THREATENED, ENDANGERED, AND NONGAME BIRD AND MAMMAL INVESTIGATIONS

Wyoming Game and Fish Department Nongame Program
Biological Services Section
Wildlife Division

Annual Completion Report

Period Covered:
15 April 2013 to 14 April 2014

Edited by:
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OVERVIEW OF NONGAME PROGRAM PROJECTS AND FUNDING SOURCES

Species/Project	BLM CA	BOR CA	PRWE	PAPA	RCF	USACE	USFWS CA	USFWS S6	USFWS SWG	USFS BTNF	USFS CA	USFS RMRS	USNPS	WAFWA	WAFD	WG BGLC	WG ESAF	WLCI	WSL GFA	WWTF
Preble's Meadow Jumping Mouse																	X		X	
Black-footed Ferret								X											X	
Trumpeter Swan							X										X		X	
Common Loon					X								X			X				
American Bittern																	X		X	
Bald Eagle monitoring						X				X									X	
Bald Eagle PAPA			X	X																
Northern Goshawk									X										X	
Mountain Plover																	X		X	
Upland Sandpiper																	X		X	
Long-billed Curlew																	X		X	
Great Gray Owl									X										X	
Black-backed Woodpecker																	X		X	
Peregrine Falcon							X												X	
Wind energy and grassland birds									X											

Species/Project	BLM CA	BOR CA	PRWE	PAPA	RCF	USACE	USFWS CA	USFWS S6	USFWS SWG	USFS BTNF	USFS CA	USFS RMRS	USNPS	WAFWA	WAFD	WG BGLC	WG ESAF	WLCI	WSL GFA	WWTF
Bat inventory									X										X	
Bat acoustic surveys																X			X	
Pygmy Rabbit																	X		X	
Northern Flying Squirrel							X									X			X	
Swift Fox																	X		X	
Fisher									X										X	
Falconry																	X		X	
Raptor nest survey	X																		X	
Golden Eagle	X		X	X								X			X		X		X	X
Breeding Bird Survey	X	X									X		X		X				X	
WYPIF/IMBCR	X								X		X						X		X	
White-tailed Prairie Dog									X					X					X	
Central Flyway NMBTC																	X		X	
WY Bird Records Committee																			X	

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PREFACE

Most Wyoming residents and visitors know and cherish the thought of the State being rich in wildlife diversity. There is strong public interest in wildlife conservation and, along with that interest, high expectations. A 2011 national survey by the U.S. Fish and Wildlife Service <http://digitalmedia.fws.gov/cdm/singleitem/collection/document/id/858/rec/10> found that, in addition to $797 million spent on hunting and fishing in Wyoming, over $350 million was added to the State's economy by wildlife watchers. Wyoming is also rich in other natural resources that contribute to our economy, such as livestock forage; timber; a variety of minerals; and oil, gas, and coal. However, sometimes the best management of one or more resources can conflict with the needs of another.

Over the past few decades, public expectations of wildlife managers have diversified. Unfortunately, traditional funding sources were not sufficient to meet these new demands. Beginning in 2005, Wyoming's Legislature approved general fund appropriations for the Wyoming Game and Fish Department's (Department) Veterinary Services section, sage-grouse conservation, and fisheries work. In 2008, Wyoming's Legislature and former Governor Freudenthal agreed to increase appropriations to fund the Department's Terrestrial Nongame Program in order to boost data collection and strengthen management for Wyoming's nongame species, particularly those considered sensitive. In the following biennium budget sessions, funding for these Department programs, as well as the Wyoming Wildlife and Natural Resources Trust, has continued. Funding of nongame efforts is a significant and progressive expansion of the Legislature's support for natural resources in Wyoming. The expectation that accompanies such funding is to develop the information base and expertise to allow for effective decision making associated with resource management and to avoid unnecessary conflicts and restrictions.

These expectations are similar to the expectations associated with the Department's past portfolio of funding sources for nongame, but they are more targeted. In the past, the Department's nongame efforts were funded primarily by user fees collected from hunting and fishing. Many of the hunting and fishing public recognizes that sound management of nongame fish and wildlife helps provide additional support for maintaining functioning ecosystems for game species. Yet, for most of us, there is a limit to how user fees should be spent on management of non-target wildlife.

