 0.09 - 0.19 | 2.7 - 5.6 | Low | 0.47 – 1.0 | No mitigation[7] | 28 - 60 | 0.57 - 1.2 | Low | 1.3 - 2.7 | Low |
| Sugarcane | 0.24 - 0.34 | 7.1 - 10 | Low[7] | 1.3 - 1.8 | Low | 27 - 58 | 0.54 - 1.2 | Low | 1.2 - 2.7 | Low |
| Vegetables (unspecified) | 0.04 - 0.09 | 1.2 - 2.7 | Low | 0.21 - 0.47 | No mitigation | 12 - 30 | 0.25 - 0.60 | No mitigation | 0.56 - 1.4 | Low |
| Wheat | 0.05 - 0.09 | 1.5 - 2.7 | Low | 0.26 - 0.47 | No mitigation | 15 - 30 | 0.30 - 0.61 | No mitigation | 0.68 - 1.4 | Low |

[1] Small waterbodies are those that are smaller than the EPA farm pond. This correlates to aquatic bins 2, 5, and 8. For small waterbodies, the EECs for the wetland (calculated in PAT; in lb a.i./A or µg a.i./L) are compared to the terrestrial plant toxicity endpoints and the aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[2] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).

[3] EPA did not use the results from the Species Sensitivity Distribution for trifluralin (as explained in **Section 17.3.1**). For animals that generally rely upon wetland plants for diet or habitat and for designated critical habitats in wetlands and small waterbodies, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $EC_{25}$ for monocots or $IC_{25}$ for dicots) while considering the differential toxicity of trifluralin to monocots and dicots. Therefore, the magnitude of difference for generalist animals and designated critical habitats in wetlands or small waterbodies is the ratio of the EEC to the most sensitive monocot $EC_{25}$.

[4] The magnitude of difference values in this column are only relevant for listed dicots in wetlands and animals that obligately rely on wetland dicots. See footnote 3 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.

[5] Because a Species Sensitivity Distribution is not appropriate for aquatic plants for trifluralin, EPA could not use alternative endpoints (*i.e.,* 25$^{th}$ percentile of $IC_{50}$ values) for determining the magnitude of difference between the EEC and toxicity endpoint for generalist animals. Therefore, listed aquatic plants, animals obligately depending on aquatic plants, and animals generally relying on aquatic plants in wetlands or small waterbodies all have equivalent magnitude of difference values.

[6] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.

[7] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 17-12** outlines the proposed mitigation categories identified for listed wetland and aquatic plants, animals that rely on those plants, and designated critical habitats in wetlands or small waterbodies[266]. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when considering the different, relevant PWC scenarios available[267]. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 3.3.3**. For trifluralin, EPA determined that proposed mitigation categories presented in **Table 17-12** based on the weight of evidence discussed below, which is specifically relevant for use on asparagus, soybeans, sugarcane, and corn.

In **Table 17-12**, the magnitude of difference for wetland dicots ranges from 0.47 to 1.0 for use on asparagus and on soybeans. Because the highest ratio is equivalent to, but does not exceed, the threshold for identifying low mitigation (*i.e.,* 1.0) with all other ratios below 1.0, EPA set the mitigation category at no mitigation for these two uses for protection of listed wetland dicots.

Similarly, for use on sugarcane, the magnitude of difference for wetland monocots ranges from 7.1 to 10. Because the highest ratio is equivalent to, but does not exceed, the threshold for identifying medium mitigation (*i.e.,* 10.0), EPA identified low mitigation use on sugarcane for protection of listed wetland monocots.

For use on corn, the magnitude of difference ranges from 0.21 to 1.3 for wetland dicots. Out of 34 wetland magnitude of difference values estimated for use on corn, only two reached the low mitigation category rating, with 32 magnitude of difference values below 1.0; both values were the result of modeling the MScornSTD PWC scenario, which is a conservative scenario for screening-level assessments that is known to result in substantially higher runoff EECs than all other corn scenarios. Therefore, given that this scenario (MScornSTD) provides upper bound EECs and these EECs only marginally exceed the toxicity endpoint, EPA set the mitigation category as no mitigation to protect wetland dicots for use on corn.

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[266] Small waterbodies are those that are smaller than the EPA Standard Pond. This correlates to aquatic bins 2, 5, and 8 (as discussed in **Section 3.1**). For small waterbodies, the EECs for the wetland (in lb a.i./A or µg a.i./L) are compared to the terrestrial or aquatic plant toxicity endpoints as discussed in **Section 3.2**.

[267] For more information on the surface water modeling conducted in the Pesticide in Water Calculator (PWC), see **Section 3.1.1**.

**Table 17-13. Use-Specific Magnitude of Difference (Ratio of EEC to Toxicity Endpoint) and Identified Runoff/Erosion Mitigation Category, Representing Terrestrial Plants, Animals that Rely on Terrestrial Plants, and Designated Critical Habitats in Terrestrial Environments**

| Use | Range of EECs (lb a.i./A)[1] | Terrestrial Monocots[2] | | Terrestrial Dicots[3] | |
|---|---|---|---|---|---|
| | | Range of Magnitude of Difference[4] | Mitigation Category | Range of Magnitude of Difference[4] | Mitigation Category |
| Alfalfa | 0.24 - 1.5 | 7.1 - 45 | Medium | 1.3 – 8.0 | Low |
| Almond | 0.18 - 0.72 | 5.3 - 21 | Medium | 0.95 - 3.8 | Low |
| Asparagus | 0.20 - 0.71 | 5.9 - 21 | Medium | 1.1 - 3.7 | Low |
| Carrot | 0.09 - 0.32 | 2.7 - 9.4 | Low | 0.47 - 1.7 | Low |
| Citrus | 0.13 - 0.97 | 3.8 - 29 | Medium | 0.68 - 5.1 | Low |
| Cole Crops | 0.06 - 0.35 | 1.8 - 10 | Medium | 0.32 - 1.8 | Low |
| Corn | 0.06 - 0.87 | 1.8 - 26 | Medium | 0.32 - 4.6 | Low |
| Cotton | 0.23 - 2.1 | 6.8 - 62 | Medium | 1.2 – 11 | Low[5] |
| Grape | 0.14 - 1.9 | 4.1 - 56 | Medium | 0.74 – 9.9 | Low |
| Legumes | 0.05 - 0.38 | 1.5 - 11 | Medium | 0.26 - 2.0 | Low |
| Melon | 0.06 - 0.42 | 1.8 - 12 | Medium | 0.32 - 2.2 | Low |
| Oilseed Crops | 0.06 - 0.35 | 1.8 - 10 | Medium | 0.32 - 1.8 | Low |
| Peaches | 0.25 - 0.74 | 7.4 - 22 | Medium | 1.3 - 3.9 | Low |
| Peanuts | 0.08 - 0.27 | 2.4 – 8.0 | Low | 0.42 - 1.4 | Low |
| Pecans | 0.81 - 1.2 | 24 - 35 | Medium | 4.3 - 6.3 | Low |
| Potato | 0.06 - 0.71 | 1.8 - 21 | Medium | 0.32 - 3.7 | Low |
| Sorghum | 0.45 - 0.77 | 13 - 23 | Medium | 2.4 - 4.1 | Low |
| Soybean | 0.13 - 0.72 | 3.8 - 21 | Medium | 0.68 - 3.8 | Low |
| Sugarcane | 1.1 - 2.1 | 31 - 63 | Medium | 5.5 - 11 | Medium |
| Vegetables (unspecified) | 0.08 - 0.39 | 2.4 - 12 | Medium | 0.42 - 2.1 | Low |
| Wheat | 0.06 - 0.34 | 1.8 - 10 | Low[5] | 0.32 - 1.8 | Low |

