Exhibit G-25

Saint Mary's University of Minnesota

GeoSpatial Services

Clean Water Rule Spatial Analysis

A GIS-based scenario model for comparative analysis of the potential spatial extent of jurisdictional and non-jurisdictional wetlands

ON THE COVER
Photo of wetland restoration site in Bowler, WI.

Clean Water Rule Spatial Analysis

A GIS-based scenario model for comparative analysis of the potential spatial extent of jurisdictional and non-jurisdictional wetlands

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Acronyms and Abbreviations

AGOL – ArcGIS online

API – Application Programming Interface

ASWM – Association of State Wetland Managers

CFR – Code of Federal Regulations

CWA – Clean Water Act

CWR – Clean Water Rule

DEM – Digital Elevation Model

DNR – Department of Natural Resources

DRG – Digital Raster Graphic

EPA – United States Environmental Protection Agency

ESRI – Environmental Systems Research Institute

FEMA – Federal Emergency Management Agency

FP – Flood Protection Wetland Function

FSH – Fish Habitat Wetland Function

GIS – Geographic Information Systems

GSS – GeoSpatial Services

HUC – Hydrologic Unit Code

LLWW – Landscape Position, Landform, Water Flow Path, Waterbody Type

LR – Lotic River

LS – Lotic Stream

MPCA – Minnesota Pollution Control Agency

NHD – National Hydrography Dataset

NHDPlus – National Hydrography Dataset Plus

NRCS – Natural Resources Conservation Service

Acronyms and Abbreviations (continued)

NWI – National Wetland Inventory

OHWM – Ordinary High Water Mark

PLLC – Professional Limited Liability Company

WH – Wildlife Habitat Wetland Function

RPW – Relatively Permanent Water

SMUMN – Saint Mary's University of Minnesota

SQL – Structured Query Language

SSURGO – Soil Survey Geographic Database

TMDL – Total Maximum Daily Load

TNW – Traditionally Navigable Water

USDA – United States Department of Agriculture

USACE – United States Army Corps of Engineers

USFS - United States Forest Service

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WH – Wildlife Habitat Wetland Function

WQ – Water Quality Wetland Function

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Executive Summary

In February 2017, the U.S. President issued an executive order directing the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) to undertake a proposed rulemaking for notice and comment to rescind or revise the joint 2015 Clean Water Rule, also known as the Waters of the United States or "WOTUS" rule. The rule was originally intended to clarify the jurisdictional scope of the Clean Water Act. Per comments by the President and other members of the Executive Office, the intent of this Order potentially signals a move to substantially narrow the jurisdictional scope of the Clean Water Act. If this is the case, the new rule may remove protection from a range of ephemeral and intermittent flowing waters (streams and rivers) and the wetlands that abut or are hydrologically connected to those waters and provide such functions as streamflow maintenance, water quality management and floodwater storage.

The Clean Water Act of 1972 (CWA) is the primary piece of federal legislation regulating discharge of pollutants to navigable waters or "waters of the United States". This term has been contentious since the Act was written over 40 years ago and the latest attempt at clarification was the 2015 Clean Water Rule (CWR), developed by the EPA under the Obama Administration. The intent of this Rule was to ensure that CWA programs were more precisely defined and to save time and avoid costs and confusion in future implementations of the Act. The rule intended to make it easier to predict what action(s) would be taken by the EPA and what processes companies and other stakeholders would have to undergo for projects and permitting. Unfortunately, shortly after the rule was announced, numerous legal challenges were filed and implementation of the rule was halted in several states, pending resolution of these issues.

Challenges to the 2015 CWR were not the first litigation actions involving implementation of the Clean Water Act. Originally, the USACE applied the law narrowly, but this view was found to be unlawful by a federal court. Subsequently, the law was applied very broadly, until what has become known as the 2001 SWANCC litigation (Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers). This litigation established that the jurisdictional coverage of the CWA did not extend to isolated waters that were not directly adjacent or connected to navigable waters where CWA jurisdiction is based solely on the Migratory Bird Rule. The SWANCC decision did allow for CWA jurisdiction over such isolated waters based on other rationales, such as flood storage or pollution filtration that demonstrate physical, chemical, or biological connectivity to navigable waters. Then, in 2006, the Supreme Court was asked again to take up the scope of the CWA in what has become known as the Rapanos Decision. This litigation resulted in a split decision of the Supreme Court justices, which included opinions by two of the Justices (Scalia and Kennedy) adopting different interpretations of the Act's jurisdictional limitations.

With the decision of the current administration to initiate a new rulemaking aimed at shrinking the jurisdictional scope of the CWA and with the availability of new wetland spatial data sets and collateral data layers, this project was initiated to spatially document the extent of protection for wetlands and waters of the U.S. under three different jurisdictional scenarios. The scenarios draw distinctions using geographic concepts deemed relevant in Justice Scalia's plurality opinion and Justice Kennedy's concurring opinion, and from the 2015 CWR. However, the scenarios do not depict the precise limits imposed by any specific legal framework or opinion. Each of these scenarios are modelled spatially using commonly available geodatabases, current wetland mapping and Geographic Information Systems (GIS) technology. The parameters used to define jurisdictional extent are drawn directly from the legal guidance of each scenario. The completed models are fully

documented and stored in ESRI's (Environmental Systems Research Institute) ArcGIS ModelBuilder environment and are available for users to run and adapt for their own assessments.

Results from this project are presented using three digital communication tools: an ESRI Story Map based on ArcGIS Online; a dashboard summary of project outputs hosted using ESRI Operations Dashboard on the Saint Mary's University of Minnesota GeoSpatial Services (SMUMN GSS) portal; and an interactive spatial Web Map hosted by SMUMN GSS. The jurisdictional scenario models for each of three case study watersheds were summarized for comparative analysis of the spatial extent of jurisdictional wetlands that would be regulated and protected by the federal government using the criteria, as well as non-jurisdictional wetlands. Total jurisdictional and non-jurisdictional wetland acres, percent of total jurisdictional and non-jurisdictional wetland acres, number of jurisdictional and non-jurisdictional wetland polygons, and percent jurisdictional and non-jurisdictional polygons were compiled and summarized for each scenario in the case study watersheds. Potential impacts on the FP, WH, FSH, and WQ wetland functions were assessed by compiling total wetland acres that were identified as potentially jurisdictional and non-jurisdictional for those National Wetland Inventory (NWI) polygons that were rated as having a high or moderate functional rating by the functional assessment models.

Summarization of jurisdictional scenario modeling results for all sample watersheds is presented in the form of change from the Less Restrictive Scenario. The Most Restrictive Scenario produced the highest number of potentially non-jurisdictional wetland acres with comparative totals ranging from 125% to 1,774% increase in non-jurisdictional wetland acres when compared to the Less Restrictive Scenario. The Very Restrictive Scenario increased non-jurisdictional acres from between 37% to 426% when compared to the Less Restrictive Scenario. In the Cottonwood River Watershed of southern Minnesota, the Most Restrictive Scenario removed more than 50% of the wetland acres with high or moderate water quality function from protection. In the South Platte Headwaters watershed of Colorado, 40 to 45% of the wetland acres were removed from protection for each of the wetland functions. Impacts on wetland function for the Cimarron River watershed in New Mexico were more significant, with greater than 50% of wetland acres for each evaluated wetland function removed from protection.

Results from this project support the conclusion that a narrower definition of jurisdictional waters, as proposed by the current administration, will have a significant impact on the protection of wetlands and waters nationwide. In addition, the risk is more pronounced for ephemeral and isolated wetlands such as those found in semi-arid environments and the glaciated prairie pothole region of the U.S. Many ephemeral and intermittently flowing streams and rivers, and wetlands adjacent to these streams and rivers could be potentially removed from federal protection. Future work could include: further refinement of the spatial models to include additional variables which help adjust and refine each modelling scenario; modelling of the proposed rulemaking as additional details become available from the EPA and USACE; further automation of modelling scenarios to increase accessibility for concerned practitioners; and incorporation of down-scaled climate predictive model outputs to simulate potential changes in precipitation for modelled watersheds.

Introduction

Discharge of pollutants into waters of the U.S., including dredged and fill material, is regulated by the Clean Water Act (CWA) of 1972. Over the last 40 years, the regulatory scope of waters protected under the CWA has been subject to numerous legal challenges and judicial review, including multiple litigation actions in the Supreme Court. The basis for these legal challenges is the premise that the administering agencies of the CWA, the EPA and the USACE, have expanded the jurisdictional scope of federally protected waters and wetlands beyond original Congressional intent.

The 2015 Clean Water Rule (CWR) was published jointly by the EPA and the USACE to address confusion that has persisted around the scope of jurisdictional waters protected under the CWA. The Rule was challenged immediately and the U.S. Court of Appeals for the Sixth Circuit issued a nationwide stay on implementation of the Rule about six weeks after it became effective. On 28 February 2017, the Trump Administration issued an executive order directing the EPA and the USACE to issue a proposed rulemaking for notice and comment to rescind or revise their joint 2015 CWR. The Supreme Court ruled that the Sixth Circuit lacked authority to hear the case, effectively lifting the nationwide stay on the rule in January of 2018. The Trump Administration responded by suspending the rule until February 6, 2020, ostensibly in order to provide more time to develop replacement regulations. That suspension was invalidated, which had the effect of making the rule effective in any state where it was not on hold due to other litigation. Following the suspension, the Administration has also proposed to repeal the CWR and, more recently, replace it with a completely new scheme.

These actions by the Trump Administration signal a move toward a substantially narrower jurisdictional scope for waters protected by the CWA. This move could have major implications for protection of waters and wetlands nationwide, especially for ephemeral and isolated wetlands such as those found in semi-arid environments and the glaciated prairie pothole region of the U.S. The new rule may remove protection from a range of ephemeral and intermittent flowing waters (streams and rivers) and the wetlands that abut or are hydrologically connected to those waters. Removal of these wetlands from federal protection could have detrimental effects on important ecological functions such as streamflow maintenance, water quality management, floodwater storage, and habitat provision.

Given the questions that exist around the jurisdictional extent of the CWA, it is important for public agencies, private corporations and other stakeholders to have an understanding of the waters at stake under different approaches, such as those envisioned by the CWR and a narrower scope of jurisdictional waters advocated by the current Administration. SMUMN GSS, working in collaboration with project sponsors and partners, developed a GIS-based model to compare and contrast the potential spatial extent of regulatory protection for U.S. waters. The model presents two jurisdictional scenarios that draw on distinctions using geographic concepts deemed to be relevant based on opinions from the 2006 Rapanos Supreme Court decision (Scalia and Kennedy) and a third scenario based on concepts embodied in the 2015 CWR. Three geographically and hydrologically diverse case study watersheds were selected for comparative analysis of the spatial extent of potentially jurisdictional and non-jurisdictional wetlands using these three modeling scenarios.

It is envisioned that the data resulting from this analysis will be used as the basis for commentary on proposed changes to the CWR under the new executive order. It is also anticipated that the research and data created through this project will: enhance public education about the CWA (including regional stakeholders, property owners, businesses and others); provide a foundation from which others can continue to investigate the jurisdictional scope of the CWA and the CWR; and extend scientific understanding of the ecological functions and societal services associated with wetlands and other surface waters.

Background

The CWA of 1972[1] established the legal basis for regulating the discharge of pollutants into "navigable waters" of the U.S., defined in the Act as "the waters of the United States, including the territorial seas." The EPA and USACE have interpreted jurisdictional waters broadly to include navigable waters and their tributaries, including wetlands adjacent to these waters.[2] This language in the CWA, along with the claim that the administering agencies have expanded the scope of jurisdictional waters beyond original Congressional intent, has resulted in intense debate, litigation, and judicial review over the last 40 years (Figure 1). Legal challenges to the EPA's and USACE's interpretation of jurisdictional waters reached the Supreme Court in 1985, 2001 and again in 2006, and have redefined the scope of federally protected waters.[3–5]

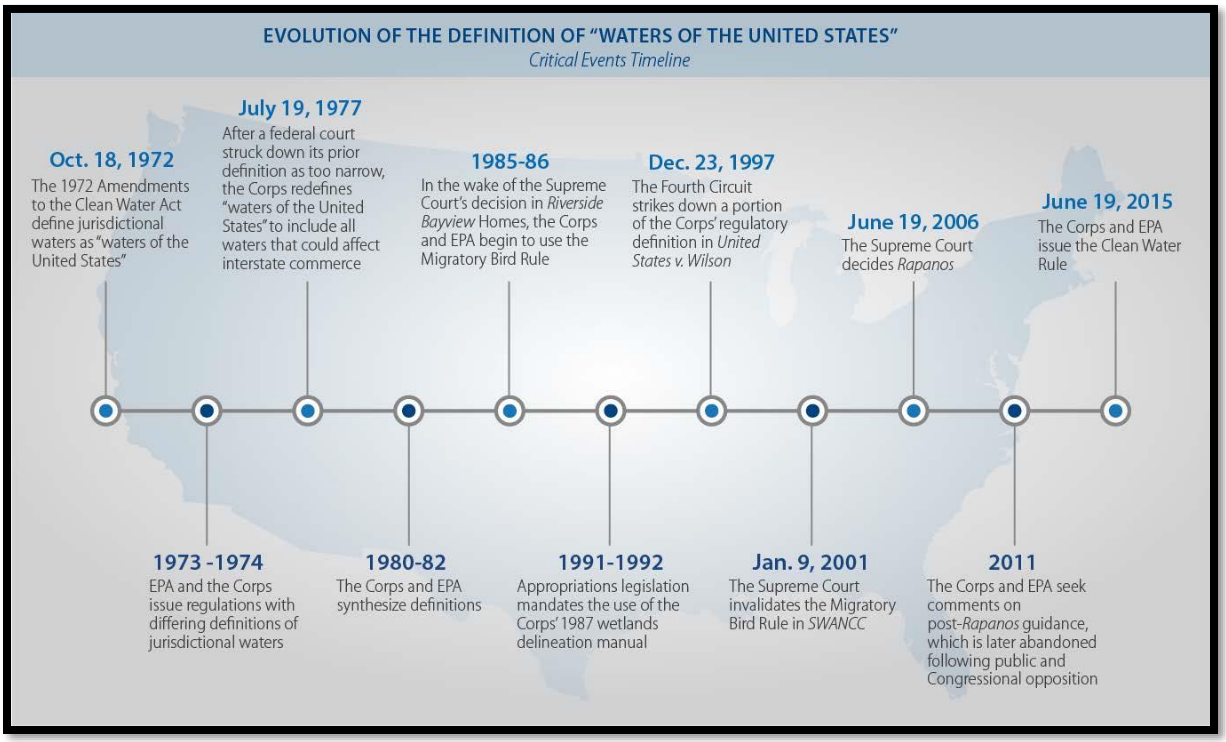

Figure 1. Critical events timeline: Evolution of "Waters of the United States". Congressional Research Service[6]