Over the past two decades, at both the national and state level, a number of efforts have focused on find alternate funding for nongame species conservation. Many of the same individuals contributing to Wyoming's economy through expenditures associated with hunting, fishing, and wildlife watching were, no doubt, involved in intense national lobbying efforts to develop nongame funding.

In response, Congress established the federally funded State Wildlife Grants (SWG) program in 2000. Since then, the Department has received over $6 million of SWG funds to address data needs for nongame birds, mammals, fish, amphibians, and reptiles, and to collect information that may provide an early warning of species heading for a potential listing under the

Endangered Species Act. Most states tended to focus SWG projects on species that would grab the attention of supporters and Congress who debate federal budgets on an annual basis. But the expectations associated with SWG also extend to species like the American pika or Harlequin Duck that are high on the interest scale for wildlife watchers but have little potential for conflict with other resource users because of the habitats they occupy in the State.

During the early years of SWG funding, we tended to focus on planning efforts that produced documents such as the Trumpeter Swan Habitat Enhancement Project, Wyoming Bird Conservation Plan, A Plan for Bird and Mammal Species of Greatest Conservation Need in Eastern Wyoming Grasslands, and A Comprehensive Wildlife Conservation Strategy in Wyoming. The latter planning document, approved in 2005, provides guidance for development of more recent SWG proposals and was the foundation for the Wyoming State Wildlife Action Plan 2010. We have used SWG funding to develop and implement inventory methods for sensitive species, such as Harlequin Duck, American Bittern, black-tailed prairie dog, and white-tailed prairie dog. We have also used SWG funds to collect additional information on several species of bats, Canada lynx, pygmy rabbit, swift fox, wolverine, Mountain Plover, Brewer's Sparrow, Sage Sparrow, and Sage Thrasher. Recent SWG projects also include initial inventories of raptors in the Wyoming Range and small mammals in southwest Wyoming.

The funding provided by the Wyoming State Legislature has greatly enhanced our ability to collect information on Species of Greatest Conservation Need. Not only has funding from the State allowed us to greatly increase our knowledge of distribution and abundance of these species, it has also allowed us to increase our understanding of what is needed for effective and proactive management of those species. This funding has also allowed us to work cooperatively with other entities, such as the University of Wyoming, Wyoming Natural Diversity Database, Rocky Mountain Bird Observatory, Audubon Rockies, and private contractors, as well as interested volunteers, to implement projects that will provide population status and trend information on additional Species of Greatest Conservation Need, such as the Ferruginous Hawk, Grasshopper Sparrow, Preble's meadow jumping mouse, and Wyoming pocket gopher. Finally, we have also had the opportunity to implement funds provided by the US Fish and Wildlife Service for several additional projects, including a collaborative survey effort for Northern Goshawks in the Wyoming Range and a study to determine the potential effects of energy development on raptor populations in Wyoming.

The future remains uncertain as we progress through challenging economic times. Anthropogenic and environmental stressors, such as climate change and lingering drought, will undoubtedly continue to put a strain on the Department's ability to effectively meet our statutory mandate to manage all wildlife in Wyoming. In conjunction with our partners, we will continue this collaborative endeavor to conserve this unique and diverse resource on behalf of the citizens of Wyoming.

INTRODUCTION

The Nongame Program of the Wyoming Game and Fish Department (Department) was initiated in July 1977. This report summarizes data collected from 15 April 2012 to 14 April 2013 on various nongame bird and mammal surveys and projects conducted by Department personnel, other government agencies, non-governmental organizations, and individuals in cooperation with the Department. Cooperating agencies and individuals are listed in the individual completion reports, but we recognize that the listing does not completely credit the valuable contributions of the many cooperators, including Wyoming Game and Fish Department District personnel and members of the public.

In October of 1987, a Nongame Strategic Plan was distributed; this plan was updated and renamed in May of 1996. The 1996 Nongame Bird and Mammal Plan (Plan) presents objectives and strategies for the management and study of nongame birds and mammals in Wyoming. As part of the State Wildlife Grants funding program to provide long-term conservation planning for those species most in need, information was gleaned from the Plan and other pertinent sources and compiled into A Comprehensive Wildlife Conservation Strategy for Wyoming, which was approved by the Wyoming Game and Fish Commission (Commission) on 12 July 2005. This has since undergone a 5-year revision, was renamed the Wyoming State Wildlife Action Plan, and was approved by the Commission in 2010. This Nongame Annual Completion Report presents information in four major sections similar to these planning efforts: threatened and endangered species, species of greatest conservation need, raptors taken for falconry, and other nongame surveys.