[1] The ranges of EECs reflect modeling different potential applications (*e.g.,* aerial vs. ground applications) as well as different PWC scenarios (based on PWC version 2.001).
[2] EPA did not use the results from the Species Sensitivity Distribution for trifluralin (as explained in **Section 17.3.1**). For animals that generally rely upon terrestrial plants for diet or habitat and for terrestrial designated critical habitats, EPA calculated the magnitude of difference as the ratio of the EEC to the most sensitive endpoint applicable for generalists and critical habitats (*i.e.,* $EC_{25}$ for monocots or $IC_{25}$ for dicots) while considering the differential toxicity of trifluralin to monocots and dicots. Therefore, the magnitude of difference for generalist animals and terrestrial designated critical habitats is the ratio of the EEC to the most sensitive monocot $EC_{25}$.
[3] The magnitude of difference values in this column are only relevant for listed terrestrial dicots and animals that obligately rely on terrestrial dicots. See footnote 2 for the magnitude of difference values applicable for listed generalist animals and designated critical habitats.
[4] Magnitude of difference is the ratio of the EEC to the toxicity endpoint.
[6] The range for the magnitude of difference spans more than one mitigation category. The mitigation category was chosen using a weight evidence approach and does not align with the highest magnitude of difference value. See the subsequent text for more details.

**Table 17-13** outlines the proposed mitigation categories identified for listed terrestrial plants, animals that rely on those plants, and designated critical habitats. In some instances, the range of the magnitude of difference spans across multiple mitigation categories when different application assumptions (*e.g.,* ground vs. aerial applications) are modeled and when

considering the different, relevant PWC scenarios available. In these instances, EPA used the weight of evidence to determine the mitigation category, as discussed in **Section 3.3.3**. For trifluralin, EPA determined that proposed mitigation categories presented in **Table 17-13** based on the weight of evidence discussed below, which is specifically relevant for use on cotton and wheat.

For use on cotton, the magnitude of difference ranges from 1.2 to 11 for terrestrial dicots (**Table 17-13**). Out of ten terrestrial magnitude of difference values estimated for use on cotton, only one exceeded 10 and reached the medium mitigation category rating (NCcottonSTD, aerial application). Therefore, because 90% of scenarios modeled indicated only low mitigation, EPA set the mitigation category as low for use on cotton.

For use on wheat, the magnitude of difference for terrestrial monocots ranges from 1.8 to 10. Because the highest ratio is equivalent to, but does not exceed, the threshold for identifying medium mitigation (*i.e.,* 10.0), EPA determined that low mitigation would apply for this use for protection of listed terrestrial monocots.

As outlined in Section 6.3 of the Strategy Framework document, EPA assigns the number of runoff/erosion mitigation points to each use in order to protect two types of habitat areas for listed species (*i.e.,* aquatic (including wetland) habitats and terrestrial habitats). For aquatic (including wetland) habitats, mitigation points are assigned based on the maximum mitigation category for each use considering all magnitude of difference ratios calculated for aquatic vascular and nonvascular plants (**Table 17-11** and **Table 17-12**) and wetland plants (**Table 17-12**). For trifluralin, the mitigation points for these aquatic (including wetland) habitats are equivalent regardless of whether the habitat is for protection of listed plants, obligate animals, or generalist animals, because of the available toxicity data where the most sensitive monocot $EC_{25}$ is applicable to plants, obligate animals, and generalist animals (as discussed below). Similarly, for terrestrial habitats, mitigation points are assigned based on the maximum mitigation category for each use (**Table 17-13**).

**Table 17-14** provides the runoff/erosion mitigation points identified for each evaluated use of trifluralin. Although EPA calculated the magnitude of difference values and determined the runoff mitigation categories for listed dicots and listed animals that obligately rely on dicots, these values are not presented in **Table 17-14**. The mitigation categories and mitigation points identified for listed dicots and animals obligately depending on dicots are lower than the values for generalist animals. This is because EPA did not use the SSD for trifluralin and instead used the most sensitive dicot $IC_{25}$ to calculate the magnitude of difference for listed dicots and the most sensitive monocot $EC_{25}$ to calculate the magnitude of difference for listed monocots, animals obligately relying on monocots, and generalist animals. This is based on the assumption that generalist animals rely on both monocots and dicots, depending on what is available in their habitat. By using the monocot $EC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed dicots. However, listed dicots and animals obligately relying on dicots occur in geographic areas where listed generalist animals occur. Therefore, for identifying the runoff/erosion mitigation levels for trifluralin, EPA grouped listed dicots and animals that

obligately rely on dicots with listed monocots, listed animals obligately relying on dicots, and generalist animals.