The Clean Water Rule[7] was published in 2015 by the EPA and USACE with the intent of replacing the EPA-USACE guidance issued in 2008 following the Rapanos decision and to further clarify the scope of waters protected under the CWA. Opponents of the rule claimed that the administering agencies were exceeding their authority in defining the scope of jurisdictional waters and immediately challenged the rule in several courts, where litigation remains ongoing. President Trump signed an executive order in February of 2017 calling on the EPA and USACE to rescind and revise the CWR to incorporate a narrower scope of jurisdictional waters as opined by Justice Scalia in the 2006 Rapanos Supreme Court ruling.[8]

Rapanos Supreme Court Decision

The 2006 Supreme Court case, *Rapanos et al.* v. *United States*, did not clarify disputes over jurisdictional waters but instead added to the confusion.[9,10] In the Rapanos case, the justices split 4-1-4 and ruled against the government, sending the case back to the lower courts for further analysis. However, the Supreme Court did not agree on a standard for jurisdictional determination, resulting in a plurality opinion written by Justice Scalia for four of the justices and a concurring opinion written by Justice Kennedy on behalf of himself. These two opinions offered different criteria for defining the scope of jurisdictional waters and created uncertainty regarding which criteria to apply. The EPA and USACE issued a joint memorandum in 2008 to provide guidance for implementing the Rapanos decision, to determine federal jurisdiction of waters protected under the CWA.[11] Despite the EPA-USACE guidance, confusion persisted, especially regarding the degree to which isolated wetlands and small streams are jurisdictional.[12]

Scalia Plurality Opinion

Justice Scalia's plurality opinion in the Rapanos decision was the narrowest approach in the case to defining federal jurisdictional waters protected under the CWA. He defined waters of the United States to mean only "relatively permanent, standing or flowing bodies of water" found in streams, lakes and rivers, and excludes "ordinarily dry channels through which water occasionally or intermittently flows." Wetlands must have a "continuous surface connection" to bodies that are "waters of the United States" to be considered jurisdictional waters. Isolated wetlands, even those that have an intermittent hydrological connection, are not considered to be jurisdictional waters using Scalia's definition.

Kennedy Concurring Opinion

Justice Kennedy's concurring opinion in the Rapanos decision provided alternative criteria for identifying jurisdictional waters. Kennedy's criteria included adjacent, non-contiguous wetlands without a continuous surface connection if they demonstrated a "significant nexus" with traditional navigable waters. Significant nexus was determined if a wetland "alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity of other covered waters understood as navigable in the traditional sense." Thus, isolated wetlands or wetlands adjacent to intermittent and ephemeral streams could be included as jurisdictional, provided they demonstrated a significant nexus. Major criticism of Kennedy's significant nexus test focused on the lack of guidance in how to implement the test and the administrative burden placed on the EPA and USACE to determine significant nexus, when doing so on a case by case basis.[13]

2015 Clean Water Rule

In 2015, the EPA and USACE jointly published the CWR in an attempt to clarify the confusion that persisted following the Rapanos decision. The Rule centered on the concept of significant nexus and the concurring opinion written by Justice Kennedy in the Rapanos decision. The intent of the 2015 CWR was to ensure that jurisdictional waters covered by the CWA programs were more precisely defined in order to save time and money during the permitting process. Numerous legal challenges were filed after the announcement of the Rule; due to this litigation, implementation has been halted in 28 states, pending resolution of these issues.

The 2015 CWR, while still less inclusive than the 1980s regulations, offers very specific criteria for identifying jurisdictional waters and wetlands. Tributaries are defined in the Rule as features having a defined bed, bank and ordinary high water mark (OHWM). Specific distance criteria are provided for identifying jurisdictional wetlands adjacent to these tributaries. The following sections detailing the criteria for jurisdictional determination under the 2015 CWR were adapted from Copeland's Congressional Research Report.[12]

Categorically Jurisdictional Waters

The following categories of waters are jurisdictional by rule without significant nexus case analysis:

- Traditional navigable waters supporting interstate commerce.
- All interstate waters, including wetlands.
- The territorial seas.
- Tributaries of above waters; these waters must have a bed, bank and OHWM.
- Impoundments of above waters or a tributary.
- All waters, including wetlands, ponds, lakes, oxbows, and similar waters, that are adjacent to a water identified in the above categories.

Specific distance limits are set in the Rule to define adjacent waters:

- Waters in whole or in part within 100 feet of the OHWM of a jurisdictional water.
- All waters located in whole or in part within the 100-year floodplain that are not more than 1,500 feet from the OHWM of a jurisdictional water.
- All waters located in whole or in part within 1,500 feet of the high tide line of a traditional navigable water, the territorial seas, or an interstate water, or within 1,500 feet of the OHWM of the Great Lakes.

Significant Nexus Waters

Subcategories of wetlands are jurisdictional if they are found to have significant nexus to downstream jurisdictional waters: prairie potholes, Carolina bays and Delmarva bays, pocosins, western vernal pools, and Texas coastal prairie wetlands. Additional waters requiring significant nexus analysis are waters located in the 100-year floodplain of a traditional navigable water, interstate water, or the territorial seas, and those waters within 4,000 feet of the OHWM or high tide line of a jurisdictional water. Specific ecological functions demonstrating significant nexus to downstream jurisdictional waters include:

- Sediment trapping,
- Nutrient recycling,
- Pollutant trapping, transformation, filtering, and transport,
- Retention and attenuation of flood waters,
- Runoff storage,
- Contribution of flow,
- Export of organic matter,
- Export of food resources, and
- Provision of life cycle-dependent aquatic habitat (such as foraging, feeding, nesting, breeding, spawning, or use as a nursery area) for species located in a jurisdictional water.

Categorically Excluded Waters

The following waters are categorically excluded from protection in the CWR:

- Prior converted cropland.
- Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of the CWA.
- The following ditches:
  - Ditches with ephemeral flow that are not a relocated tributary or excavated in a tributary.
  - Ditches with intermittent flow that are not a relocated tributary, excavated in a tributary, or drain wetlands.
  - Ditches that do not flow, either directly or through another water, into a traditional navigable water, interstate water, or territorial sea.
- Artificially irrigated areas that would revert to dry land should application of water to that area cease.
- Artificial, constructed lakes and ponds created in dry land such as farm and stock watering ponds, irrigation ponds, settling basins, fields flooded for rice growing, log cleaning ponds, or cooling ponds.
- Artificial reflecting pools or swimming pools created in dry land.
- Small ornamental waters created in dry land.
- Water-filled depressions created in dry land incidental to mining or construction activity, including pits excavated for obtaining fill, sand, or gravel that fill with water.
- Erosional features, including gullies, rills, and other ephemeral features that do not meet the definition of tributary, non-wetland swales, and lawfully constructed grassed waterways and puddles.
- Groundwater, including groundwater drained through subsurface drainage systems.
- Stormwater control features constructed to convey, treat, or store stormwater that are created in dry land.

Modeling Jurisdictional Determination Review

Supreme Court decisions and administering agency guidance has had a direct impact on federal jurisdiction of waters protected by the CWA. The status of protections for a high percentage of intermittent and ephemeral waters and geographically isolated wetlands, particularly in the semi-arid western U.S., under the CWA has been uncertain as a result of implementation of this guidance.[14–16] Development of tools and resource inventories are needed to assist in determining characteristics and mapping of jurisdictional and non-jurisdictional waters.[15,17] Successful implementation of a GIS-based model for analysis of jurisdictional scenarios that draws distinctions using geographic concepts from the Rapanos decision and the 2015 CWR requires modeling of several essential environmental processes: hydrologic connectivity to traditional navigable waters; hydrologic permanence using stream classification; and some form of proximity analysis to determine adjacency and possibly significant nexus.

Determination of jurisdiction is most often done on a case-by-case basis using field surveys, but a few studies have investigated the possibility of using nationally-available datasets and tools to aid in determining jurisdictional waters at the watershed or regional scales. Caruso and Haynes[14] utilized NHDPlus data to develop stream classes based on hydrological permanence and stream order to aid in regional planning and analysis of jurisdictional waters. Vance[16] used buffer proximity to medium and high-resolution National Hydrography Dataset (NHD) hydrography data to categorize streams and identify wetlands that were geographically isolated. In a separate study, Caruso[18] used a GIS-based analysis of stream characteristics in a mountain watershed to produce a three-level hierarchical classification scheme to aid in determining jurisdictional status of waters at a watershed scale. Caruso's methods used nationally-available NHD and U.S. Geological Survey (USGS) StreamStats data along with field observations to classify streams using flow duration, stream order, and other biophysical metrics to aid in determining jurisdictional status.

Methods

Overview

The first step in implementation of this project was to assemble a project advisory committee to provide guidance for model implementation, assessment, and validation of the analysis techniques and results. Members of this committee were drawn from nationwide wetlands and natural resource experts who have a working understanding of the CWA and the CWR, wetland functional assessment, and spatial analysis techniques. Members of the advisory team included:

Kevin Stark - Project Manager, SMUMN GSS
Roger Meyer - GIS Analyst, SMUMN GSS
Andy Robertson - Director, SMUMN GSS
Nick Miller - Senior Wetland Scientist, The Nature Conservancy
Jeanne Christie - Executive Director, Association of State Wetland Managers (ASWM)
Joanna Lemly - Wetland Ecologist, Colorado Natural Heritage Program
Sarah Marshall - Wetland Hydrologist, Colorado Natural Heritage Program
Steve Kloiber - Wetlands Program Manager, MN Department of Natural Resources
Mark Ryan - Principal Lawyer, Ryan & Kuehler PLLC
Jon Devine – Director, Federal Water Policy, Natural Resources Defense Council
Jan Goldman-Carter - Counsel, National Wildlife Federation

Different approaches to modeling were first explored at SMUMN GSS and presented to the advisory group for feedback. Feedback from the group resulted in the following objectives and requirements for development of the GIS model:

- The model should allow users to compare potential jurisdiction of wetlands for three scenarios: a Most Restrictive Scenario and a Very Restrictive Scenario that draw distinctions using geographic concepts deemed relevant in Justice Scalia's plurality opinion and Justice Kennedy's concurring opinion; and, a Less Restrictive Scenario that incorporates some of the guidance from the 2015 Clean Water Rule (Table 1).
- Model input parameters should be user interactive and modifiable for exploratory analysis.
- The model should be simple, transparent, and easy to explain to a general audience.

- The model should use nationally-available GIS datasets.
- The model should be transferable and utilize a process that can be reproduced for other watersheds.

Table 1. Descriptions of the three jurisdictional scenarios utilized in the GIS model.

Scenario Name	Description
Most Restrictive	This scenario limits protection of wetlands to those directly adjacent to perennial (permanent) streams/rivers only.
Very Restrictive	This scenario limits protection of wetlands to those adjacent to protected perennial (permanent) and intermittent (seasonal) streams/rivers.
Less Restrictive	This is the least restrictive of the modeled scenarios and limits protection of wetlands to those adjacent to protected perennial, intermittent and ephemeral (temporary) streams, and ditched or channelized streams.

With technical guidance provided by the advisory group, SMUMN GSS developed the jurisdictional scenario models using ESRI's ArcGIS ModelBuilder. The goal was to produce a flexible, interactive and transferable modeling tool that allowed users to view potentially jurisdictional and non-jurisdictional wetlands within a watershed using model criteria developed for the jurisdictional scenarios. Three case study watersheds were chosen by the group for comparative analysis of the scenarios. As part of this analysis, wetland functional assessments were performed to determine potential jurisdictional impacts on broad wetland functions within the case study watersheds.

Model Development and Interface

ArcGIS ModelBuilder was chosen for development of the GIS model for the project. ModelBuilder is a visual programming interface that can be used for building geoprocessing workflows or models. These geoprocessing models automate and document the spatial analysis process, providing a transparent and effective way to document and distribute processing methods. Within ModelBuilder, the user can link multiple tools and submodels together into a single geoprocessing workflow, which can then be packaged and distributed to other users as a toolbox (Figure 2). A user with ModelBuilder experience can step through the model, observe intermediate output to better understand how the model is working, and easily make modifications to the model if desired.

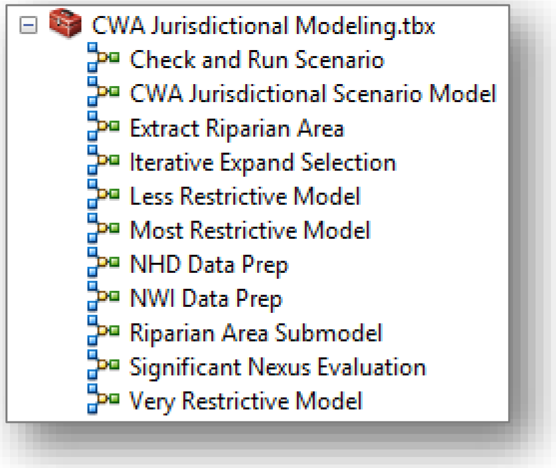

Figure 2. CWA Jurisdictional Modeling toolbox containing the jurisdictional scenario models.

Table 2 provides a general description of the models stored in the CWA Jurisdictional Modeling toolbox in ArcGIS. The tools are documented with help metadata to assist users with the input data requirements and determining the model parameters that are needed to run the model. The *CWA Jurisdictional Scenario Model* as seen in the toolbox is the main model that the user interacts with to run the jurisdictional scenarios. The other models contained in the toolbox are submodels linked together in the main model that perform specific functions in the scenario modeling workflow (Figure 3). The *CWA Jurisdictional Scenario Model* identifies potential jurisdictional and non-jurisdictional wetlands in a watershed using three different modeling scenarios. The *Very Restrictive* scenario assumes the jurisdictional scope of wetlands protected under the CWA is limited to wetlands that are adjacent to jurisdictional perennial and intermittent streams and rivers. The *Most Restrictive* scenario is the least protective and assumes the jurisdictional scope of wetlands protected under the CWA is limited to wetlands that are adjacent to perennial streams and rivers only. The *Less Restrictive* scenario assumes the jurisdictional scope of wetlands protected under the CWA includes wetlands adjacent to jurisdictional perennial, intermittent, and ephemeral streams, and tributary ditches. None of these scenarios is directly reflective of a specific legal opinion, as nationwide spatial datasets that replicate the criteria of each decision are not available.