Legislative funding has enabled the Department to significantly expand nongame and sensitive species conservation efforts, enhancing our ability to inventory, initiate monitoring, and assess the status of many species of wildlife classified as sensitive in 2010. The FY09/10 biennium budget provided general fund appropriations to the Department for the first time for all aspects of its nongame/sensitive species program: $1.2 million Maintenance and Operations (M&O) budget for existing personnel and administrative support and $609,000 in direct general fund appropriations for sensitive species program projects. In addition, $1.3 million from the Governor's endangered species administration general fund appropriation was provided to the Department to supplement sensitive species project work. We also used several sources of federal funding for specific projects. General fund appropriations for M&O were essential for normal duties and for personnel to manage all of the special projects in this report. Specific funding sources in addition to M&O budgets are identified for each specific report.

This proactive approach is Wyoming's most effective strategy in reducing the chance that a species will be listed as threatened or endangered under the federal Endangered Species Act. The Department's Nongame Program is geared toward collecting information that has practical application for understanding the status of each species as well as identifying potential risks and management actions that may be needed to secure the healthy status of those species needing some help.

This report serves several purposes. First, it provides summaries of nongame surveys for the benefit of the Department, other agencies, and individuals that need this information for management purposes. Second, it provides a permanent record of summarized data for future use. Although some of this information is in lengthy tables, it was felt that these data should be published rather than kept in the files of the Nongame Program staff. Some information, such as Bald Eagle and Ferruginous Hawk nest sites and bat roost locations, is sensitive and is not provided in this document. Those needing this information for purposes that will lead to better management of these species can request the data from the Nongame Program staff.

Common bird names used in this report follow the most recent American Ornithologists' Union guidelines and supplements. Mammal names follow the "Revised checklist of North American mammals north of Mexico, 2003".

THREATENED AND ENDANGERED SPECIES

PREBLE'S MEADOW JUMPING MOUSE (*ZAPUS HUDSONIUS PREBLEI*) DISTRIBUTION AND RESPONSE TO WILDFIRE IN SOUTHEASTERN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need / Threatened Species – Preble's Meadow Jumping Mouse

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Nichole Cudworth, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Wildfire activity in the western US has increased in the last century due to anthropogenic and climatic changes. Wildfires change vegetative components of landscapes, which may impact wildlife communities. Because of their dependence on the local environment and short generation times, small mammals may be especially susceptible to these changes. The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is restricted to riparian areas and is listed as Threatened by the US Fish and Wildlife Service throughout its range in Wyoming and Colorado. We used live-trapping surveys to investigate the effects of recent wildfires on persistence of populations at burned and control sites and to conduct presence surveys to update distributional boundaries in Wyoming. Overall captures were low, and we only captured jumping mice at two sites. Preble's meadow and western jumping mice (*Z. princeps*) were known from both sites as a result of previous survey efforts. Both individuals captured at Lodgepole Creek were confirmed as western jumping mice, conforming to results of recent surveys. However, five individuals at Friend Creek were confirmed as western jumping mice, and three individuals were confirmed as Preble's meadow jumping mice, representing one of only a few sites where species have been shown to be sympatric and providing a unique site at which to evaluate sympatry, competition, and succession. We did not detect jumping mice at either the burned or unburned control site. Because small mammals may display considerable annual variation as well as variation in response to wildfire, future surveys should monitor both disturbed and undisturbed sites to elucidate persistence, survival, and abundance of populations in addition to those designed to update distributional boundaries in order to ensure the continued presence of the Preble's meadow jumping mouse in Wyoming.