**Table 17-14. Use-Based Runoff/Erosion Mitigation Identified to Reduce the Potential for Population-Level Impacts for Aquatic, Wetland, and Terrestrial Habitats.[1,2]**

| Use | Aquatic and Wetland Habitats | Terrestrial Habitats |
|---|---|---|
| | Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points) | Listed Plants, Listed Animals Relying on Plants, and CHs (Mitigation Points) |
| Alfalfa | Low (3 pts) | Medium (5 pts) |
| Almond | Low (3 pts) | Medium (5 pts) |
| Asparagus | Low (3 pts) | Medium (5 pts) |
| Carrot | Low (3 pts) | Low (3 pts) |
| Citrus | Low (3 pts) | Medium (5 pts) |
| Cole Crops | Low (3 pts) | Medium (5 pts) |
| Corn | Low (3 pts) | Medium (5 pts) |
| Cotton | Medium (5 pts) | Medium (5 pts) |
| Grape | Low (3 pts) | Medium (5 pts) |
| Legumes | Low (3 pts) | Medium (5 pts) |
| Melon | Low (3 pts) | Medium (5 pts) |
| Oilseed Crops | Low (3 pts) | Medium (5 pts) |
| Peaches | Low (3 pts) | Medium (5 pts) |
| Peanuts | Low (3 pts) | Low (3 pts) |
| Pecans | Low (3 pts) | Medium (5 pts) |
| Potato | Low (3 pts) | Medium (5 pts) |
| Sorghum | Low (3 pts) | Medium (5 pts) |
| Soybean | Low (3 pts) | Medium (5 pts) |
| Sugarcane | Low (3 pts) | Medium (5 pts) |
| Vegetables (unspecified) | Low (3 pts) | Medium (5 pts) |
| Wheat | Low (3 pts) | Low (3 pts) |

CH=designated critical habitat

[1] See Section 6.3 of the Strategy Framework document for discussion of aquatic (including wetland) and terrestrial habitats for listed species.

[2] The use-based mitigation identified in this table reflects the maximum mitigation category for each use identified for listed aquatic and wetland plants (**Table 17-11** and **Table 17-12**), listed animals that obligately or generally depend on aquatic and wetland plants (**Table 17-11** and **Table 17-12**), listed terrestrial plants (**Table 17-13**), and listed animals that obligately or generally depend on terrestrial plants (**Table 17-13**).

## 17.5 Framework Step 3: Identify Extent of Mitigation Measures

As described in the **Strategy Framework**, the mitigation measures for the Herbicide Strategy are either applicable for all use areas or are geographically specific. When mitigation is identified for generalist animals in terrestrial, wetland, or aquatic environments, EPA's current thinking is that the identified mitigation measures and associated points would be applied

throughout the 48 lower United States and therefore would be stated on the general pesticide product labeling. When EPA identifies mitigations for listed plants and obligate animals, EPA proposes to implement geographically specific mitigations (and associated points) through Bulletins including the relevant Pesticide Use Limitation Areas (PULAs). For this illustrative example, the proposed mitigation measures for trifluralin are discussed in this section.

Trifluralin targets annual grasses (monocots) and broadleaf weeds (which are typically dicots). Based on the submitted toxicity data, trifluralin is more toxic to monocots than to dicots. Monocots represent grasses and sedges, which are prevalent plant species in terrestrial and wetland habitats where many listed animals are likely to occur. Given the higher toxicity to monocots and the prevalence of monocots in habitats for listed animal, EPA identified more restrictive mitigations for listed monocots, listed animals that obligately rely on monocots, and generalist animals than for other listed species such as listed dicots and listed animals that obligately rely on listed dicots. Although dicots are less sensitive than monocots, EPA used the most sensitive monocot $EC_{25}$ (instead of the most sensitive dicot $IC_{25}$) to calculate the magnitude of difference for generalist animals because generalist animals are assumed to rely on both monocots and dicots, depending on what is available in their habitat, and because monocots are prevalent in many habitats. By using the most sensitive monocot $EC_{25}$, EPA identified higher mitigation levels for generalist animals than for listed dicots (as explained in **Sections 17.4.1** and **17.4.2**). However, listed dicots and animals obligately relying on dicots occur in areas where listed generalist animals occur. Therefore, for identifying the extent of mitigation measures, EPA determined that differential mitigations are not necessary for trifluralin. In other words, to cover the wide geographic range of listed generalist animals across the United States and also to provide sufficient protection to monocot species, EPA would only generate one set of spray drift mitigation measures (**Table 17-10**) and one set of runoff/erosion mitigation measures (**Table 17-14**). These mitigations apply to all types of habitats considered (*i.e.,* terrestrial, wetland and aquatic), and EPA would propose to put all of the mitigations on the general label without using use Bulletins because the mitigations do not differ for different geographic areas.

## 17.6 EPA's Analysis of Population-Level Impacts Prior to Mitigation

For this part of the case study, EPA applied the method described in the **Section 5**. This summary explains the approach to estimating overlap of potential exposure areas with specific species and CHs. EPA considered overlap and magnitude of effect (**Section 17.3.3.3**) to identify potential population-level impacts for specific listed species and CHs.

For the overlap, EPA included species and CHs that had 5% or more overlap with an individual Use Data Layer (UDL) that represents the selected, registered uses of trifluralin. For major crops (*e.g.,* corn, wheat, grapes), the crop-specific UDLs were selected. For other uses such as on asparagus and sorghum, EPA selected the grouped UDLs represented by vegetables and ground fruit and other grains (respectively). As indicated in **Section 17.2**, EPA focused on the agricultural uses assessed in the 2018 risk assessment, so this case study example does not

necessarily include every registered use of trifluralin, meaning that additional UDLs may be applicable for trifluralin. EPA's overlap analysis was based on the offsite transport area where spray drift and runoff/erosion may occur and lead to exposures to listed species. This area is represented by a 300 m (1000 ft) extension around the individual UDLs representing potential trifluralin use sites (see **Appendix C of the Strategy Framework document for more information**).

EPA identified species and CHs with potential population-level impacts if the overlap of the range or CH was >5% with a UDL and if the use-specific magnitude of effect was medium or high (**Table 17-9**). Because the spatial extent differs by UDL, there are different species and CHs that have 5% or greater overlap for each UDL; however, there are some species with >5% overlap with multiple UDLs. Table 17-15 summarizes the number of species and CHs with potential population-level impacts for each of the UDLs and the total when all of the selected trifluralin UDLs[268] are considered. For illustrative purposes of the Herbicide Strategy, the **Herbicide Strategy Species Overlap and Characteristics Supporting Case Studies** spreadsheet (posted to the docket) includes the specific species and CHs for which population-level impacts are identified for diuron based on the Herbicide Strategy framework; however, as stated previously, this analysis is not for regulatory purposes and will be revisited during future evaluations or consultation with FWS.

In general, as discussed in the **Strategy Framework** document, EPA is proposing to use four PULAs that are based on overlap of species and CHs with the cultivated landcover UDL. As mentioned above (**Section 17.5**), based on this illustrative example, EPA would not propose to use the four PULAs for trifluralin at this time. However, if additional toxicity data are submitted and EPA is able generate robust SSDs for trifluralin in the future, EPA could identify differential mitigations for groups of species, allowing EPA to use the PULAs in regulatory actions for trifluralin.