The *CWA Jurisdictional Scenario Model* can run directly from the graphical ESRI ModelBuilder interface as seen in Figure 3 or from the tool user interface as seen in Figure 4. The user is required to designate an output geodatabase workspace, select a modeling scenario, input the NHD and NWI datasets, and a feature class representing the nearest downstream, jurisdictional traditionally navigable water (TNW). If running the *Less Restrictive* scenario, the user needs to also select a riparian area model and the input data for creating the riparian area model.

Model parameters provide the option to model wetland-to-wetland connectivity in the modeling scenarios using a user-specified distance, or to add a buffer restriction distance also using a user-specified distance. The wetland-to-wetland connectivity option will do a series of iterative adjacent-to-adjacent selection queries on the initial jurisdictional wetland selection set to add additional wetlands to the jurisdictional selection set that are connected within the user-specified distance. The buffer restriction option will do a final select-by-location query on the jurisdictional selection set that will remove any wetlands that are beyond the user-specified buffer distance from the NHD and NWI lake jurisdictional waters. Finally, the user has the option for the *Less Restrictive* scenario to enter a

SQL expression to extract any pre-determined categorical significant nexus wetlands from the input NWI dataset.

Table 2. Description of ArcGIS ModelBuilder models in the CWA Jurisdicitonal Modeling toolbox. TNW = traditionally navigable water, RPW = relatively permanent waters.

Model Name	Model Description
Check and Run Scenario	This is a utility model that checks to see what scenario model has been selected by the user (i.e., *Most, Very, Less Restrictive*). Output true/false Boolean variables determine which branch of the model will run based on the user selection.
CWA Jurisdictional Scenario Model	This is the main model which runs the jurisdictional scenario models. All the other models in the toolbox are linked together in this model in a single geoprocessing workflow.
Extract Riparian Area	This is a submodel called by the CWA Jurisdictional Scenario Model which extracts the riparian areas used for the less restrictive scenario model and significant nexus evaluation. The model requires a minimum input of SSURGO, LLWW with LR and LS attributes, or FEMA flood zone data. The user has the option to combine and dissolve this data together into a single riparian area mask by selecting the desired riparian area model (options are FEMA, SSURGO, LLWW, FEMA_SSURGO_LLWW, FEMA_SSURGO, FEMA_LLWW, or SSURGO_LLWWW).
Iterative Expand Selection	This is a utility model which does an iterative selection of all adjacent polygons within a user-specified distance. The model requires an initial selection set of polygons as input.
NHD Data Prep	This model extracts NHD flowlines that are flow-connected to the input downstream TNW feature. These flowlines represent RPWs which are used in proximity analysis to determine potential wetland jurisdiction. The NHD FCode is used to extract NHD perennial, intermittent, ephemeral or ditches connected to the TNW. Isolated flowlines are removed. The extracted flowlines include NHD connectors and artificial paths.
NWI Data Prep	Submodel that extracts and dissolves bordering palustrine NWI polygons that will be used for the jurisdictional evaluation. NWI lacustrine polygons without the K water regime are also extracted from the NWI dataset for use as RPWs in the jurisdictional evaluation of the dissolved palustrine wetlands.
Riparian Area Submodel	Submodel called by the Riparian Area Model which uses select by attribute queries to extract the initial riparian area from the FEMA, LLWW or SSURGO input data. SSURGO query: muname LIKE 'Water%' OR geomdesc LIKE '%flood%' OR taxsuborder LIKE '%Fluv%' OR flodfreqdcd IN (‘Rare’, ‘Frequent’, ‘Occasional’, 'Very frequent’); LLWW lotic query: LLWW LIKE 'LR%' OR LLWW LIKE 'LS%’; FEMA query: FLD_ZONE IN ('A' , 'AE', 'AH', 'AO').
Very Restrictive Model	Submodel called by the main model that models a very restrictive scenario. NHD perennial and intermittent streams are used in the selection criteria.
Most Restrictive Model	Submodel called by the main model that models the most restrictive scenario. Only NHD perennial streams are used in the selection criteria.
Significant Nexus Evaluation	Submodel that identifies and flags significant nexus wetlands for the Less Restrictive jurisdictional model.
Less Restrictive Model	Submodel called by the main model that models the most protective scenario. NHD perennial, intermittent, ephemeral streams, and ditches are used in the selection criteria.

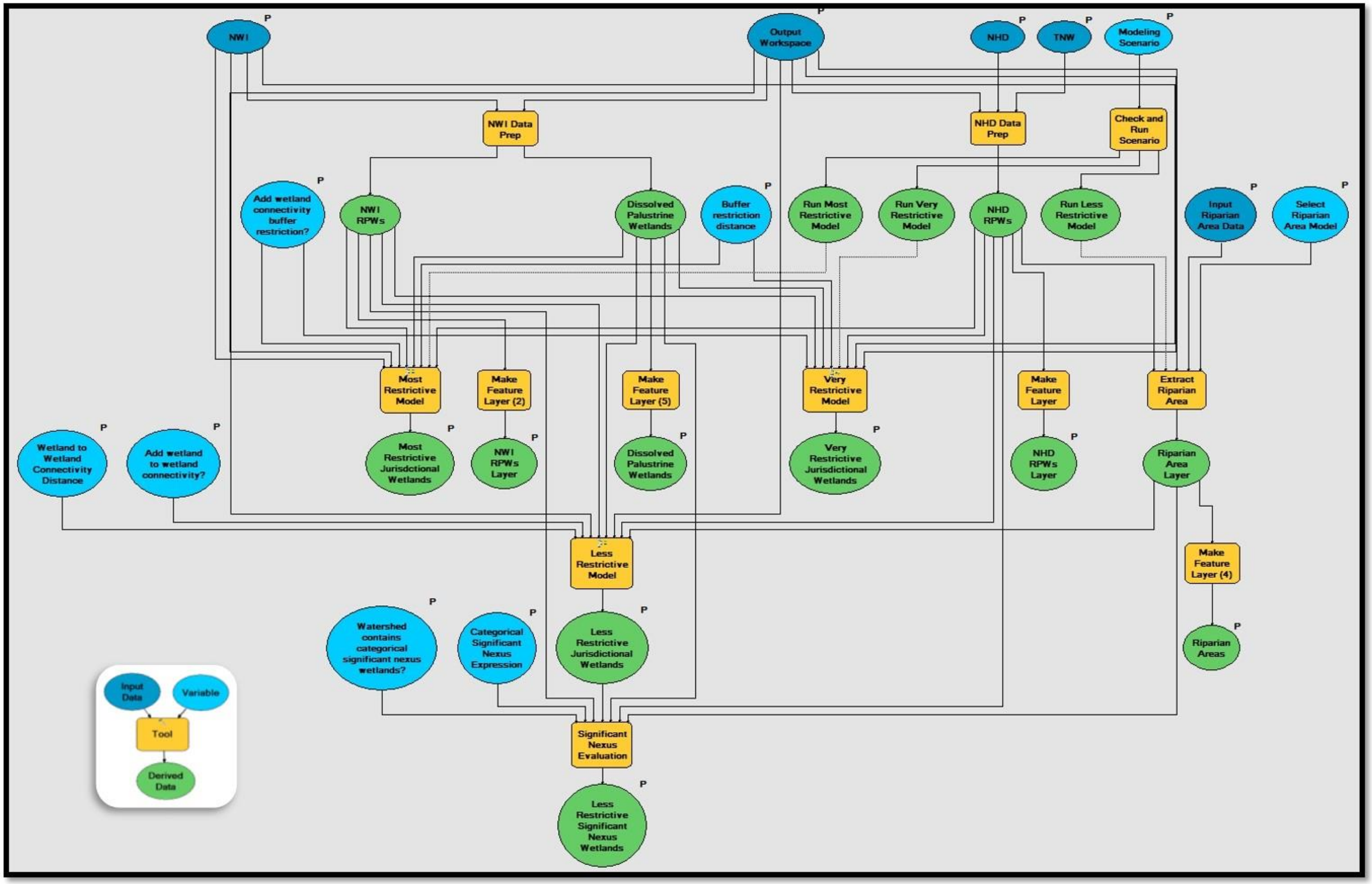

Figure 3. View of the main CWA Jurisdictional Scenario Model in the ArcGIS ModelBuilder graphical interface, showing how the model is composed of multiple submodels linked together in a geoprocessing workflow.

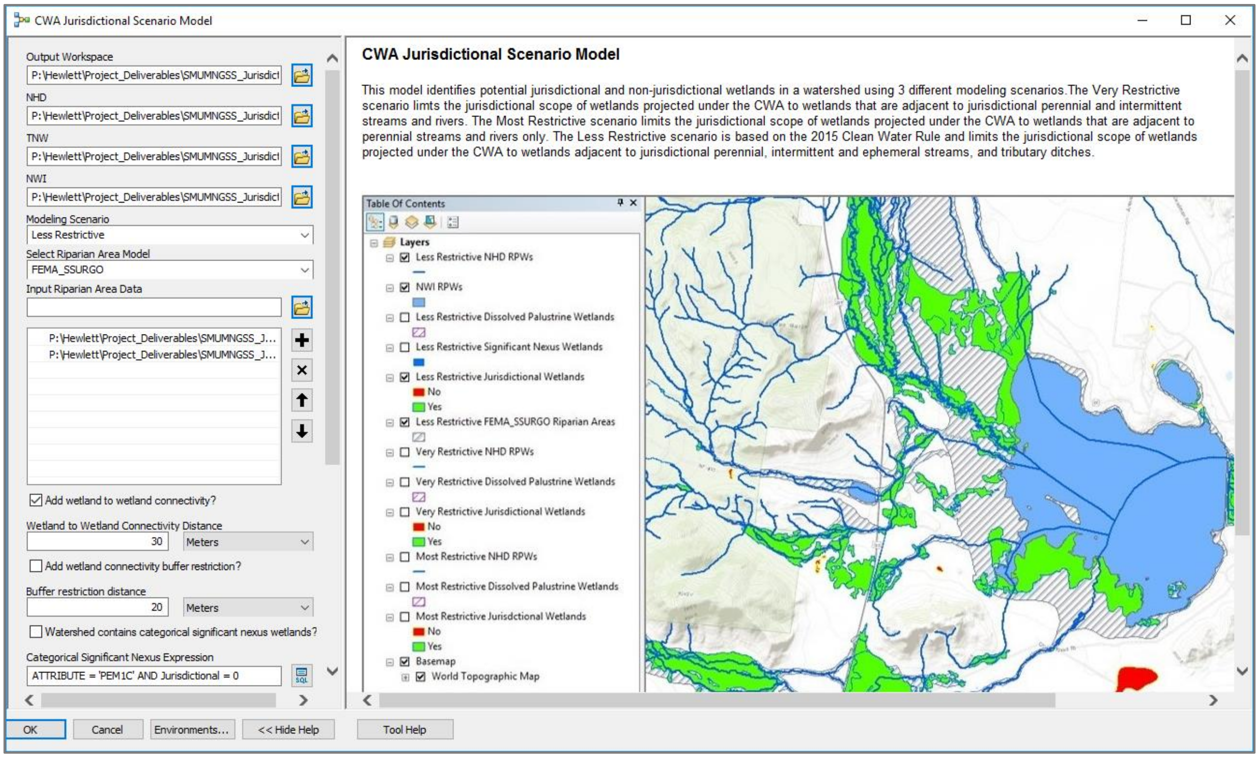

Figure 4. Tool user interface for the *CWA Jurisdictional Scenario Model*.

Model Input

One of the model requirements was to leverage nationally-available GIS datasets for model input data. Use of nationally-available datasets allows the model to be easily transferable to other geographic areas and watersheds. The *CWA Jurisdictional Scenario Model* requires three primary input datasets: the NHD, Soil Survey Geographic Database (SSURGO) soils data, and NWI wetland data.

NHD Hydrography Data

The NHD dataset is produced by the USGS and provides digital vector GIS data representing surface water features and the water drainage network of the United States. NHD is available at medium resolution (1:100,000 scale) or high resolution (1:24,000 scale). NHD data can be downloaded using the National Map Download viewer by state or Hydrologic Unit Code (HUC) subbasin.

It was determined from meetings with the advisory group that successful modeling of the jurisdictional scenarios would be highly dependent on the accurate classification of hydrography (i.e., identifying streams as perennial, intermittent, ephemeral, and ditches) within a watershed. Accurate classification of streams in a watershed would normally require intensive field work, which was beyond the scope and budget of this project. Other approaches to capture additional ephemeral and intermittent headwater streams that are not typically mapped or detected in NHD, such as deriving synthetic streams from a digital elevation model (DEM), were explored, but the issues of accurate classification of the resulting synthetic streams still remained an issue. Ultimately, it was concluded that despite the variability and accuracy of classification of NHD streams in some geographic areas, high resolution NHD was the best nationally-available hydrography dataset for model input. Proximity analysis of wetlands to NHD streams/rivers types is one of the major modeling components in determining jurisdictional status of wetlands for the three modeling scenarios.

SSURGO Data for Floodplain Mapping

The SSURGO is a digital soils database produced by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The SSURGO database contains soil map units linked to a relational database, which can be used to derive the proportionate extent of the component soils and their properties. ESRI provides a SSURGO Downloader application that can be used to download soils data by HUC8. Soil map units have been pre-compiled with ready-to-use attributes eliminating the pre-processing steps previously required to work with the soils data.

Model criteria for the *Less Restrictive* jurisdictional scenario requires a representation of the floodplain for determining categorically jurisdictional wetlands and for identifying significant nexus wetlands. There are many GIS techniques for modeling floodplains, ranging from basic topographic analysis of DEMs to highly complex 2D/3D hydraulic models. Most of these techniques rely on informed user input of modeling parameters. SSURGO data offers a convenient method to model flood inundation with nationally-available data, and has been found to be as effective as methods using DEMs.[19] An attribute query of SSURGO data is used to extract a model of riparian areas (Figure 5). These extracted SSURGO floodplain/riparian areas can be combined in the model with FEMA and LLWW lotic features if they are available for the watershed to generate a more comprehensive model of flooded riparian areas.

```
muname LIKE 'Water%' OR geomdesc LIKE '%flood%' OR
taxsuborder LIKE '%Fluv%' OR flodfreqdcd IN ('Rare',
'Frequent', 'Occasional', 'Very frequent')
```

Figure 5. SSURGO query for extracting riparian areas.