INTRODUCTION

Fires have always been an important component of forests in the western US. However, changes in fire regimes due to anthropogenic and climatic changes have led to increases in wildfire activity over the last century (Heyerdahl et al. 2001, Westerling et al. 2006). Wildfires change vegetation components of the landscape, which can impact abundance and assemblage of wildlife communities (Fisher and Wilkinson 2005, Converse et al. 2006, Kirchner et al. 2011). Small mammals are especially responsive to changes in habitats because they often have short generation times and are dependent on the local environment for food, nesting sites, and predator avoidance (Pearson et al. 2001, Ostoja and Schupp 2009). Additionally, these fauna are ecologically important because they help shape vegetative communities by serving as seed predators and dispersers (Vander Wall 1993, Bass et al. 2006, Bricker et al. 2010). Consequently, they are model organisms with which to assess changes in habitat quality. However, not all small mammals respond similarly to changes in habitat quality and availability due to disturbance, such as wildfire outbreaks (Clark and Kaufman 1990, Fisher and Wilkinson 2005, Kirchner et al. 2011). Understanding how wildlife respond to wildfires, especially species considered sensitive, is important as wildfires continue to increase in frequency and intensity.

The Preble's meadow jumping mouse (Preble's; *Zapus hudsonius preblei*) is listed as Threatened by the US Fish and Wildlife Service (USFWS) throughout its range in Wyoming and Colorado. The Preble's is dependent on riparian habitat with relatively undisturbed grassland vegetation interspersed with shrubs (USFWS 2003a, Trainor et al. 2007). Riparian habitats often support a diverse assemblage of terrestrial species and, consequently, are important to biodiversity (Knopf et al. 1988, Maisonneuve and Rioux 2001, Poff et al. 2011). However, these riparian areas represent only a small part of the landscape overall and are exposed to a variety of threats that can diminish or degrade availability and quality (Knopf et al. 1988, Poff et al. 2011). Consequently, degradation and loss of habitat is recognized as the critical limiting factor for Preble's populations (USFWS 1998, 2008).

Despite considerable initial controversy over the taxonomy of the Preble's (Ramey et al. 2005, 2006; Vignieri et al. 2006; Cronin 2007), King et al. (2006) settled the debate in 2006 and concluded that the Preble's deserved subspecific status. As a result, the Wyoming Game and Fish Department (Department) funded annual projects beginning in 2009 to document presence and distribution of the Preble's throughout the state (Thompson and Grenier 2010; Thompson et al. 2011, 2012). In 2012, this project was expanded to include systematic surveys along the northern edge of the Preble's distribution (Cudworth and Grenier 2013). However, significant wildfire outbreaks in 2012 impacted the landscape throughout the state, including locations of known Preble's populations. Consequently, our objectives in 2013 were two-fold. First, we conducted systematic surveys at two sites known to support Preble's populations, one that had burned in recent wildfires as well a similar control site that was unimpacted. Second, we continued survey efforts to further refine distribution and increase records of occurrence of Preble's in Wyoming.

METHODS

We conducted surveys from 1 June through 29 August 2013. To evaluate the response of Preble's to wildfire, we conducted repeated surveys once per month along North Cottonwood Creek, which burned in 2012, and the Laramie River, which served as our control site (Fig. 1). Sites had roughly similar elevation (1,887 and 1,969 m, respectively) and contained Preble's in previous surveys: 2009 at Laramie River and 2011, the year immediately preceding wildfire outbreaks, at North Cottonwood Creek (Thompson and Grenier 2010, Thompson et al. 2012). North Cottonwood Creek was burned at low severity (USFS 2012), which resulted in the loss of riparian grasses as well as death of willows (*Salix* spp.) and conifers near the study area; however, grasses had returned by the beginning of our study season, and willows began to resprout (Fig. 1). In order to increase our knowledge of distribution, we also conducted surveys along a number of other waterways throughout the distribution of Preble's in Wyoming (Table 1, Fig. 2).