[268] The selected use data layers (UDLs) do not necessarily represent every registered use of trifluralin. See **Section 17.2** for more information on the selected uses evaluated in this example.

**Table 17-15. The Number of Listed Species and Designated Critical Habitats Identified where there may be Potential for Population-Level Impacts in CONUS for Trifluralin Prior to Considering the Identified Mitigation. This identifies potential species and CHs that will be protected by proposed mitigation measures.**

| Use Data Layer (UDL) | # of Species / # of CH | # of potential species/CHs with population-level impacts[1] | |
|---|---|---|---|
| | | Listed Species | CHs |
| **Listed Plants and Animal Obligates** | | | |
| Alfalfa | 469 / 142 | 141 | 42 |
| Vegetables and Ground Fruit | | 123 | 23 |
| Corn | | 124 | 24 |
| Cotton | | 71 | 13 |
| Grapes | | 117 | 31 |
| Citrus | | 50 | 10 |
| Other Orchards | | 131 | 36 |
| Other Grains | | 236 | 51 |
| Other Row Crops | | 45 | 5 |
| Wheat | | 146 | 31 |
| Soybeans | | 88 | 9 |
| Total across all UDLs above[2] | | 326 | 74 |
| **Listed Animal Generalists** | | | |
| Alfalfa | 534 / 316 | 140 | 75 |
| Vegetables and Ground Fruit | | 152 | 74 |
| Corn | | 277 | 126 |
| Cotton | | 158 | 64 |
| Grapes | | 52 | 29 |
| Citrus | | 32 | 5 |
| Other Orchards | | 122 | 70 |
| Other Grains | | 255 | 118 |
| Other Row Crops | | 94 | 38 |
| Wheat | | 267 | 116 |
| Soybeans | | 190 | 75 |
| Total across all UDLs above[2] | | 367 | 183 |

CH=designated critical habitat

[1] These values are based on EPA's analyses for example purposes for trifluralin. A future effects determination, and, as appropriate, ESA consultation with FWS could result in more refined analyses and outcomes. These values do not include the 27 listed species included in the Vulnerable Species Pilot project.

[2] The values in this row reflect the unique number of potential species or designated critical habitats with population-level impacts when considering all UDLs selected and considered for trifluralin.

## 17.7 Appendix 1: Species Sensitivity Distribution Data (SSD) and Results

The ranges of $IC_{25}$ values for fresh weight from the seedling emergence studies are 0.064 to 0.74 lb a.i./A (excluding non-definitive endpoints[269]) for monocots and 0.19 to 2.4 lb a.i./A (excluding non-definitive endpoints) for dicots, with mean $IC_{25}$ values of 0.33 and 1.3 lb a.i./A, respectively. The median $IC_{25}$ values for monocots and dicots are 0.22 and 1.1 lb a.i./A, respectively.

The available, definitive $EC_{25}$ values for monocot survival range from 0.04 to 0.25 lb a.i./A, with only half of the weight $IC_{25}$ values below the highest survival $EC_{25}$, meaning that survival is affected at lower concentrations than growth for many test species. At the estimated 5$^{th}$ percentile of the SSD based on the weight data (0.066 lb a.i./A), there was more than a 25% effect on survival for two of the tested monocot species (oat and ryegrass) and nearly a 25% effect for a third monocot species (sorghum) in one of the submitted seedling emergence tests (MRID 49177202). Because the data are too few to generate separate monocot and dicot SSDs, EPA determined that use of the SSD values generated from combining monocot and dicot data—as included in the Excel spreadsheet—was not appropriate for calculating the magnitude of difference between the EEC and toxicity endpoint. As discussed in **Section 17.3.1**, EPA used the most sensitive toxicity endpoints presented in **Table 17-2** (instead of the SSD endpoints) to calculate the magnitude of difference ratios this case study example (**Table 17-4**).

[269] Non-definitive endpoints are endpoints expressed as greater than the highest application rate tested (*e.g.,* $IC_{25}$ > 4 lb a.i./A), because 25% or greater inhibition in growth was not detected in any of the tested application rates in the toxicity test.

## 17.8 Appendix 2: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

### Summary

EPA fit Species Sensitivity Distributions (SSDs) to inhibition concentrations ($IC_{25}$ values) for seedling emergence (SE) and vegetative vigor (VV) dry weight and height toxicity endpoints for plants exposed to trifluralin. For trifluralin, EPA only generated an SSD based on weight data from the seedling emergence studies since height data were too few to generate robust SSDs.

EPA fit six distributions (normal, logistic, triangular, Gumbel, Weibull, and Burr) to the available vegetative vigor and seedling emergence data for each of the case study chemicals. EPA selected best fit distributions from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight and confidence limits for the different distributions. **Section 17.7** and subsection 5.1 below provide summary statistics from the fitted SSD for dry weight and height (if sufficient data are available). Following EPA's standard process, the Agency used the $5^{th}$ and $25^{th}$ percentiles of the plant height and/or weight SSDs to calculate the magnitude of difference representing impacts to listed species of plants and listed animals that depend on plants for diet/habitat.

### Toxicity Data

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, EPA standardized the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. Typically, the $IC_{25}$ values, from registrant-submitted studies, that EPA included in the analysis are all height or dry weight endpoints that follow the OCSPP 850.4100 or 850.4150 guideline, and EPA does not include endpoints without definitive values to derive SSDs.

For trifluralin, survival was the most sensitive endpoint for monocots. Because data were too few for monocot survival data, the $EC_{25}$ for survival was used in place of the growth endpoints for monocots. As EPA assessed monocots separately from dicots and the dicot data were too few to generate a dicot only SSD, EPA assessed dicots using the $IC_{25}$ for fresh weight from the seedling emergence studies.

Although EPA did not use the SSD endpoints based on the seedling emergence weight data in this case study, the subsequent sections present the SSD procedure and results for trifluralin.

## Determining Distribution with Best Fit

### *P-values*

EPA considered six potential distributions for the chemical endpoint data (*i.e.,* normal, logistic, triangular, Gumbel, Weibull and Burr). To fit each of the six distributions, EPA transformed the toxicity values to common log ($log_{10}$). The SSD toolbox includes four different fitting methods (*i.e.,* maximum likelihood, moment estimators, linearization and metropolis-hastings). EPA fit all six distributions using the maximum likelihood (ML) method. To test goodness-of-fit, EPA fit all six distributions to the trifluralin weight data from the seedling emergence studies and ran bootstrap goodness-of-fit tests with 10,000 replicates. Since distributions with p-values <0.05 are considered a poor fit to the endpoint data, EPA did not consider them further.