NWI and NWI-Plus Data

NWI data, managed by the U.S. Fish and Wildlife Service (USFWS), is a public, nationally-available dataset that provides detailed GIS vector data of nationwide wetlands and deepwater habitats. Wetland data is mapped and classified using a wetland classification system developed by the NWI program.[20] NWI data can be downloaded using the NWI Wetlands Mapper application.

NWI-Plus attributes, also referred to as LLWW, are hydrogeomorphic descriptive attributes that describe wetland landscape position, waterbody, landform, and waterflow path. These attributes are added to NWI by skilled interpreters using digital raster graphics (DRGs), hydrographic data such as NHD, and aerial imagery. The combination of these attributes with standard NWI attributes are used to facilitate the prediction of wetland function. These attributes are not included with downloaded NWI data and are not needed to run the modeling scenarios. However, for this project the NWI-Plus attributes are used as an option for generating the riparian area floodplain for the *Less Restrictive* scenario model and also for determining potential jurisdictional impacts on wetland function within a watershed. NWI-Plus data for the Cottonwood River and Cimarron River watersheds was developed by GSS SMUMN. NWI-Plus data for the South Platte Headwaters watershed was developed by the Colorado Natural Heritage Program. [21]

Model Function and Scenario Criteria

All of the modelled scenarios in this project are translated into criteria that can be processed and modeled in a GIS. In general, this process uses a series of select-by-attributes and select-by-location spatial queries to identify jurisdictional and non-jurisdictional wetlands for each scenario. The basic model function is to first use the translated scenario criteria to extract NHD relatively permanent waters (RPWs) that are flow-connected to the nearest downstream jurisdictional TNW. For example, for the *Most Restrictive* scenario, only perennials that are connected to the downstream TNW would be extracted as NHD RPWs. RPW lakes that are not artificially flooded are also extracted from the NWI data. Next, palustrine wetlands are extracted from the NWI data and all bordering polygons are dissolved. A single wetland complex can be composed of multiple NWI polygons that contain different descriptive attributes (

Figure **6**). The dissolved palustrine polygons are used in the proximity analysis to determine whether the polygon can be considered jurisdictional based on scenario distance criteria from the NHD and NWI Lake RPWs. Wetlands are flagged in the attribute table with a value of 0 if they are non-jurisdictional and a value of 1 if they are jurisdictional. The jurisdictional determination for a dissolved palustrine polygon is then transferred to all NWI polygons contained within the dissolved polygon.

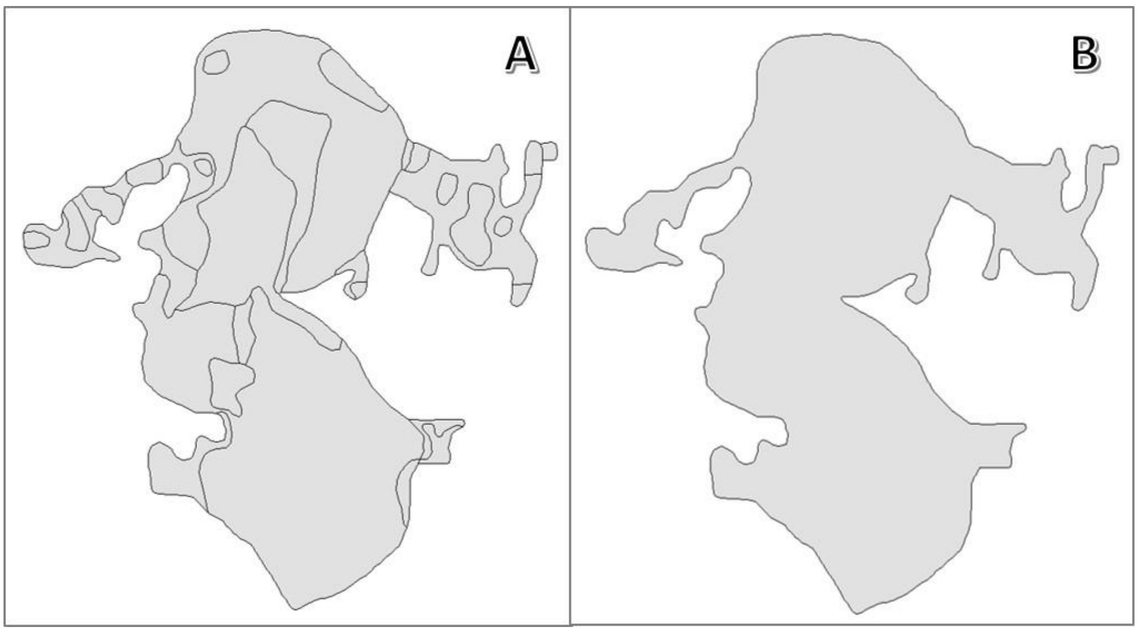

Figure 6. (A) Undissolved NWI palustrine polygons, (B) dissolved NWI palustrine polygons.

Very Restrictive and Most Restrictive Model Criteria

For the scenarios guided by the 2006 Rapanos decision, less (*Most Restrictive)* and more (*Very Restrictive*) protective scenarios are modeled. The *Most Restrictive* scenario provides less federal protection for wetlands by limiting the classes of NHD streams that are considered jurisdictional. For example, wetland jurisdiction for the *Most Restrictive* scenario is based on proximity to NHD RPW perennial streams only, whereas the *Very Restrictive* scenario is based on proximity to NHD RPW perennial and intermittent streams. The specific model criteria used by these scenarios is as follows:

- Wetlands intersecting with a “continuous surface connection” to the nearest TNW and RPWs are adjacent and jurisdictional.
- NWI lacustrine polygons (ATTRIBUTE LIKE ‘L’) that are not artificially flooded are jurisdictional RPWs.

- Stream and river jurisdictional RPWs are NHD perennials for the *Most Restrictive* scenario, and perennial and intermittent streams and rivers for the *Very Restrictive* scenario that are connected by flow to the nearest downstream TNW.
- Wetlands intersecting RPW lakes and RPW streams/rivers are jurisdictional.
- NWI palustrine wetlands with the K water regime, or the d (drained), x (excavated) or f (farmed) modifiers are excluded from the jurisdictional selection.

Less Restrictive Model Criteria

For the *Less Restrictive* scenario based on aspects of the 2015 CWR, proximity of wetlands is evaluated using NHD RPW perennial, intermittent and ephemeral streams, and ditches. The specific model criteria used by the *Less Restrictive* scenario are as follows:

- Adjacency is defined by specific distance criteria given in the 2015 CWR.
- NWI lacustrine polygons (ATTRIBUTE LIKE 'L') that are not artificially flooded are jurisdictional RPWs.
- Stream and river jurisdictional RPWs are NHD perennial, intermittent, ephemeral and ditches connected by flow to the nearest downstream TNW.
- Wetlands intersecting within 100 ft of RPW lakes and RPW streams/rivers are jurisdictional by rule.
- Wetlands intersecting the floodplain and within 1,500 ft of a RPW are jurisdictional by rule.
- By default, wetland-to-wetland connectivity is modeled for this scenario (i.e., all adjacent-to-adjacent of the initial jurisdictional selection set within the user-specified distance are added to the final jurisdictional selection set).
- NWI palustrine wetlands with the K water regime or f modifier are excluded from the jurisdictional selection.
- Significant nexus wetlands are flagged if a categorical SQL query is input or if the wetland intersects the riparian area floodplain, and is greater than 1,500 ft but less than 4,000 ft from an NWI or NHD RPW.

Model Output

If running the *CWA Jurisdictional Scenario Model* from the ModelBuilder interface, the model spatial output layers will be added directly to an open ArcMap document using predefined layer symbology (Figure 7). Table 3 contains descriptions of the spatial layers output by the scenario models. The output layer names will vary depending on the scenario that is modeled. Spatial output layers are prefixed with the scenario name (i.e., *Less Restrictive*, *Very Restrictive*, *Most Restrictive*).

Table 3. Description of model output layers.

Output Layer Name	**Layer Description**
"Scenario Name" Jurisdictional Wetlands	Layer containing NWI wetland polygons that have been identified as jurisdictional (value of 1) and non-jurisdictional (value of 0)
"Scenario Name" Dissolved Palustrine Wetlands	Dissolved palustrine polygons that were used for proximity analysis
"Scenario Name" NHD RPWs	The extracted scenario NHD RPWs
Less Restrictive *"Riparian Area Model"* Riparian Areas	The riparian area floodplain that was used by the *Less Restrictive* modeling scenario; layer name will vary depending on riparian area model selected by the user
NWI RPWs	Extracted Lacustrine NWI RPWs
Less Restrictive Significant Nexus Wetlands	NWI wetland polygons flagged as potentially significant nexus wetlands when running the *Less Restrictive* model scenario

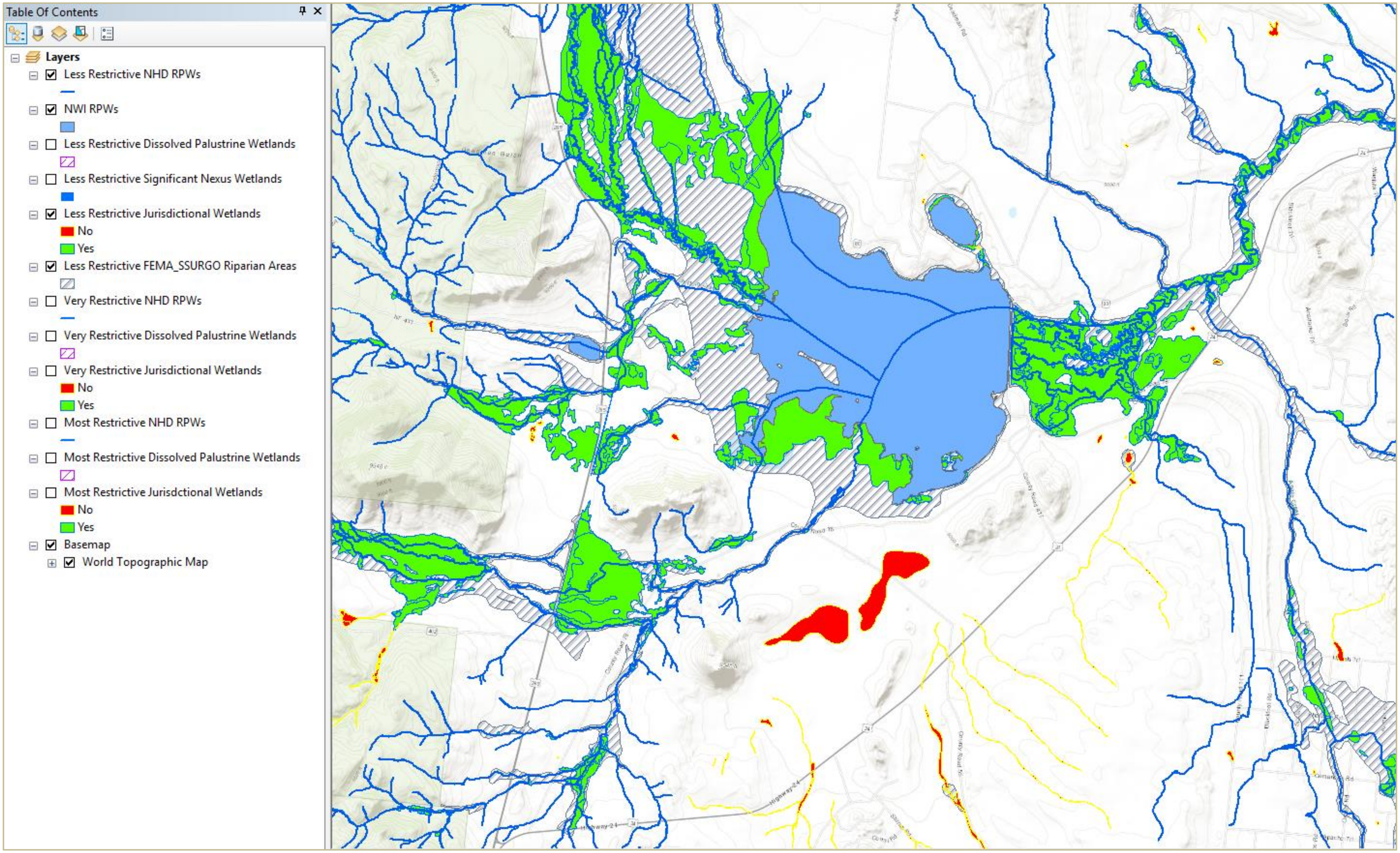

Figure 7. Example of model output in ArcMap, if running the model from the ArcGIS ModelBuilder interface.

Wetland Functional Assessment

Advancements in wetland mapping over the past decade have focused on extending traditional inventories to include additional abiotic metrics that further describe wetland resources. These hydrogeomorphic metrics, such as landscape position, hydrologic connectivity, landform and water body type, can contribute to an understanding of the ecological functions provided by particular wetland types. Using a best professional judgement and field reconnaissance process, wetland scientists have developed correlation tables that link existing wetland classification metrics (biotic and abiotic) to the predicted performance of various ecological functions. These functional assessments can then be used to provide an indication of ecological gain or loss across a project study area when wetlands are added (restoration, enhancement) or removed (dredge, drain, or fill) from jurisdictional protection.

Wetlands play an important role in the ecological balance of natural landscapes. In the past, wetlands were drained and filled without much consideration of their value. It is now commonly understood that wetlands provide essential physical, chemical, and biological processes that help maintain the integrity of the surrounding environment. These functions are recognized as particularly crucial in semi-arid regions such as New Mexico, where only a small percentage of the land area is occupied by wetlands.

Wetlands are called the "kidneys of the landscape"[22] due to their function as headwater and downstream receivers of water and waste from both natural and human sources. They stabilize water supply, lessening the extreme effects of flood, drought, and fire. Wetlands are critical to the food chain and biodiversity, with a significant percentage of terrestrial animals using wetlands for a portion of their life cycle. On a global scale, wetlands contribute to the stability of worldwide levels of available nitrogen, atmospheric sulfur, carbon dioxide and methane.[21] Wetlands are important sinks for carbon and increase landscape resilience and adaptation to climate change. Finally, functioning wetlands directly provide services to humans in the form of food, air and water quality, flood attenuation, energy resources (peat), recreation, and aesthetic values.