We followed protocols established by the USFWS to capture jumping mice (USFWS 2004). We used Sherman live traps (Models LFG and XLK folding and 339A non-folding traps; H.B. Sherman Traps, Inc., Tallahassee, FL) baited with a variety of bait types, including a mixture of peanut butter and oats as well as 3-way grain mix with and without molasses (Ranch-Way Feeds, Inc.) to capture mice. We also supplied traps with poly-fil for bedding. We placed traps every 5 m along 2 parallel line transects spaced 10 m apart. When possible, we placed transects on opposite sides of the waterway; for larger water bodies, we placed transects on the same side of the waterway. We opened traps within 3 hrs of sunset and checked within 3 hrs of sunrise for 4 consecutive nights. We used a GPS to document locations and took photographs of all sites. We also recorded weather conditions each morning, including wind speed, temperature, and any moisture accumulated throughout the night, and noted dominant overstory species. Although we attempted to fulfill the recommendation of 750 trap nights per survey, weather occasionally resulted in <750 trap nights. However, both sites where this occurred were surveyed more than once throughout the season, and at least one survey resulted in >750 trap nights.

For each jumping mouse captured, we recorded sex, age, and reproductive condition; weight; morphometric measurements including total body length, tail length, hind foot length, and ear length; UTM location; and distance to open water. Because the Preble's is morphometrically similar to the closely related western jumping mouse (*Z. princeps*), identification in the field is impossible, and genetic analyses are required to distinguish between species. Consequently, we also collected a tissue and blood sample from each individual, affixed a numbered ear tag (model 1005-1; National Band and Tag Co., Newport, KY), and documented each individual with photographs before releasing at the capture site. We used a 2-mm ear punch (World precision Instruments, Sarasota, FL) to collect a small tissue sample from the ear, which we stored in a 1.2-ml vial containing 85% ethanol. We then pressed a Watman FTA card (model 09-923-334; Thermo Fisher Scientific, Inc., Pittsburgh, PA) to the ear to collect a blood sample. We sent all biological samples to the lab of Dr. Tim King, US Geological Survey, which conducted both nuclear and mtDNA genetic analysis for each sample following protocol outlined by King et al. (2006).

For each nontarget capture, we identified individuals to species whenever possible; documented sex, age, and reproductive condition; and recorded morphometric measurements, including total body length, ear length, hind-foot length, and weight when necessary for identification. All individuals were released at the capture site. We report summary statistics (±SE) where applicable.

RESULTS

We surveyed eight different sites throughout the predicted range of the Preble's in Wyoming; we surveyed Laramie River twice and North Cottonwood Creek three times. Sites averaged 751.3 (±31.7) trap nights per trapping session (range: 522 to 886.5). We captured jumping mice at two sites (Fig. 2). Along North Fork of Lodgepole Creek (elevation: 2,345 m), we captured two adult females, both of which showed signs of past lactation, indicating a breeding population of jumping mice. Both individuals were confirmed as western jumping mice (Table 2). At Friend Creek (elevation: 2,246 m), we captured three adult males and five adult females. Five individuals were confirmed as western jumping mice (3 males, 2 females), and three individuals were confirmed as Preble's (3 females). Although none of the females at Friend Creek were in reproductive condition, all males had descended testes, indicating they were capable of reproduction (Table 2). On average, individuals along the North Fork of Lodgepole Creek tended to be larger than those along Friend Creek in both body weight (Lodgepole: 30.0 ± 2.0 g; Friend: 22.9 ± 1.6 g; $t_8 = 5.06$, $P = 0.078$) and total body length (Lodgepole: 237.5 ± 8.5 mm; Friend: 200.0 ± 3.1 mm; $t_8 = 12.91$, $P < 0.001$; Table 2). Preble's and western jumping mice were previously detected at both sites (Table 1).

We captured 317 nontarget individuals, which included 10 different species. Nontarget captures, in order of number of captures, included: deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), long-tailed vole (*Microtus longicaudus*), meadow vole (*M. pennsylvanicus*), least chipmunk (*Neotamias minimus*), prairie vole (*M. ochrogaster*), dusky shrew (*Sorex monticolus*), masked shrew (*S. cinereus*), bushy-tailed woodrat (*Neotoma cinerea*), and garter snake (*Thamnophis* spp.). We also captured a number of voles (*Microtus* spp.) and shrews (*Sorex* spp.) for which we did not or were not able to identify species. Nontarget captures resulted in two updates to distribution and breeding locations in the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012; Table 3).