### *Akaike's Information Criteria Weights*

EPA used Akaike's Information Criterion corrected for sample size ($AIC_c$) to compare the distributions for plant height and weight at the 5$^{th}$ percentile of the $IC_{25}$ values from the SSD. Based on the AIC weights, EPA selected those distributions with the highest weight for plotting. EPA considered the relationship of the 5$^{th}$ percentile of the SSD to the most sensitive $IC_{25}$ when selecting how many distributions to evaluate further. If the 5$^{th}$ percentiles for the best fit distributions (based on the goodness of fit and AIC) were higher than the $IC_{25}$, then EPA included other distributions in the visual evaluations of the distributions.

## Distributions

The cumulative distribution functions for seedling emergence plant dry weight SSD, which EPA chose based on the process described above, are provided below. EPA made comparisons of the 5$^{th}$ and 25$^{th}$ percentiles of the $IC_{25}$ values from the SSD across seedling emergence studies.

## Species Sensitivity Distribution (SSD) for Trifluralin

The toxicity endpoints included in the SSDs and the resulting percentiles of the $IC_{25}$ values from the SSD can be found in **Section 17.7.** As stated previously, EPA only generated SSDs for the seedling emergence weight data.

### *Seedling Emergence Weight SSD*

Goodness of fit:

Results:

| | Distribution | Method | HC05 | P |
|---|---|---|---|---|
| 1 | normal | ML | 0.1049 | 0.8971 |
| 2 | logistic | ML | 0.0985 | 0.7393 |
| 3 | triangular | ML | 0.0993 | 0.7972 |
| 4 | gumbel | ML | 0.1082 | 0.9181 |
| 5 | weibull | ML | 0.0661 | 0.6663 |
| 6 | burr | ML | 0.0941 | 0.6743 |

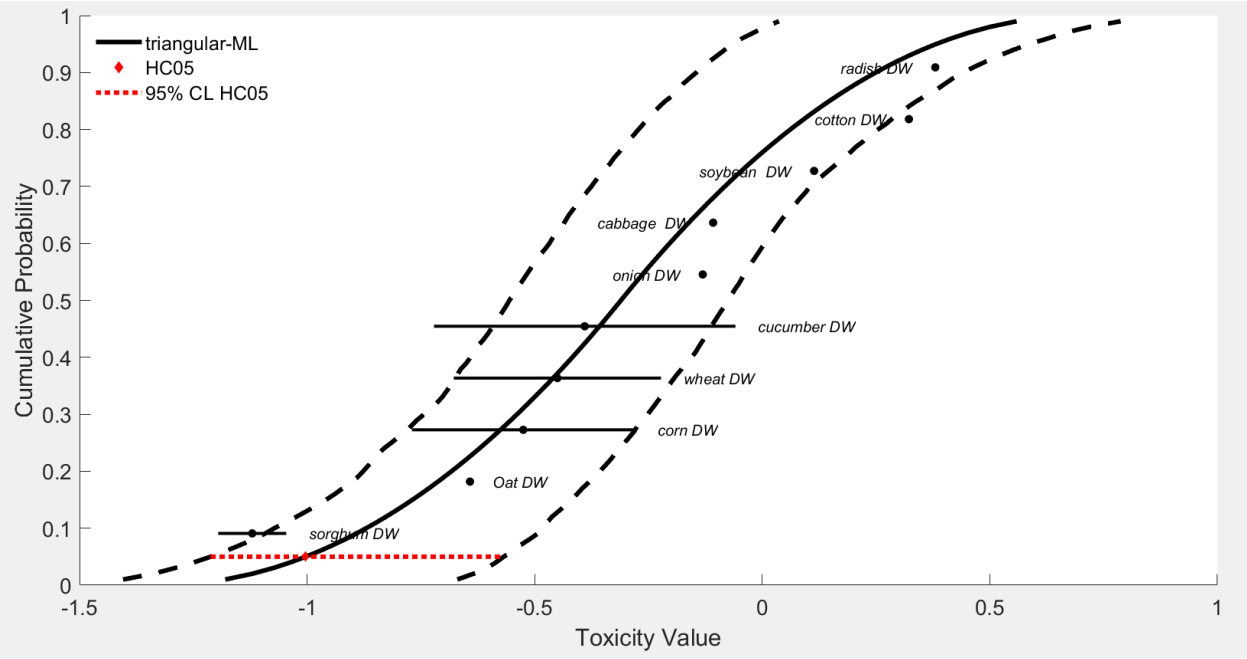
No significant lack of fit observed.

| | |
|---|---|
| Percentile of interest: | 5 |
| Model-averaged HCp: | 0.09391 |
| Model-averaged SE of HCp: | 0.050784 |
| CV of HCp: | 0.54077 |