Wetlands perform a number of ecological functions that help improve and maintain environmental quality. When natural wetlands are degraded or filled, some wetland functions may still occur through human intervention or technology. Healthy natural wetland systems provide functions most effectively in terms of cost and performance. Four wetland functions were examined to determine potential jurisdictional scenario impacts on wetland function within the case study watersheds of this project.

Fish Habitat (FSH) – Wetlands performing the FSH function provide an environment for various portions of the aquatic life cycle. The FSH function provides an indication of the capacity to support an abundance of native fish species for functions other than spawning (e.g., cover/refugia, foraging, and connectivity). Organisms essential to fish survival depend on wetlands to survive. Wetlands provide spawning and nursery areas, and wetland vegetation provides cover for small and young fish avoiding predators. Shade provided by wetland trees or shrubs also helps maintain cooler water temperatures for cold water species.

Water Quality (WQ) – Wetlands can break down nutrients from natural sources, fertilizers, or other pollutants in a process known as nutrient transformation, thereby providing treatment of pollutants in storm water runoff. Nutrient transformation refers to the natural chemical processes that remove or recycle compounds in the environment. In the case of many wetlands, nitrates and phosphorous from agricultural runoff are the primary nutrients of concern. The WQ function provides a measurement of the effectiveness of a wetland and wetland vegetation in chemical absorption, conversion and retention of these organic compounds. Wetlands are perhaps the most effective component of the landscape in removing nitrate from surface water particles, acting as a sink for excess nitrogen. In terms of phosphorus retention, sediment dynamics and local geology are the determining factors in whether a wetland is a source, sink, or convertor of phosphorus over long periods of time (>1 growing season). Nutrients are prevented from moving further through the watershed either through storage or by wetland vegetation using the nutrients for their own life cycle.

Wetlands also improve water quality by physically trapping particles in a process referred to as sediment retention. In addition to nutrient transformation, the WQ function provides a measurement of a wetland's effectiveness in filtering and intercepting suspended inorganic particles. In contrast to nutrient transformation, which involves chemical processes, sediment retention is a physical process where the suspended particles are filtered by the soil and plant roots. This removal of suspended particles helps to improve water clarity and helps maintain cooler temperatures on cold water streams. Generally, wetlands perform the WQ function if they are vegetated with herbaceous plants and are flooded seasonally, semi-permanently, permanently, or intermittently.

<u>Flood Protection (FP)</u> - Wetlands capture and store surface water from precipitation or spring snow melt. The FP function provides a measurement of the effectiveness of a wetland to store or slow the flow of surface water. Water is then slowly released through surface or underground hydrologic networks. In general, depression wetlands that capture and store precipitation or runoff are performing the FP function. This important function also provides groundwater recharge points found in wetlands near stream or river floodplains or in lake basins, fringe areas, or islands. From the human perspective, this process equates to lower, shorter-duration, and less-frequent peak flood levels downstream.

<u>Wildlife Habitat (WH)</u> - A number of bird species rely on wetlands and associated habitats for survival. The WH function provides an indication of the capacity to support an abundance and diversity of feeding and nesting water birds. Wetlands performing this function provide semiaquatic or riparian habitats for many species of waterfowl, water birds or shorebirds. Depending on the species, critical water bird habitat is typically associated with open water in lakes, or forested ponds or streams.

Case Study Watersheds

For comparative analysis of the jurisdictional scenarios, three geographically-diverse case study watersheds were selected: the Cottonwood River Watershed in Minnesota, the South Platte Headwaters Watershed in Colorado, and the Cimarron River Watershed in New Mexico. Selection of case study watersheds was limited by the availability of NWI wetlands data containing the NWI-Plus attributes.

Cottonwood River Watershed, MN

The Cottonwood River Watershed (USGS HUC 07020008) encompasses approximately 1,284 square miles and is located in southern MN (Figure 8). The Cottonwood River flows into the Minnesota River which is a TNW, regulated under the CWA. According to the Minnesota Pollution Control Agency (MPCA) [23], the Cottonwood River watershed is mostly agricultural with 88% of the land in cultivation. The remaining land consists of 6% grassland, 1% wetlands or water, and only about 3% forested land. The climate within the Cottonwood River Watershed is continental, with cold dry winters and warm wet summers, and annual precipitation ranging from 26 to 29 inches. NHD streams and rivers in the watershed are mostly classified as perennial or intermittent (65% intermittent, 21% perennial, and 7% ditches).

South Platte Headwaters Watershed, CO

The South Platte Headwaters Watershed (USGS HUC 10190001) encompasses approximately 1,604 square miles and contains the headwaters of the South Platte River, a designated TNW protected under the CWA (Figure 9). The watershed is characterized by an intermontane valley surrounded by steep, high mountains. Majority land use in the watershed is composed of 51% rangeland/grassland and 40% forest. The climate is continental, semi-arid and heavily influenced by the local mountainous terrain. Droughts are frequent, with precipitation falling in the valleys in spring and late summer as brief, intense rain events and in the mountains as snowfall during the winter months. Annual precipitation ranges from 30 to 40 inches in the surrounding higher elevation alpine forests to 11 inches in the semiarid intermontane valley at lower elevations. Surges in water flow in the South Platte River occur during the spring snowmelt. NHD streams and rivers are mostly classified as intermittent, ephemeral, and perennial (46% intermittent, 11% perennial, 33% ephemeral, 2% pipeline, and 5% ditches).

Cimarron River Watershed, NM

The Cimarron River Watershed (USGS HUC 11080002) is located in northeastern NM and drains approximately 1,049 square miles (Figure 10). The watershed is part of the Canadian River Basin that eventually drains to the Mississippi River. The Canadian River is the nearest downstream TNW connected to the Cimarron River. Most of the land in the watershed is privately owned and undeveloped. According to the New Mexico Environment Department's Surface Water Quality Bureau[24], land use in the watershed is composed of 51% forest, 31% grassland, 16% shrubland, 2% agricultural, and <1% urban. The arid to semiarid climate is characterized by wide variations in annual precipitation totals. Annual precipitation ranges from 30 inches in the higher elevation alpine forests in the west to 15 inches in the semiarid grasslands at lower elevations in the east. Flow of surface water is highly influenced by snowmelt in the higher elevations and by brief but intense rainfall events that typically occur during the summer months. NHD streams and rivers are mostly classified as intermittent (73% intermittent, 16% perennial, 4% ephemeral, and 5% ditches).

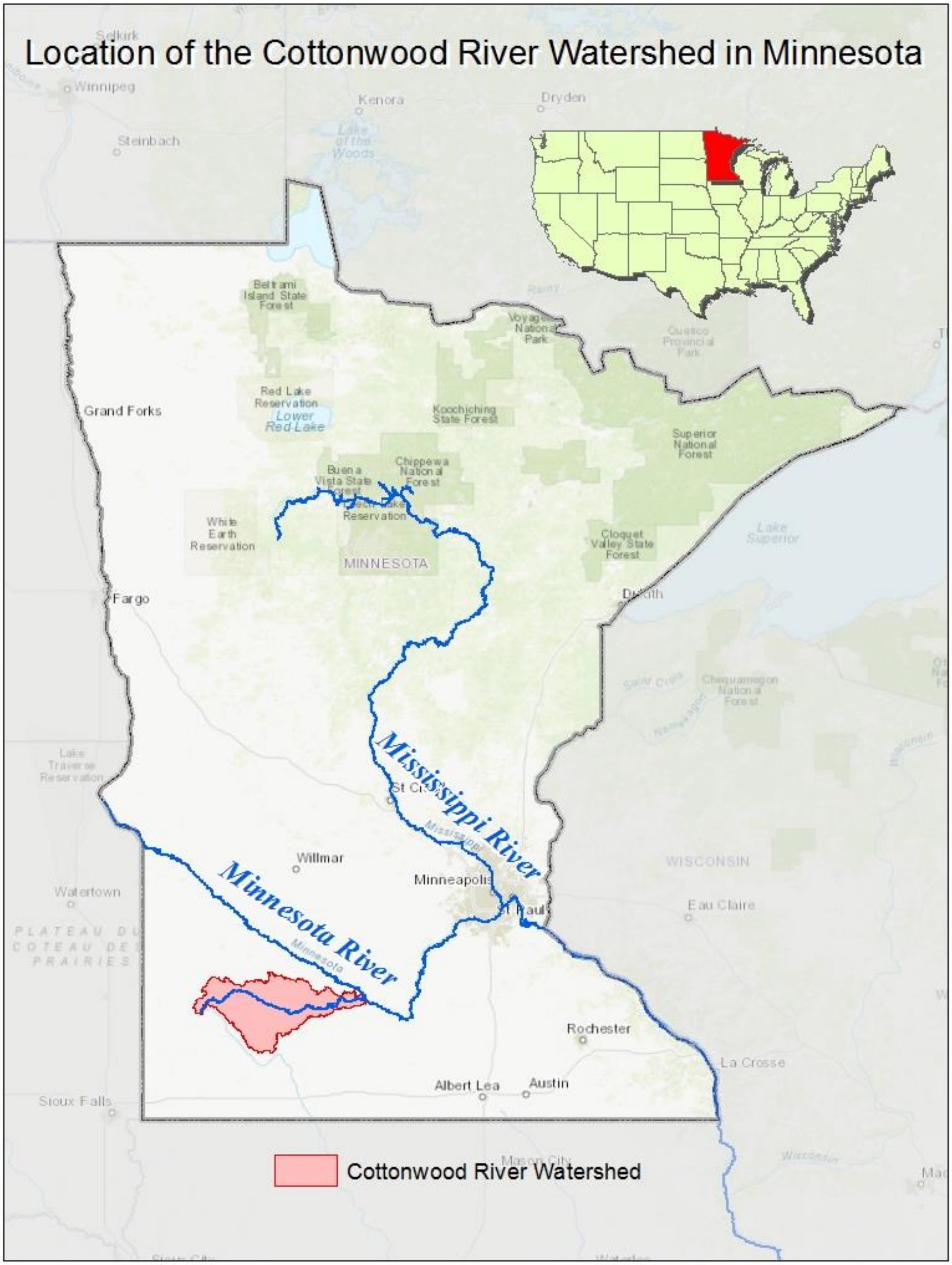

Figure 8. Location of Cottonwood River Watershed in Minnesota.

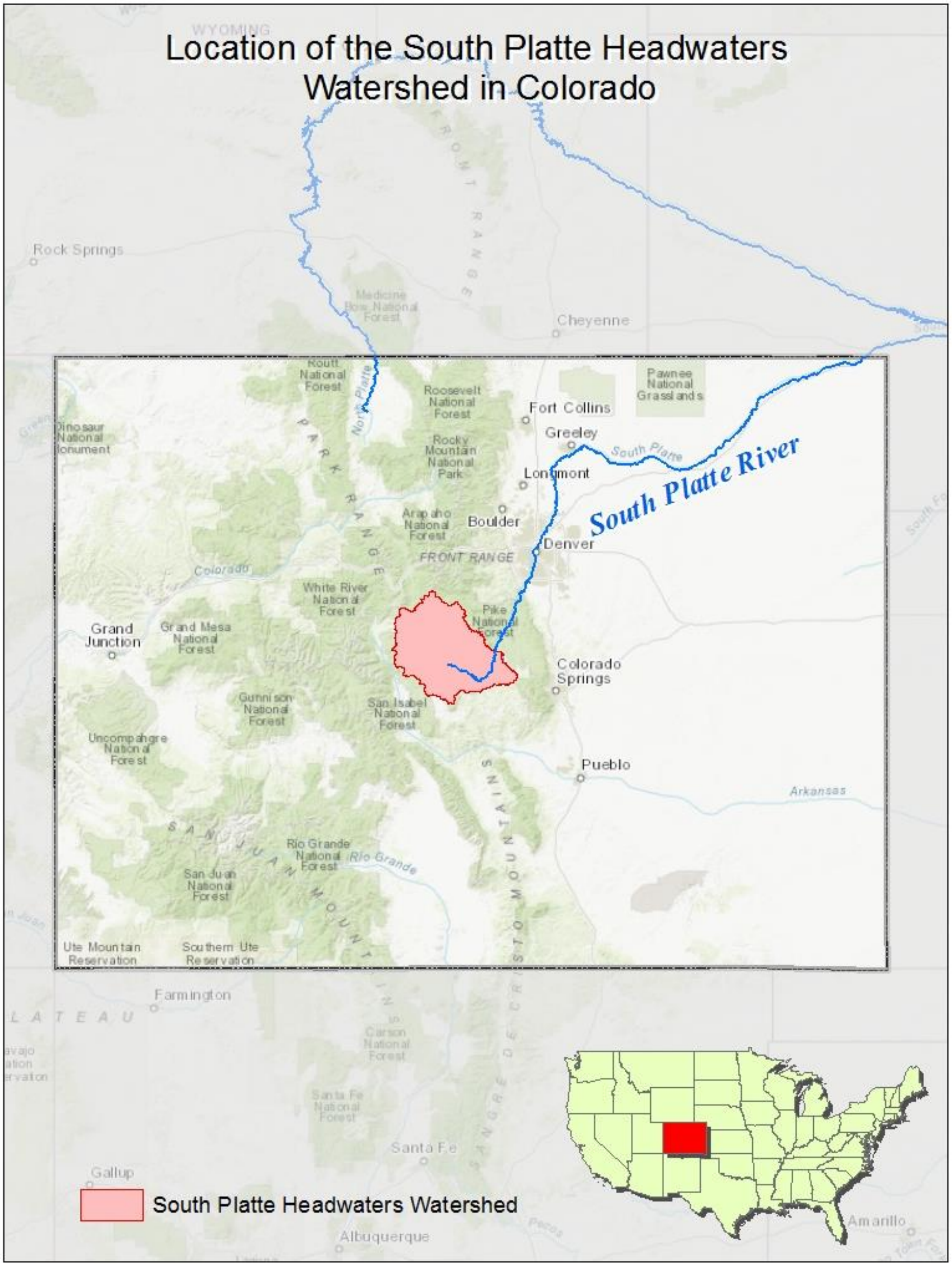

Figure 9. Location of the South Platte Headwaters Watershed in Colorado.