DISCUSSION

Despite conducting >2,200 trap nights throughout the summer along North Cottonwood Creek, we failed to detect any jumping mice. However, results should be interpreted with caution, given the low number of captures overall this season. The response of jumping mice to fire is ambiguous; as grassland species, they are expected to be among the first to colonize recent burns (Fisher and Wilkinson 2005), and there has been some support for this, although conclusions are based on small sample sizes and prescribed, controlled burns (Beck and Vogl 1972, Springer and Schramm 1972). Conversely, forest fires were one cause of habitat loss implicated for declines of the New Mexico jumping mouse (*Z. h. luteus*; Frey and Malaney 2009), suggesting the response of jumping mice to wildfire may not be straightforward. However, we did capture >130 small mammals at North Cottonwood Creek throughout the summer, nearly 80% of which were deer mice, which often demonstrate a fire-positive response (Clark and Kaufman 1990, Fisher and Wilkinson 2005, Kirchner et al. 2011). Because re-colonization of small mammals may depend on regeneration of vegetation density, not time since disturbance, it is possible that North Cottonwood Creek has not yet redeveloped the vegetation needed for jumping mice to return (Monamy and Fox 2000). However, we also failed to detect jumping mice at our control site along the Laramie River. Small mammals may demonstrate large annual variation in abundance regardless of disturbance (Converse et al. 2006); therefore, annual surveys are important to elucidate the effects of disturbance and return of jumping mice following wildfire.

The predicted distribution of Preble's in Wyoming includes all or portions of seven counties in the southeastern corner of the state. However, based on capture surveys, the current range of the Preble's appears to be restricted to drainages along the eastern front of the Laramie Mountains (Fig. 3; Bowe and Beauvais 2012). Although many drainages have yet to be surveyed, those outside the Laramie Mountains have thus far either resulted in captures of western jumping mice or no jumping mice captures at all. To document and refine the distribution of Preble's in Wyoming, we selected sites in drainages where no surveys had been previously conducted, where surveys had been conducted but results were ambiguous (i.e., both Preble's and western jumping mice were captured in different surveys), and where jumping mice had been detected but were not verified by genetics (Table 1, Fig. 2). Both Lodgepole Creek and Friend Creek had documented both species of jumping mice in previous surveys and were the only sites where we captured jumping mice in 2013. Despite being previously classified as critical habitat for the Preble's in Wyoming, all recent captures along Lodgepole Creek have been verified as western jumping mice (USFWS 2003b, Cudworth and Grenier 2012); the only Preble's capture was from 1995 and is classified as "possible" because species identity was assigned through morphometric or other non-genetic analyses [Table 1—Wyoming Natural Diversity Database (WYNDD) download from 15 May 2013 with taxonomic identification following Bowe and Beauvais 2012). Genetic results from this survey support these results as all captures were verified as western jumping mice. Friend Creek, however, resulted in both confirmed Preble's and western jumping mice captures. Both species have been confirmed at this site in the past, including 1998, when both species were detected during the same survey (Table 1—WYNDD download from 15 May 2013 with taxonomic identification following Bowe and Beauvais 2012); however, this site remains one of only a few sites that has documented temporal and spatial sympatry of Preble's and western jumping mice in Wyoming. Consequently, Friend Creek provides a unique location at which to evaluate sympatry, competition, and succession of these species and will be evaluated more intensively in future surveys.

Individuals from Lodgepole Creek were larger than those captured at Friend Creek, regardless of species, suggesting that morphometric measurements are likely not exact in allowing researchers to preliminarily distinguish between species in the field. However, Friend Creek was surveyed the last week of August, near the time when adults begin entering hibernation and may not be available for capture (Brown 1967, Meaney et al. 2003).

Consequently, it is possible that young of the year were misclassified as adults during field surveys and may not be representative of adult body size, especially since all females were classified as nonreproductive. However, although Preble's may be capable of reproduction during their first summer (Quimby 1951), western jumping mice in Wyoming are not known to reproduce until they complete their first hibernation (Brown 1967). All males captured at Friend Creek were verified as western jumping mice and displayed descended testes, suggesting these individuals were adults at least one year of age and had reached full body size, although they still represented the lower end of the range of total body length for adults (216-247 mm; Hart et al. 2004). Consequently, individuals likely display considerable variation in body size, and caution should be used when attempting to use morphometrics to preliminarily assign species in the field, especially near the end of the active season when not all captured individuals will be representative of adults that have achieved full body size.