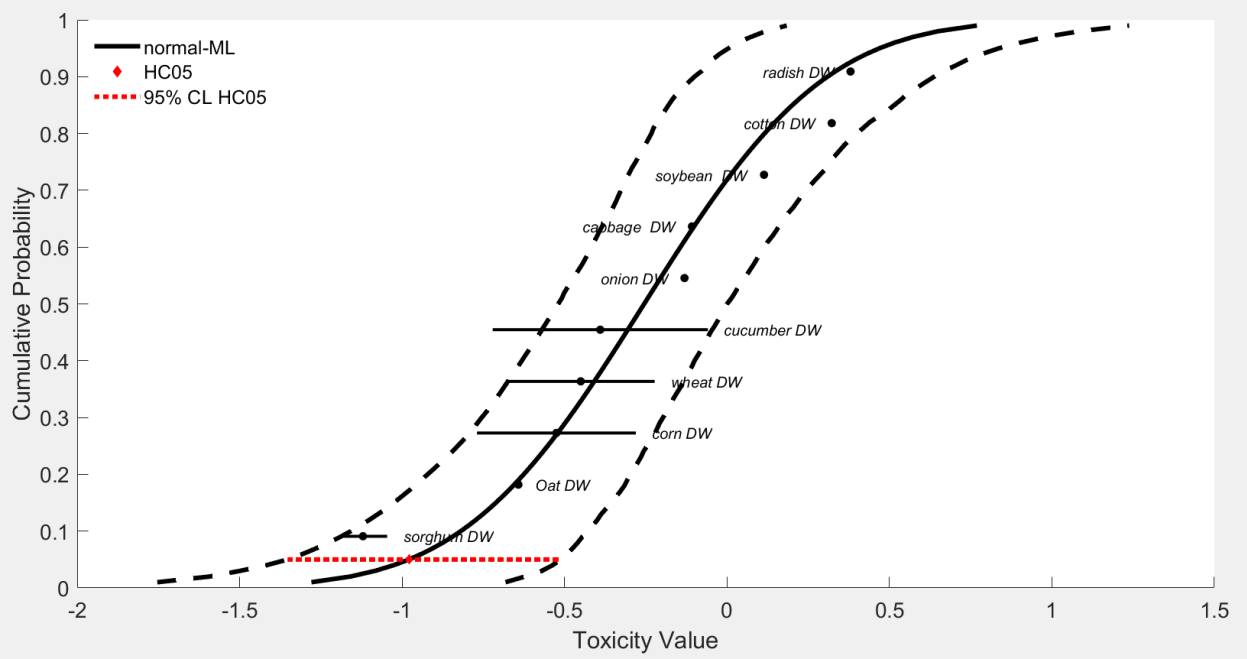
**AICc Table**

| | Distribution | AICc | delta AICc | Wt | HCp | SE HCp |
|---|---|---|---|---|---|---|
| 1 | triangular | 22.0260 | 0 | 0.2938 | 0.0993 | 0.0380 |
| 2 | normal | 22.6203 | 0.5943 | 0.2183 | 0.1049 | 0.0517 |
| 3 | weibull | 22.6528 | 0.6268 | 0.2147 | 0.0661 | 0.0524 |
| 4 | logistic | 23.1311 | 1.1051 | 0.1691 | 0.0985 | 0.0554 |
| 5 | gumbel | 24.5242 | 2.4982 | 0.0842 | 0.1082 | 0.0384 |
| 6 | burr | 27.4090 | 5.3830 | 0.0199 | 0.0941 | 0.0764 |

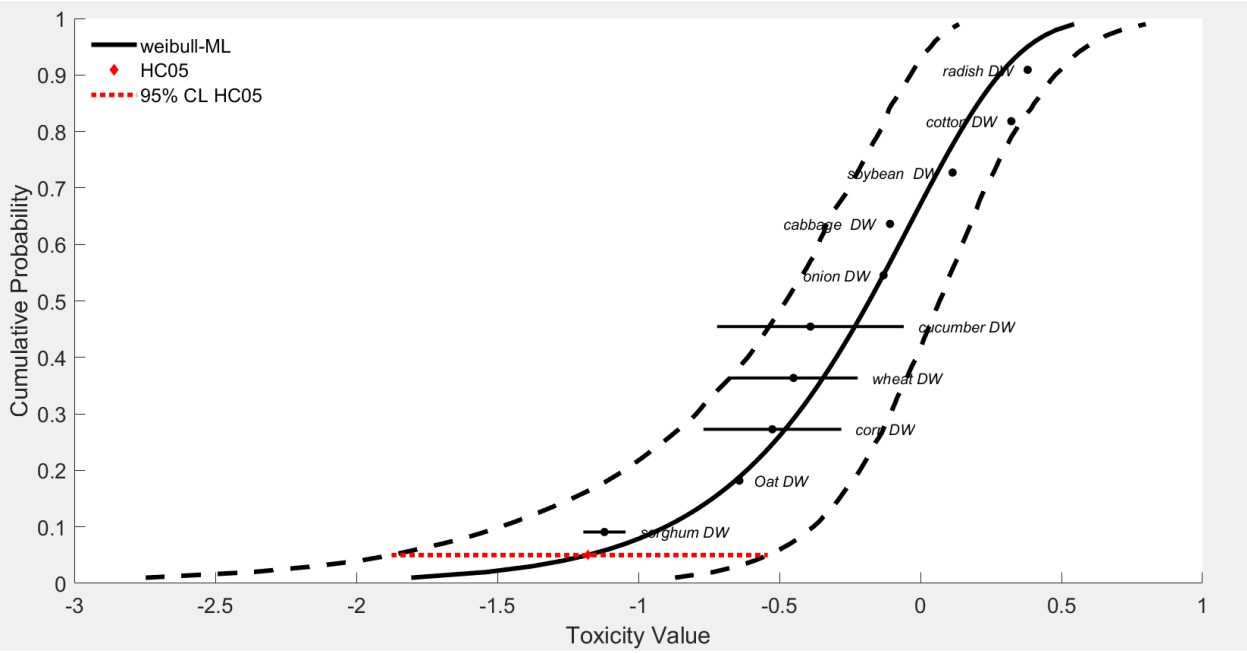
Based on the goodness of fit, EPA moved forward with triangular, normal, and Weibull distributions, and ultimately selected the Weibull distribution for the dry weight data from the seedling emergence toxicity tests.




Triangular




Normal




**Weibull (selected distribution)**

## 17.9 Appendix 3: Spray Drift Estimation for Sensitive Aquatic and Terrestrial Areas

**Table 17-16. Spray Drift Distances to the Most Sensitive Aquatic Plant Toxicity Endpoint[1]**

| | Aerial Application | | | Ground Application | | | |
|---|---|---|---|---|---|---|---|
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| **Application Rate of 2.0 lb a.i./A (maximum application rate for multiple uses)** | | | | | | | |
| Distance to Medium MoE[2] (ft) | 0* | 0* | 0* | 0* | 0* | 0* | 0* |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse, MoE=Magnitude of Effect

[1] The most sensitive aquatic plant toxicity endpoint ($IC_{50}$) is 21.9 µg a.i./L for the marine diatom (*Skeletonema costatum*) (MRID 42834101). None of the magnitude of difference values for aquatic plants exceed 1.0 (*i.e.,* medium magnitude of effect; see footnote 2 below) at the maximum buffer distances. Therefore, the spray drift buffer distances identified are less than the maximum buffer distances proposed in Section 6.1 of the Strategy Framework document.

[2] For trifluralin, the Magnitude of Effect (MoE) is low when the magnitude of difference between the EEC and toxicity endpoint is less than 1.0. This is explained further in **Section 17.3.3.3**. The MoE is medium or greater when the magnitude of difference between the EEC and toxicity endpoint is greater than 1.0. When the MoE is medium or greater and the ratio of EEC to endpoint at the maximum buffer distance is greater than 10, then mitigation measures in addition to the maximum spray drift buffer are identified.