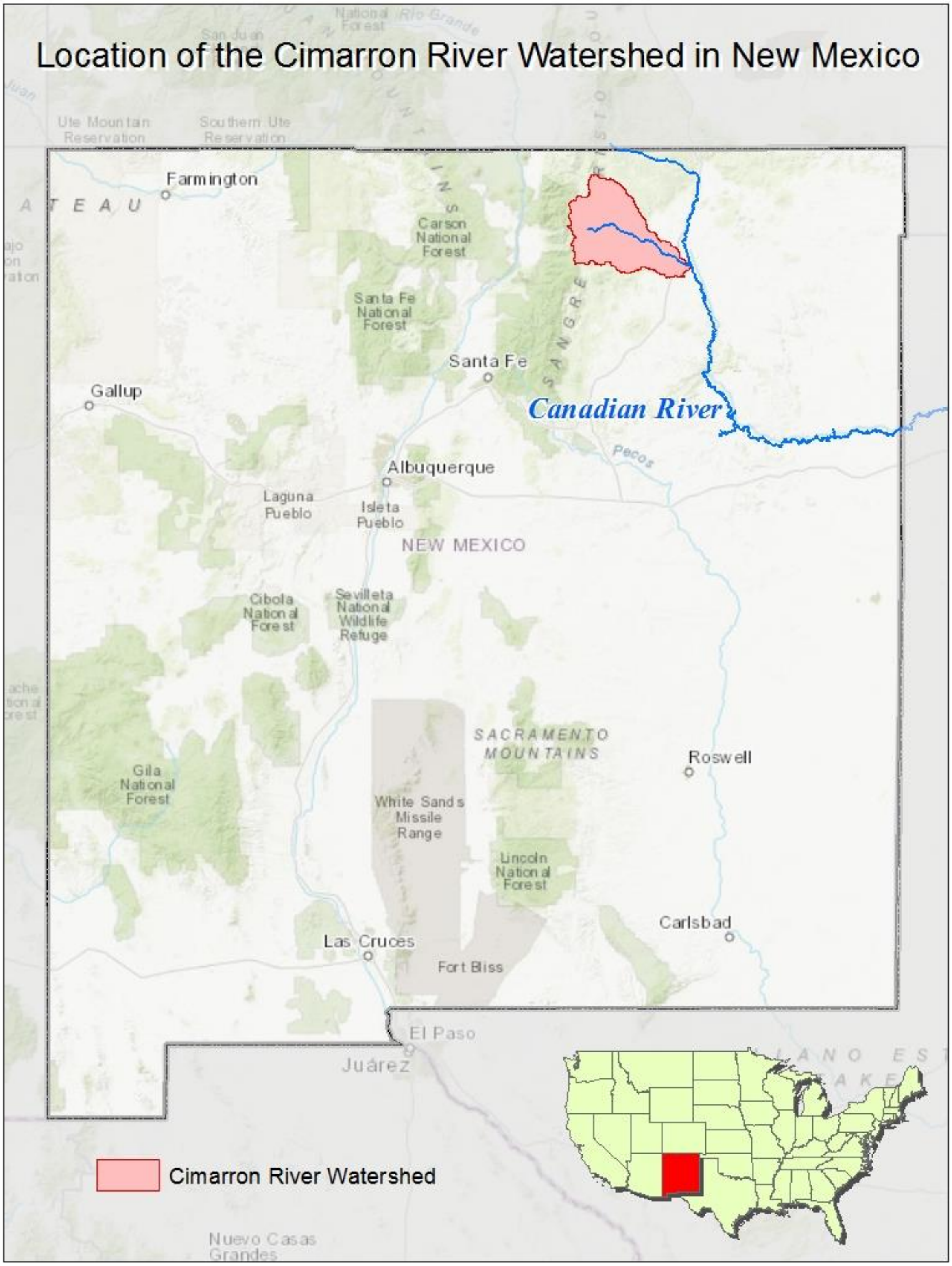

Figure 10. Location of Cimarron River Watershed in New Mexico.

Results

Overview

Results of the jurisdictional scenario models for each case study watershed were summarized for comparative analysis of the spatial extent of jurisdictional and non-jurisdictional wetlands. Total jurisdictional and non-jurisdictional wetland acres, percent of total jurisdictional and non-jurisdictional wetland acres, number of jurisdictional and non-jurisdictional wetland polygons, and percent jurisdictional and non-jurisdictional polygons were compiled and summarized for each scenario in the case study watersheds. Potential impacts on wetland function were assessed by compiling total wetland acres that were identified as potentially jurisdictional and non-jurisdictional for those NWI polygons that were rated as having a high or moderate functional rating by the functional assessment models. Functional impacts were compared for each scenario in the case study watersheds by examining percent jurisdictional and non-jurisdictional wetland acres for NWI polygons having a high or moderate functional rating for the FP, WH, FSH, and WQ functions. Modeling results were converted to web compatible format for visual comparison and communication of the spatial modeling results using GIS web applications. When reviewing and using the jurisdictional scenario modeling results, one should take into consideration the model limitations and recommendations for appropriate uses for the model and results (see **Model Limitations**).

Watershed Summaries

Summarization of jurisdictional scenario modeling results for the Cottonwood River watershed indicate that the *Most Restrictive* scenario produced the highest number of potentially non-jurisdictional wetland acres (Table 4, Figure 11). The *Most Restrictive* scenario increased the total amount of non-jurisdictional wetland acres in the Cottonwood River watershed to 20,666 acres, representing a 125% increase in non-jurisdictional wetland acres when compared to the *Less Restrictive* scenario (9,166 acres) and a 64% increase when compared to the *Very Restrictive* scenario (12,567 acres). Differences between the *Very Restrictive* and *Less Restrictive* scenario were less pronounced. Compared to the *Less Restrictive* scenario, the *Very Restrictive* scenario increased total non-jurisdictional wetland acres from 9,166 to 12,567, representing a 37% increase in non-jurisdictional wetland acres.

Table 4. Jurisdictional scenario summary statistics for the Cottonwood River watershed in MN.

Summary parameter	Jurisdictional determination	No. of polygons	% of total polygons	Area (acres)	% of total wetland acres
Watershed					
Watershed Area	--	--	--	840,784	--
All Wetlands	--	12,461	--	57,371	--
Non jurisdictional	Most	8,216	65.9	20,666	36.0
Non jurisdictional	Very	6,024	45.3	12,567	21.9
Non jurisdictional	Less	4592	36.9	9,166	16.0
Jurisdictional	Most	4,245	34.1	36,705	64.0
Jurisdictional	Very	6,437	51.7	44,803	78.1
Jurisdictional	Less	7,869	63.1	48,205	84.0
Significant nexus	Less	7	--	78.2	--

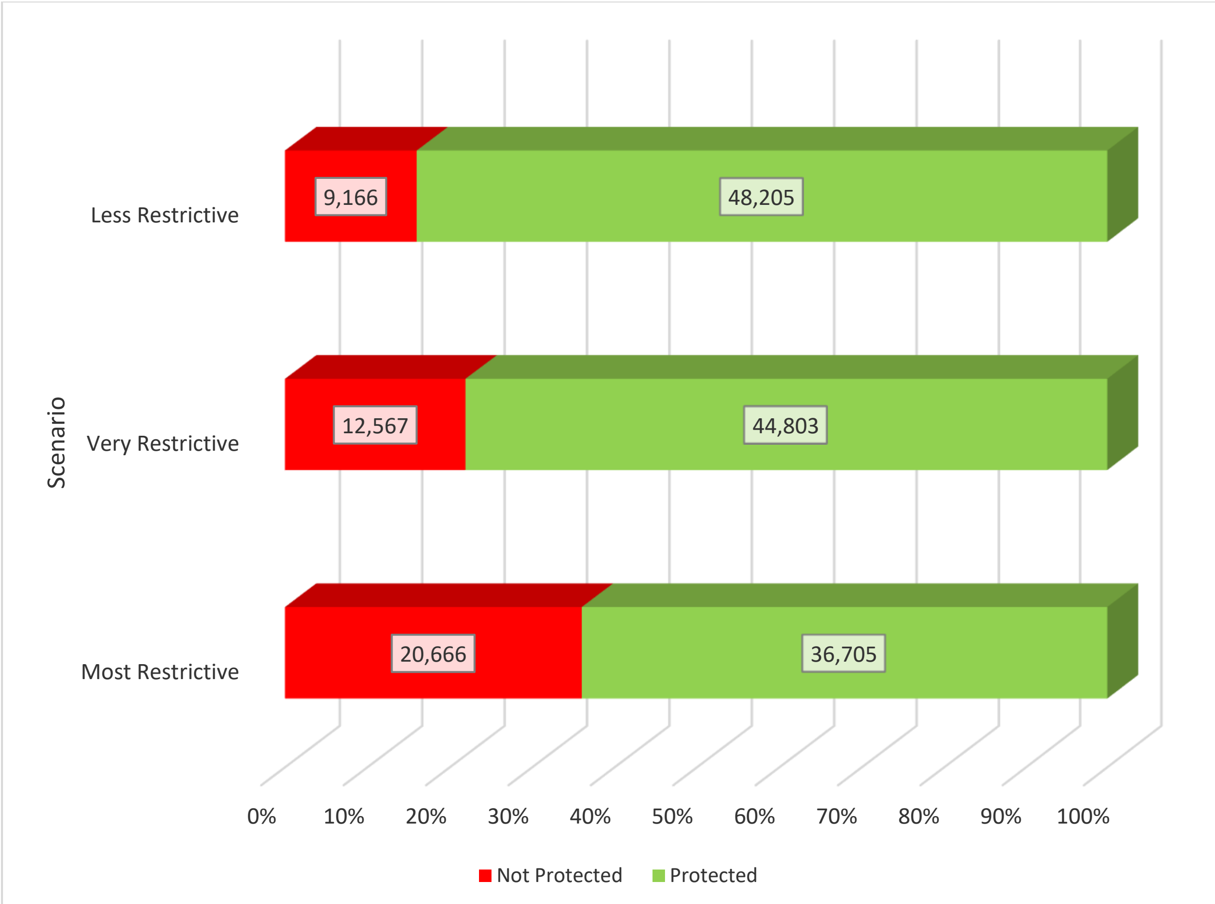

Figure 11. Cottonwood River watershed, potentially protected and non-protected wetland acres by modeling scenario.

Summarization of jurisdictional scenario modeling results for the South Platte Headwaters watershed indicate that the *Most Restrictive* scenario also produced the highest number of potentially non-jurisdictional wetland acres (Table 5, Figure 12). The *Most Restrictive* scenario increased the total amount of non-jurisdictional wetlands in the South Platte Headwaters watershed to 36,836 acres, representing a 1,774% increase in non-jurisdictional wetland acres when compared to the *Less Restrictive* scenario (1,966 acres) and a 256% increase when compared to the *Very Restrictive* scenario (10,344 acres). Differences between the *Very Restrictive* and *Less Restrictive* scenario were found to be more significant in the South Platte Headwaters watershed than in our other case study watersheds. Compared to the *Less Restrictive* scenario, the *Very Restrictive* scenario increased total non-jurisdictional wetland acres from 1,966 to 10,344, representing a 426% increase in non-jurisdictional wetland acres.

Table 5. Jurisdictional scenario summary statistics for the South Platte Headwaters watershed in CO.

Summary parameter	Jurisdictional determination	No. of polygons	% of total polygons	Area (acres)	% of total wetland acres
Watershed					
Watershed Area	--	--	--	1,026,696	--
All Wetlands	--	22,294	--	67,597	--
Non jurisdictional	Most	15,892	71.3	36,836	54.5
Non jurisdictional	Very	4445	19.9	10344	15.3
Non jurisdictional	Less	1692	7.6	1966	2.9
Jurisdictional	Most	6,402	28.7	30,761	45.5
Jurisdictional	Very	17849	80.1	57252	84.7
Jurisdictional	Less	20,602	92.4	65631	97.1
Significant nexus	Less	22	--	68.6	--

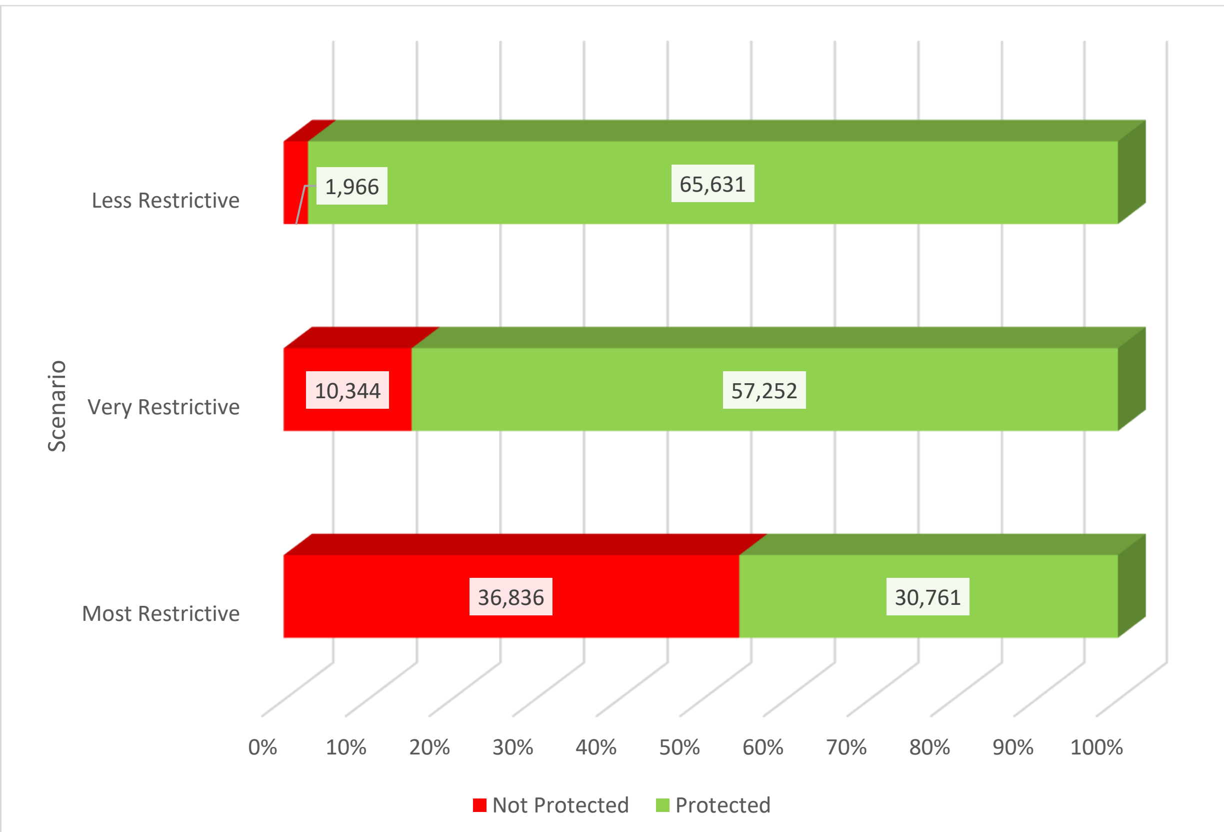

Figure 12. South Platte Headwaters watershed, potentially jurisdictional and non-jurisdictional wetland acres by modeling scenario.