*Spray drift deposition never results in aquatic bin 2 EECs that lead to medium MoE (*i.e.,* ratio of EEC to most sensitive aquatic plant toxicity endpoint is <1 at 0 ft).

**Table 17-17. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 25.1 | 25.1 | 25.1 | 52.9 | 51.1 | 50.8 | 50.5 |
| 10 | 16.9 | 15.1 | 13.9 | 13.2 | 4.7 | 2.3 | 1.4 |
| 20 | 12.5 | 10.0 | 8.6 | 6.6 | 2.2 | 1.3 | 0.8 |
| 25 | 10.7 | 8.2 | 6.8 | 4.9 | 1.6 | 1.0 | 0.6 |
| 50 | 8.4 | 5.4 | 3.6 | 2.4 | 0.8 | 0.6 | 0.4 |
| 75 | 5.9 | 3.7 | 2.4 | 1.6 | 0.6 | 0.4 | 0.3 |
| 100 | 5.0 | 2.9 | 1.8 | 1.3 | 0.5 | 0.4 | 0.2 |
| 125 | 3.7 | 2.2 | 1.4 | 1.0 | 0.4 | 0.3 | 0.2 |
| 150 | 3.1 | 1.7 | 1.1 | 0.8 | 0.3 | 0.3 | 0.2 |
| 175 | 2.6 | 1.4 | 0.9 | 0.7 | 0.3 | 0.2 | 0.1 |
| 200 | 2.3 | 1.3 | 0.8 | 0.6 | 0.3 | 0.2 | 0.1 |
| 225 | 2.1 | 1.1 | 0.6 | 0.5 | 0.2 | 0.2 | 0.1 |
| 250 | 1.8 | 0.9 | 0.5 | 0.5 | 0.2 | 0.2 | 0.1 |
| 275 | 1.7 | 0.8 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| 300 | 1.5 | 0.7 | 0.4 | 0.4 | 0.2 | 0.1 | 0.1 |
| 325 | 1.4 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 350 | 1.3 | 0.6 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 |
| 375 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 400 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 500 | 0.9 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 |
| 600 | 0.8 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.7 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.6 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.0399 lb a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 17-18. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals Obligately Relying on Dicots at an Application Rate of 2.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 5.3 | 5.3 | 5.3 | 11.1 | 10.7 | 10.7 | 10.6 |
| 10 | 3.5 | 3.2 | 2.9 | 2.8 | 1.0 | 0.5 | 0.3 |
| 20 | 2.6 | 2.1 | 1.8 | 1.4 | 0.5 | 0.3 | 0.2 |
| 25 | 2.3 | 1.7 | 1.4 | 1.0 | 0.3 | 0.2 | 0.1 |
| 50 | 1.8 | 1.1 | 0.8 | 0.5 | 0.2 | 0.1 | 0.1 |
| 75 | 1.2 | 0.8 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 |
| 100 | 1.0 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | <0.1 |
| 125 | 0.8 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 |
| 150 | 0.7 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 175 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 200 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 225 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.3 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.19 lbs a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 17-19. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 12.5 | 12.5 | 12.5 | 26.4 | 25.5 | 25.4 | 25.3 |
| 10 | 8.4 | 7.6 | 6.9 | 6.6 | 2.3 | 1.2 | 0.7 |
| 20 | 6.3 | 5.0 | 4.3 | 3.3 | 1.1 | 0.6 | 0.4 |
| 25 | 5.4 | 4.1 | 3.4 | 2.4 | 0.8 | 0.5 | 0.3 |
| 50 | 4.2 | 2.7 | 1.8 | 1.2 | 0.4 | 0.3 | 0.2 |
| 75 | 3.0 | 1.8 | 1.2 | 0.8 | 0.3 | 0.2 | 0.1 |
| 100 | 2.5 | 1.5 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 |
| 125 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 150 | 1.6 | 0.9 | 0.5 | 0.4 | 0.2 | 0.1 | 0.1 |
| 175 | 1.3 | 0.7 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 200 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 225 | 1.1 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 250 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 275 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 |
| 300 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 325 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 350 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 375 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 400 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 500 | 0.5 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.4 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.0399 lbs a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 17-20. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals Obligately Relying on Dicots at an Application Rate of 1.0 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 2.6 | 2.6 | 2.6 | 5.6 | 5.4 | 5.3 | 5.3 |
| 10 | 1.8 | 1.6 | 1.5 | 1.4 | 0.5 | 0.2 | 0.1 |
| 20 | 1.3 | 1.1 | 0.9 | 0.7 | 0.2 | 0.1 | 0.1 |
| 25 | 1.1 | 0.9 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 50 | 0.9 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 |
| 75 | 0.6 | 0.4 | 0.2 | 0.2 | 0.1 | <0.1 | <0.1 |
| 100 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 125 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.19 lbs a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 17-21. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Monocots, Listed Animals that Obligately Depend on Monocots, and Listed Generalist Animals at an Application Rate of 0.75 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 9.4 | 9.4 | 9.4 | 19.8 | 19.2 | 19.0 | 18.9 |
| 10 | 6.3 | 5.7 | 5.2 | 4.9 | 1.8 | 0.9 | 0.5 |
| 20 | 4.7 | 3.8 | 3.2 | 2.5 | 0.8 | 0.5 | 0.3 |
| 25 | 4.0 | 3.1 | 2.5 | 1.8 | 0.6 | 0.4 | 0.2 |
| 50 | 3.2 | 2.0 | 1.3 | 0.9 | 0.3 | 0.2 | 0.1 |
| 75 | 2.2 | 1.4 | 0.9 | 0.6 | 0.2 | 0.2 | 0.1 |
| 100 | 1.9 | 1.1 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 125 | 1.4 | 0.8 | 0.5 | 0.4 | 0.1 | 0.1 | 0.1 |
| 150 | 1.2 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| 175 | 1.0 | 0.5 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 |
| 200 | 0.9 | 0.5 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 |
| 225 | 0.8 | 0.4 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 250 | 0.7 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 275 | 0.6 | 0.3 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 |
| 300 | 0.6 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 |
| 325 | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 |
| 350 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 375 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 |
| 400 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.3 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for monocots ($IC_{25}$ = 0.0399 lbs a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