As with the Cottonwood River and South Platte Headwaters watershed, summarization of the jurisdictional scenario modeling results for the Cimarron River watershed indicate that the *Most Restrictive* scenario produced the highest number of non-jurisdictional wetland acres (Table 6, Figure 13). The *Most Restrictive* scenario increased the total amount of non-jurisdictional wetlands in the Cimarron River watershed to 14,069 acres, representing a 502% increase in non-jurisdictional wetland acres when compared to the *Less Restrictive* scenario (2,336 acres) and a 288% increase when compared to the *Very Restrictive* scenario (3,626 acres). Compared to the *Less Restrictive* scenario, the *Very Restrictive* scenario increased total non-jurisdictional wetland acres from 2,336 to 3,626, representing a 55% increase in non-jurisdictional wetland acres.

Table 6. Jurisdictional scenario summary statistics for the Cimarron River watershed in NM.

Summary parameter	Jurisdictional determination	No. of polygons	% of total polygons	Area (acres)	% of total wetland acres
Watershed					
Watershed Area	--	--	--	840,784	--
All Wetlands	--	5,278	--	20,445	--
Non jurisdictional	Most	4,949	93.8	14,069	68.8
Non jurisdictional	Very	2,557	48.4	3,626	17.7
Non jurisdictional	Less	1,862	35.3	2,336	11.4
Jurisdictional	Most	329	6.2	6,376	31.2
Jurisdictional	Very	2,721	51.6	16,820	82.3
Jurisdictional	Less	3,416	64.7	18,109	88.6
Significant nexus	Less	14	--	26.2	--

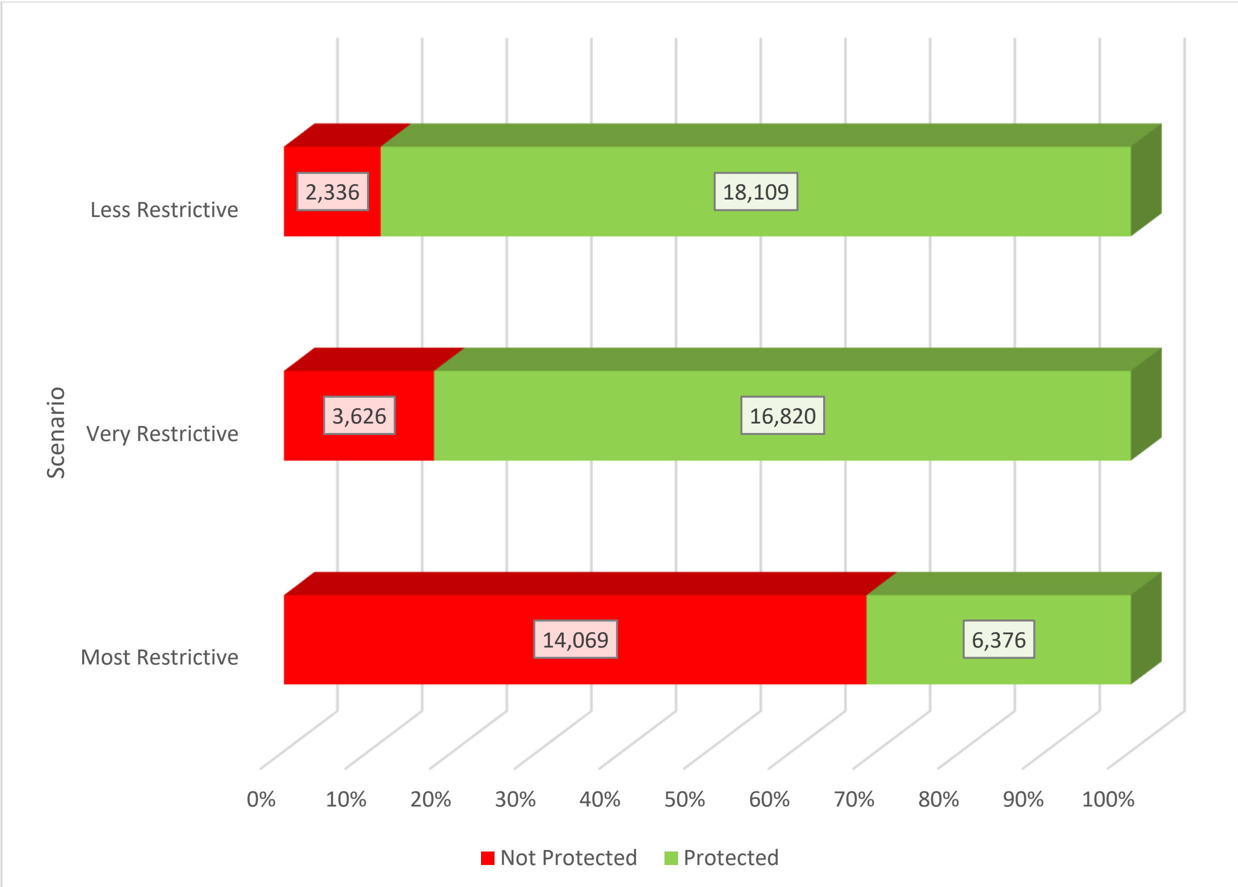

Figure 13. Cimarron River watershed, potentially jurisdictional and non-jurisdictional wetland acres by modeling scenario.

Potential Wetland Function Impacts

Wetland functional assessments conducted for the case study watersheds identified wetland polygons that had a high or moderate functional rating for the FP, WH, FSH and WQ functions. Potential impact of the jurisdictional scenarios on wetland functions was evaluated by summing the total wetland acres for NWI polygons that received a high or moderate functional rating for a particular function and determining the percentage of that acreage that was determined to be jurisdictional and non-jurisdictional by each jurisdictional scenario model. As shown in Figure 14, Figure 15, and Figure 16 the model results indicate that the *Most Restrictive* scenario could potentially remove more wetland function acres from protection for all of the evaluated functions in the case study watersheds. The *Most Restrictive* scenario in the Cottonwood River Watershed removed more than 50% of the wetland acres from protection for the water quality function. In the South Platte Headwaters watershed, 40-45% of the wetland acres were removed from protection for all of the wetland functions. Impacts on wetland function for the Cimarron River watershed were more significant, with greater than 50% of wetland acres removed from protection for all of the evaluated wetland functions.

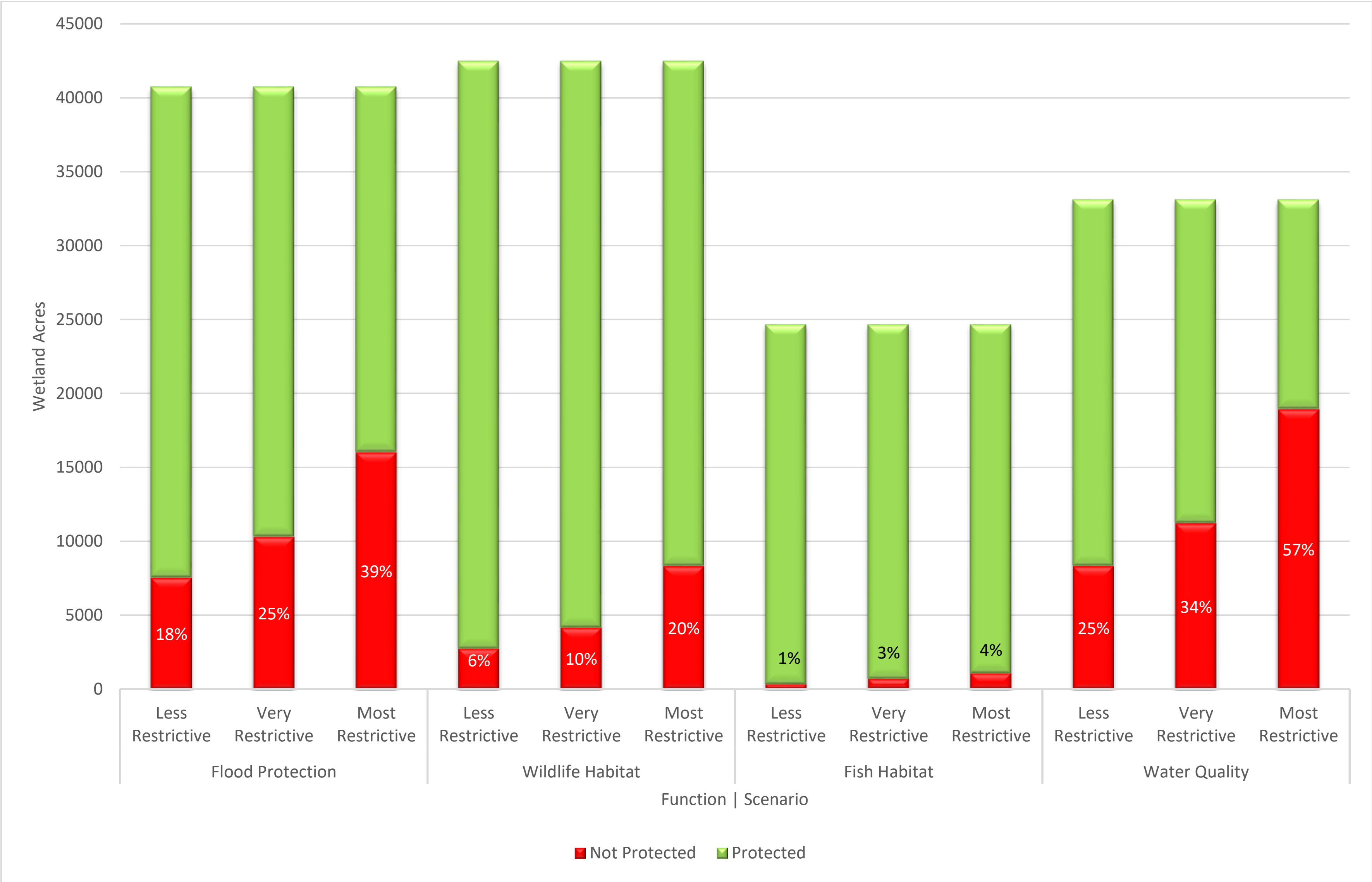

Figure 14. Percent non-jurisdictional wetland acres by jurisdictional scenario for NWI wetlands receiving a high or moderate functional rating from the wetland functional assessments in the Cottonwood River watershed.

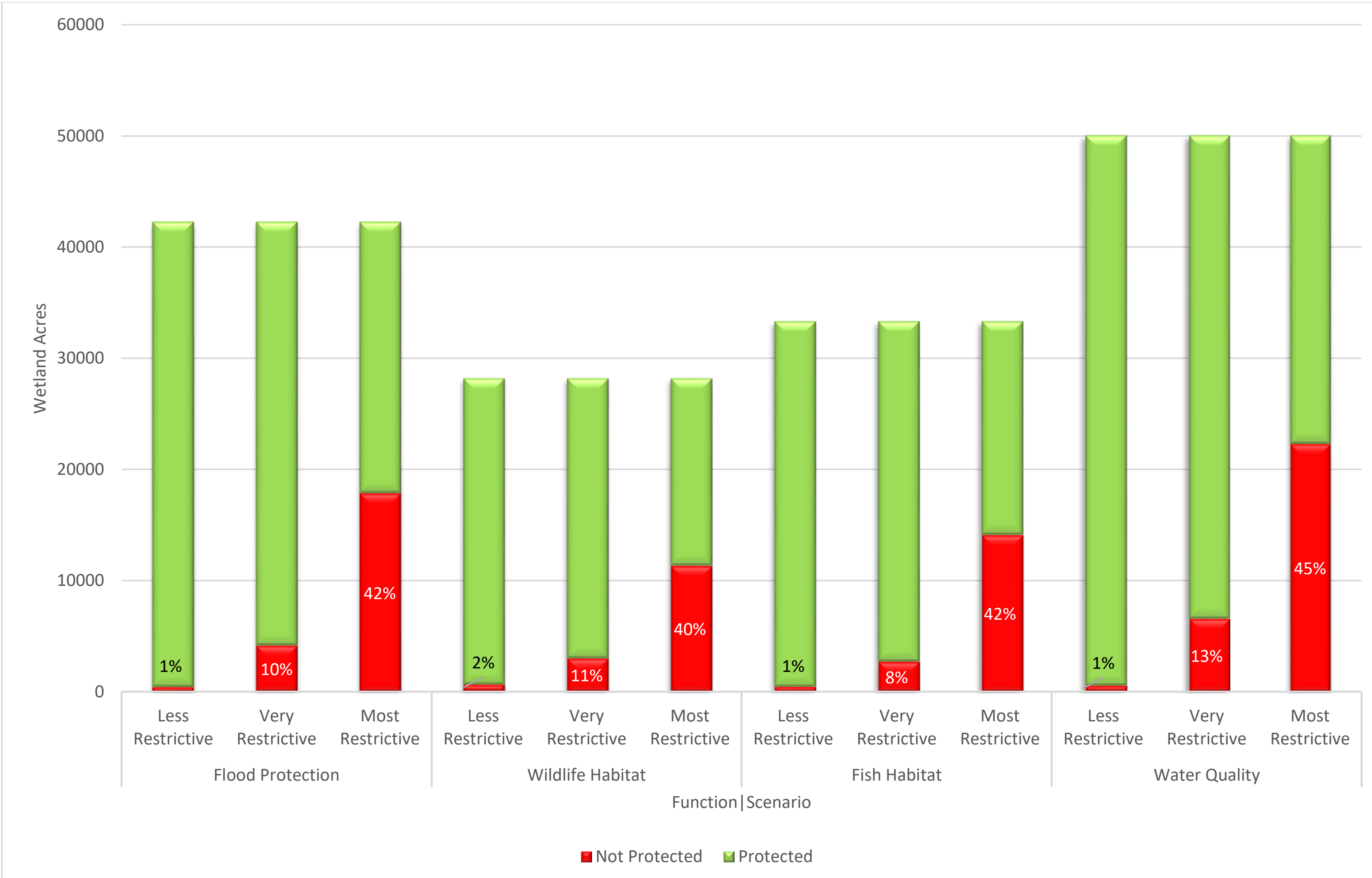

Figure 15. Percent non-jurisdictional wetland acres by jurisdictional scenario for NWI wetlands receiving a high or moderate functional rating from the wetland functional assessments in the South Platte Headwaters watershed.

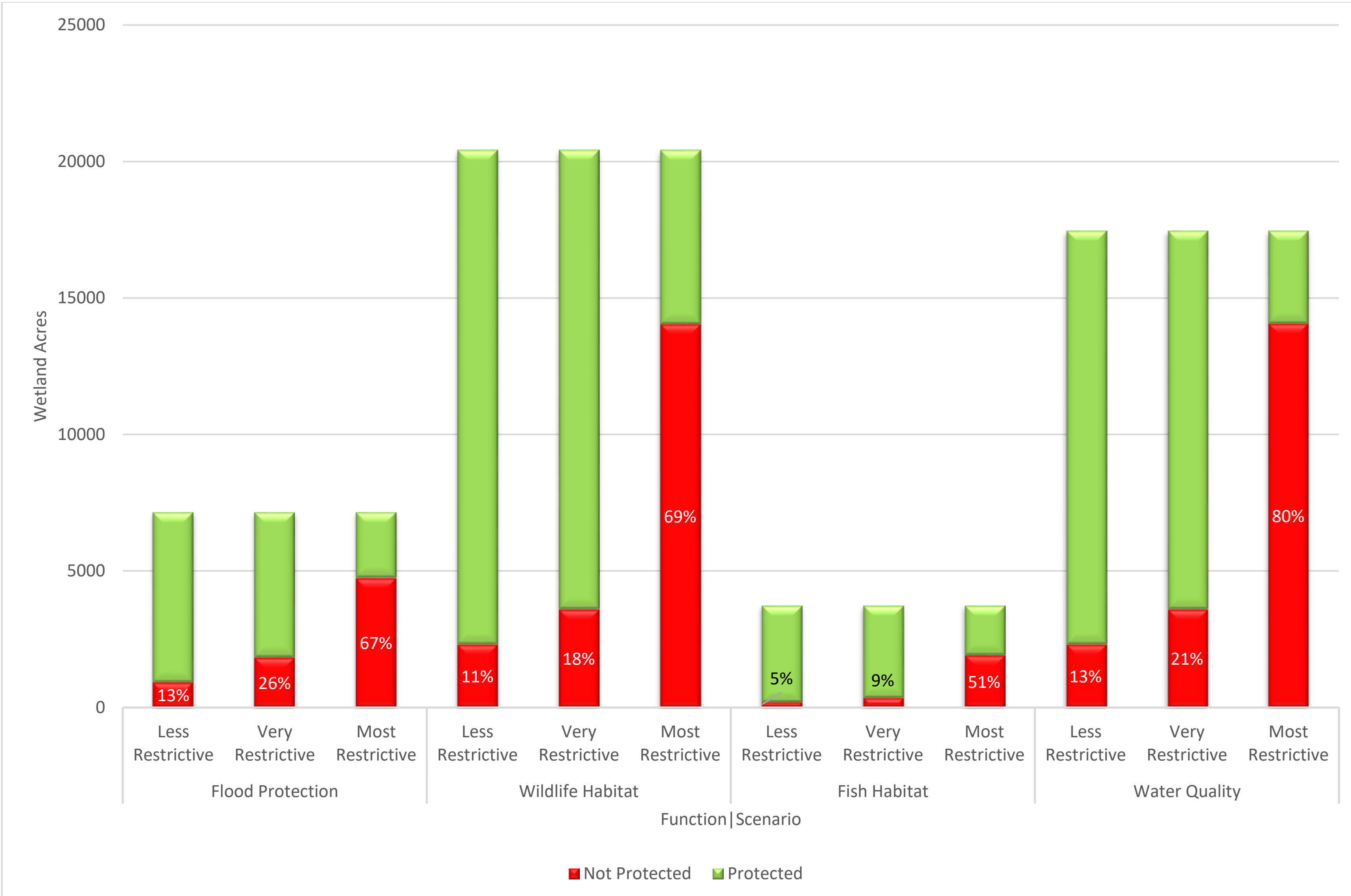

Figure 16. Percent non-jurisdictional wetland acres by jurisdictional scenario for NWI wetlands receiving a high or moderate functional rating from the wetland functional assessments in the Cimarron River watershed.

Communication of Results

Several different tools were explored to find effective ways to communicate modeling results to a diverse target audience. Spatial output layers for the scenario modeling results were converted to web GIS format and uploaded to ArcGIS Online (AGOL). ESRI GIS web applications such as Story Maps and Operations Dashboards were then developed for communicating the modeling results. A custom web application using the ESRI ArcGIS JavaScript API was also developed for visually comparing the scenario results. These applications allow spatial output from the model to be easily shared over the web without the need for specialized GIS software or expertise.

Story Map

The ESRI Story Maps are web application templates that allow maps, narrative text, multi-media and images to be combined to tell a story. The ESRI Cascade story map template was used to develop a story map for the project, entitled *Modeling Federally Protected Waters and Wetlands* (Figure 17). The story map provides an overview of the jurisdictional modeling project.

Figure 17. Cover page for the Modeling Federally Protected Wetlands story map.

Link: Story Map - Modeling Federally Protected Wetlands (https://smumn.maps.arcgis.com/apps/Cascade/index.html?appid=f3de6b30c0454c15ac9d3d881f18ae33)

Operations Dashboard

Operations Dashboard is an ESRI web application developed for monitoring events or activities using geographic data. The Dashboard application allows important quantitative metrics of spatial data to be highlighted and viewed using a series of visual graphics such as gauges, charts, lists, indicators and maps. An Operations Dashboard was created for the Cottonwood and Cimarron case study watersheds to evaluate the potential for using the application to highlight the quantitative results for each jurisdictional scenario model (Figure 18).

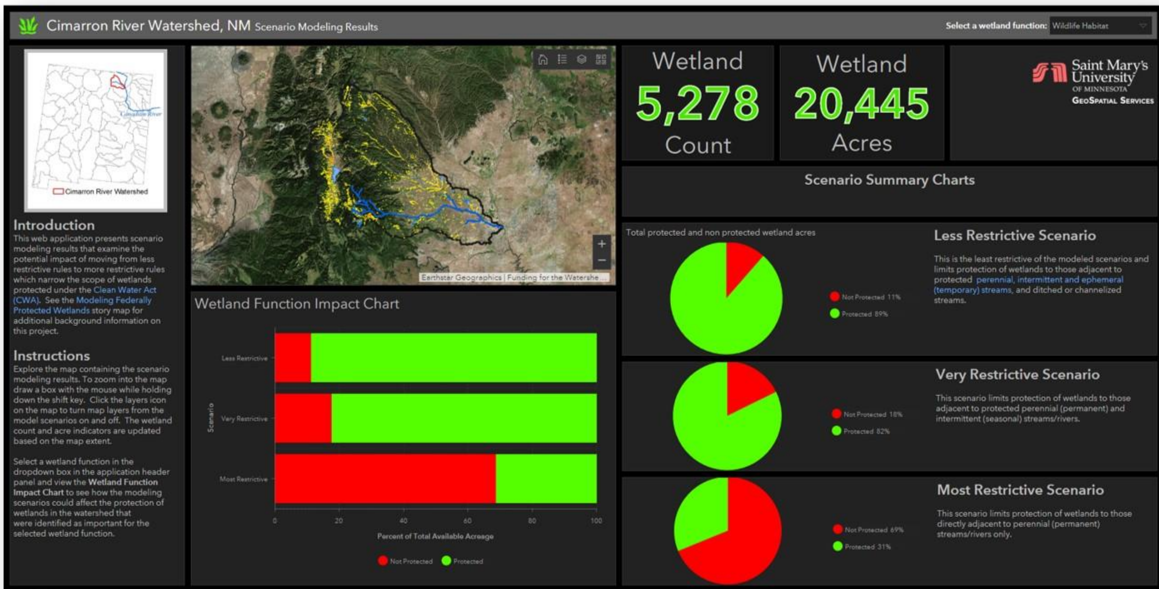

Figure 18. Graphic showing the Operations Dashboard for the Cimarron River Watershed.

Link: [Operations Dashboard - Cottonwood River watershed jurisdictional scenario results](https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/4d6b3c3fd1d34c7fb656afc6f9871293) (https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/4d6b3c3fd1d34c7fb656afc6f98712 93)

Link: [Operations Dashboard – South Platte Headwaters watershed jurisdictional scenario results](https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/dda84dfafb554b7abca39d8cecaff9a8) (https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/dda84dfafb554b7abca39d8cecaff9a 8)

Link: [Operations Dashboard - Cimarron River watershed jurisdictional scenario results](https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/cd7b28a7a4764217a369acdbda4413c8) (https://smumn.maps.arcgis.com/apps/opsdashboard/index.html#/cd7b28a7a4764217a369acdbda441 3c8)

Custom Web GIS Application

A custom web application was developed using the ArcGIS JavaScript API. This custom web application provides an opacity slider tool, which can be used to visually compare the scenario results (Figure 19). The user can use the slider to vary the opacity of the scenario results in order to observe how the spatial extent of jurisdictional and non-jurisdictional wetlands changes as you progress from the *Most Restrictive*, *Very Restrictive*, and *Less Restrictive* jurisdictional scenarios.

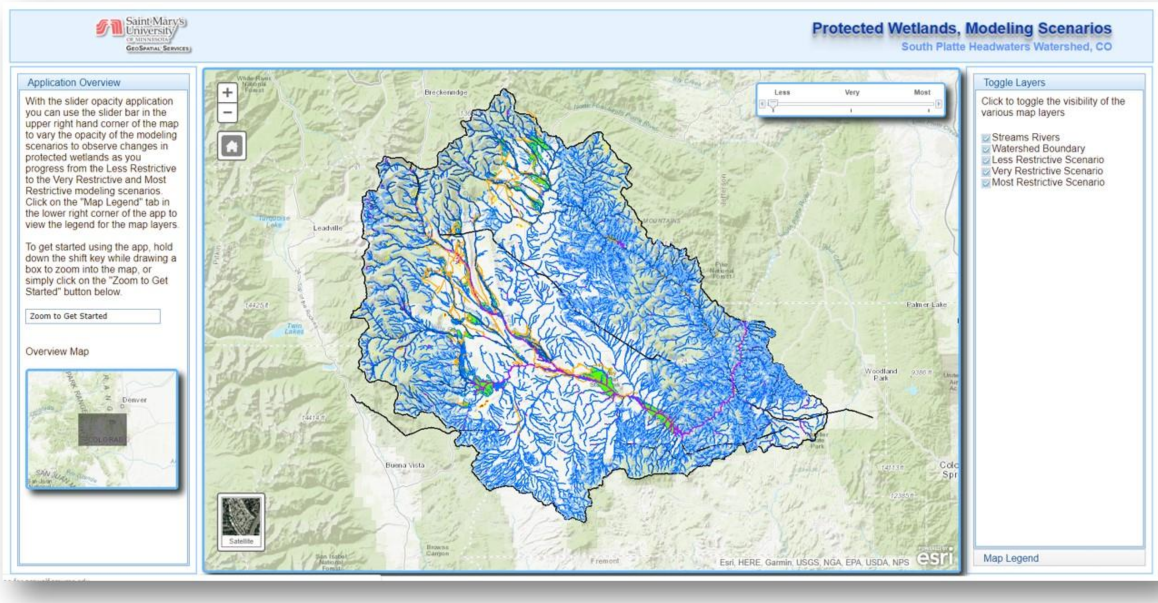

Figure 19. Graphic showing the opacity slider custom web application.

Link: Custom web application - Cottonwood River watershed jurisdictional scenario results (https://gsswolf.smumn.edu/CottonwoodJurisdictionalScenarioSlider/)

Link: Custom web application - Cimarron River watershed jurisdictional scenario results (https://gsswolf.smumn.edu/CimarronJurisdictionalScenarioSlider/)

Link: Custom web application – South Platte watershed jurisdictional scenario results (https://gsswolf.smumn.edu/SouthPlatteJurisdictionalScenarioSlider/)

Model Limitations

When using the *CWA Jurisdictional Scenario Model* and applying the results, one should be aware of the limitations of the model. This model provides a conceptual framework for evaluating and visualizing potential jurisdictional determinations using generalized criteria for the possible jurisdictional scenarios. Consequently, results of the model are only approximations of the spatial extent of potential jurisdictional and non-jurisdictional wetlands. Accuracy of the model is also limited by the accuracy of the input data used for modeling. The GIS data used as input for the model have their own inherent limitations due to spatial and attribute inaccuracies. For example, the model is highly dependent on the classification of NHD streams and rivers, which could have errors in classification that would affect model results. Thus, the results of this model are not intended to serve as the primary tool for regulatory or jurisdictional decision-making. Regulatory applications should involve rigorous field verification before any decisions or conclusions are made. Specifically, the data set was created for broad-scale evaluation and research applications at the county and regional level. Some general examples of appropriate and inappropriate uses would include:

Appropriate Uses

- Regional and county planning
- Large area resource management planning
- Educational purposes for students and citizens
- Broad-scale evaluation of environmental impact

Inappropriate Uses

- Determining the location of jurisdictional wetlands
- Establishing definite jurisdiction or non-jurisdiction of a wetland without consideration of the limitations of the model

Observations

The purpose of this project was to model and examine the potential jurisdictional impacts on wetlands that may occur if there is a transition to rules that significantly narrow the regulatory scope of federally protected waters. This was accomplished by developing a GIS-based spatial model for comparing the extent of protected wetlands in three geographically diverse case study watersheds using three different jurisdictional scenarios. The knowledge gained through completion of the project provides the basis for the following observations:

1. Results from this project support the conclusion that a narrower definition of jurisdictional waters proposed by the current administration will have a significant impact on the protection of wetlands and waters nationwide.

2. Risk is more pronounced for ephemeral and isolated wetlands such as those found in semi-arid environments and the glaciated prairie pothole region of the U.S. Many ephemeral and intermittently flowing streams and rivers, and wetlands adjacent to these streams and rivers could be potentially removed from federal protection.

3. Model results can be improved through further refinement of model input data, primarily classification of watershed hydrography, and by the addition of variables which help adjust and refine each modelling scenario.

4. More accurate modelling of the final proposed rulemaking can be achieved as additional details become available from the EPA and USACE.

5. The modeling tool can be made more accessible to concerned practitioners with limited knowledge of GIS through further automation of the tool and modeling scenarios.

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