**Table 17-22. Ratios of the Spray Drift Deposition EEC to the Most Sensitive Toxicity Endpoint for Listed Dicots and Listed Animals Obligately Relying on Dicots at an Application Rate of 0.75 lb a.i./A**

| Buffer Distance (ft) | Ratio of EEC to Toxicity Endpoint[1] at the Specified Buffer Distance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aerial Application | | | Ground Application | | | |
| | F-M | M-C | C-VC | VF-F High Boom | VF-F Low Boom | F-MC High Boom | F-MC Low Boom |
| 0 | 2.0 | 2.0 | 2.0 | 4.2 | 4.0 | 4.0 | 4.0 |
| 10 | 1.3 | 1.2 | 1.1 | 1.0 | 0.4 | 0.2 | 0.1 |
| 20 | 1.0 | 0.8 | 0.7 | 0.5 | 0.2 | 0.1 | 0.1 |
| 25 | 0.8 | 0.6 | 0.5 | 0.4 | 0.1 | 0.1 | <0.1 |
| 50 | 0.7 | 0.4 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 |
| 75 | 0.5 | 0.3 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 |
| 100 | 0.4 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 125 | 0.3 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 150 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 175 | 0.2 | 0.1 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| 200 | 0.2 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 225 | 0.2 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 250 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 275 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 300 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 325 | 0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 350 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 375 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 400 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 500 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 600 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 700 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 800 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 900 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| 1000 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |

F=Fine, M=Medium, C=Coarse, VC=Very Coarse, VF=Very fine, MC=Medium/Coarse

[1] Based on the most sensitive endpoint for dicots ($IC_{25}$ = 0.19 lbs a.i./A)

Highlighted rows indicate the maximum spray drift buffer distances as explained in the **Technical Support for Mitigation** document.

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# 19 Abbreviations

| | |
|---|---|
| a.i. | active ingredient |
| a.e. | acid equivalents |
| CH | designated critical habitat |
| $EC_x$ | concentration resulting in x% effect on plant survival |
| EEC | estimated environmental concentration |
| EPA | United States Environmental Protection Agency |
| ESA | Endangered Species Act |
| FWS | United States Fish and Wildlife Service |
| $IC_x$ | concentration resulting in x% inhibition in plant growth |
| J/AM | jeopardy or adverse modification |
| MoD | magnitude of difference |
| MoE | magnitude of effect |
| NMFS | National Marine Fisheries Service |
| NOAEC | No Observed Adverse Effect Concentration |
| PULA | pesticide use limitation area |
| SSD | species sensitivity distribution |
| TEP | typical end-use product |
| TGAI | technical grade active ingredient |
| TPEZ | Terrestrial Plant Exposure Zone |
| WPEZ | Wetland Plant Exposure Zone |

## Appendix A: Species Sensitivity Distribution Analysis for Vegetative Vigor and Seedling Emergence Endpoints

When possible, Species Sensitivity Distributions (SSDs) are relied upon in the Strategy to establish population level endpoints (see Section 3.2 for more discussion of endpoints). This appendix provides a summary of the process and considerations accounted for when EPA estimates SSDs. EPA fits SSDs to inhibition concentrations ($IC_{25}$ values) estimated from Vegetative Vigor (VV) and Seedling Emergence (SE) toxicity studies using the SSD Toolbox version 1.0[270] (a program that can be used to fit such distributions). If studies in the open literature are determined suitable for inclusion[271] relevant endpoints may also be in SSDs. Separate SSDs are generated for each study type (e.g., VV or SE) as well as for each endpoint (dry weight, height, survival).

Because an SSD depicts relative sensitivities of different species exposed to the same stressor, it is necessary to standardize the data as much as possible to eliminate variables that would confound the relative sensitivities of species. Such variables can include study exposure duration and other study design factors. Endpoints without definitive endpoints are not used to derive SSDs. Typically, data used to derive SSDs are from registrant-submitted studies and include 10 tested species. While not a requirement, SSDs are typically more robustly estimated when the number of species is 6 or more. There are often more than one study testing the effects of herbicide formulations on plants, inclusion of these, especially for lower numbers of species included, can result in better estimates of the distribution. However, careful consideration should be made to determine if it is appropriate to include endpoints from monocots and dicots, and/or endpoints from different formulated products in the same SSD.

**Types of Distributions**

Six distributions (normal, logistic, triangular, gumbel, weibull and burr) are fit to the available data. Best fit distributions were selected from distributions with p-values >0.05, based on the Akaike Information Criterion $(AIC)_c$ weight, and from visual comparison of the empirical data to the distribution and confidence limits. Summary statistics from the fitted SSD for dry weight and height are provided for each chemical. The fifth, tenth, twenty-fifth, fiftieth, seventy-fifth, ninetieth and ninety-fifth percentiles of the SSD (abbreviated $HC_{05}$, $HC_{10}$, $HC_{25}$, $HC_{50}$, $HC_{75}$, $HC_{90}$, and $HC_{95}$, respectively, where "HC" stands for "hazard concentration") are used to calculate endpoints representing effects to listed species of plants associated with height and weight.

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[270] https://www.epa.gov/chemical-research/species-sensitivity-distribution-ssd-toolbox

[271] USEPA. 2011. Evaluation Guidelines for Ecological Toxicity Data in the Open Literature. https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/guidance-identifying-selecting-and-evaluating-open

**Goodness of Fit P-values**

Six potential distributions for the chemical endpoint data are considered (*i.e*., normal, logistic, triangular, gumbel, weibull and burr). To fit each of the six distributions, the toxicity values are common log ($log_{10}$) transformed. The SSD toolbox includes four different fitting methods (i.e., maximum likelihood, moment estimators, linearization and metropolis-hastings). In EPA's typical process, all six distributions are fit using the maximum likelihood (ML) method. To test goodness-of-fit, all six distributions are fit to the data and bootstrap goodness-of-fit tests are run with 1,000 to 10,000 replicates. Distributions with p-values <0.05 are a poor fit to the endpoint data and were not considered further

**Akaike's Information Criteria Weights**

Akaike's Information Criterion corrected for sample size ($AIC_c$) is used to compare the distributions for each SSD at the $HC_{05}$. Based on the AIC weights, those with the highest weight are selected for plotting (at least 2-3 distributions are recommended for plotting).

**Final Selection of the Distribution For Use**

When making the final selection from among the best fit SSDs, visually consider the relative fit of the individual measures, or mean measures as compared to the SSD and the confidence intervals (Cis). Well-fitting SSD to the empirical data at the $5^{th}$ and $25^{th}$ percentiles are a good sign that the SSD is appropriately estimating the data.

**Distributions**

The cumulative distribution functions for SSDs, chosen based on the process described above, are extracted from the SSD Toolbox and comparison of the $5^{th}$ and $25^{th}$ Percentiles across endpoints are completed to select the representative endpoint for the assessment.