Surveys throughout the range of the Preble's in Wyoming have continued to update our knowledge of distributional boundaries. However, little work has been done thus far to evaluate site-specific issues, including density, trends, and response to disturbance. As riparian obligates, jumping mice may be exposed to a number of threats that reduce or diminish habitat, including cattle grazing, drought, development, and wildfire (Knopf et al. 1988, Frey and Malaney 2009, Poff et al. 2011). Consequently, understanding the effects of these disturbances to population functioning and persistence is vital to ensure conservation objectives are met for this Threatened species. Future surveys should monitor both disturbed and undisturbed sites known to contain Preble's to elucidate persistence, survival, and abundance of populations in addition to those designed to update distributional boundaries and increase occurrence records in order to ensure the continued presence of the Preble's in Wyoming.

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Table 1. Sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) from 1 June through 29 August 2013 in southeastern Wyoming. For each site, we list whether Preble's meadow or western jumping mice (*Z. princeps*) were previously known and the most recent survey year. Confirmed indicates species assignment was completed via genetic analysis; possible indicates species assignment was completed via morphometric or other non-genetic analysis. Sites where jumping mice were captured in 2013 are shown in bold. Taxonomic identification from Bowe and Beauvais (2012).

Site	Preble's meadow jumping mice		Western jumping mice	
	Detection	Year	Detection	Year
Boxelder Creek	None	N/A	None	N/A
Chugwater Creek	Confirmed*	2011	None	N/A
Friend Creek	**Confirmed**	**1998**	**Confirmed**	**2010**
Laramie River	Confirmed	2009	None	N/A
Lodgepole Creek (North Fork)	**Possible**	**1995**	**Confirmed**	**2011**
North Cottonwood Creek	Confirmed	2011	None	N/A
Sybille Creek	Possible†	1948	None	N/A
Trail / Horseshoe Creek	Possible	1999	None	N/A

* Detection was farther upstream than 2013 survey site.
† Detection was within the same Hydrological Unit Code as survey site.

Table 2. Identification number, species, age, sex, reproductive condition, and morphometric measurements for all Preble's meadow jumping mice (*Zapus hudsonius preblei*) and western jumping mice (*Z. princeps*) captured in southeastern Wyoming, June-August 2013.

ID number	Species	Age	Sex	Reproductive condition	Weight (g)	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)
Lodgepole Creek									
00113	*Z. princeps*	Adult	Female	Post-lactating	28	246	151	32	9
00213	*Z. princeps*	Adult	Female	Post-lactating	32	229	157	31	12
Friend Creek									
00313	*Z. h. preblei*	Adult	Female	Nonreproductive	23	206	126	28	12
00413	*Z. princeps*	Adult	Male	Scrotal	17	195			
00513	*Z. princeps*	Adult	Male	Scrotal	28	200	128	27	14
00613	*Z. princeps*	Adult	Female	Nonreproductive	29	208	130	29	11
00713	*Z. princeps*	Adult	Male	Scrotal	23	214	138	27	13
00813	*Z. h. preblei*	Adult	Female	Nonreproductive	20	190	111	29	11
00913	*Z. h. preblei*	Adult	Female	Nonreproductive	17	190	120	29	10
01013	*Z. princeps*	Adult	Female	Nonreproductive	26	197	123	21	12

Table 3. Updates to distribution and breeding status of small mammals in the Wyoming Game and Fish Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming by latilong. We used live-traps to capture individuals in southeastern Wyoming from June-August 2013. B = nest, dependent young, juvenile animals, or lactating or post-lactation females were observed; b = animals were observed and, due to limited mobility, breeding is assumed; h = historical record of occurrence before 1965, but no recent data to suggest occurrence (Orabona et al. 2012).

Species	Latilong	Current status	Updated status
Neotoma cinerea	20	h	b
Microtus longicaudus	20	h	B

a) 

b) 

Figure 1. Photographs from sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) to document effects of wildfire in southeastern Wyoming from June–August 2013. Sites included a) North Cottonwood Creek, which burned in 2012 and b) Laramie River, which was outside the burn perimeter. Note the burned willows (*Salix* spp.) in the foreground and dying conifers in the background of a. Both sites had confirmed Preble's meadow jumping mouse populations in previous surveys.

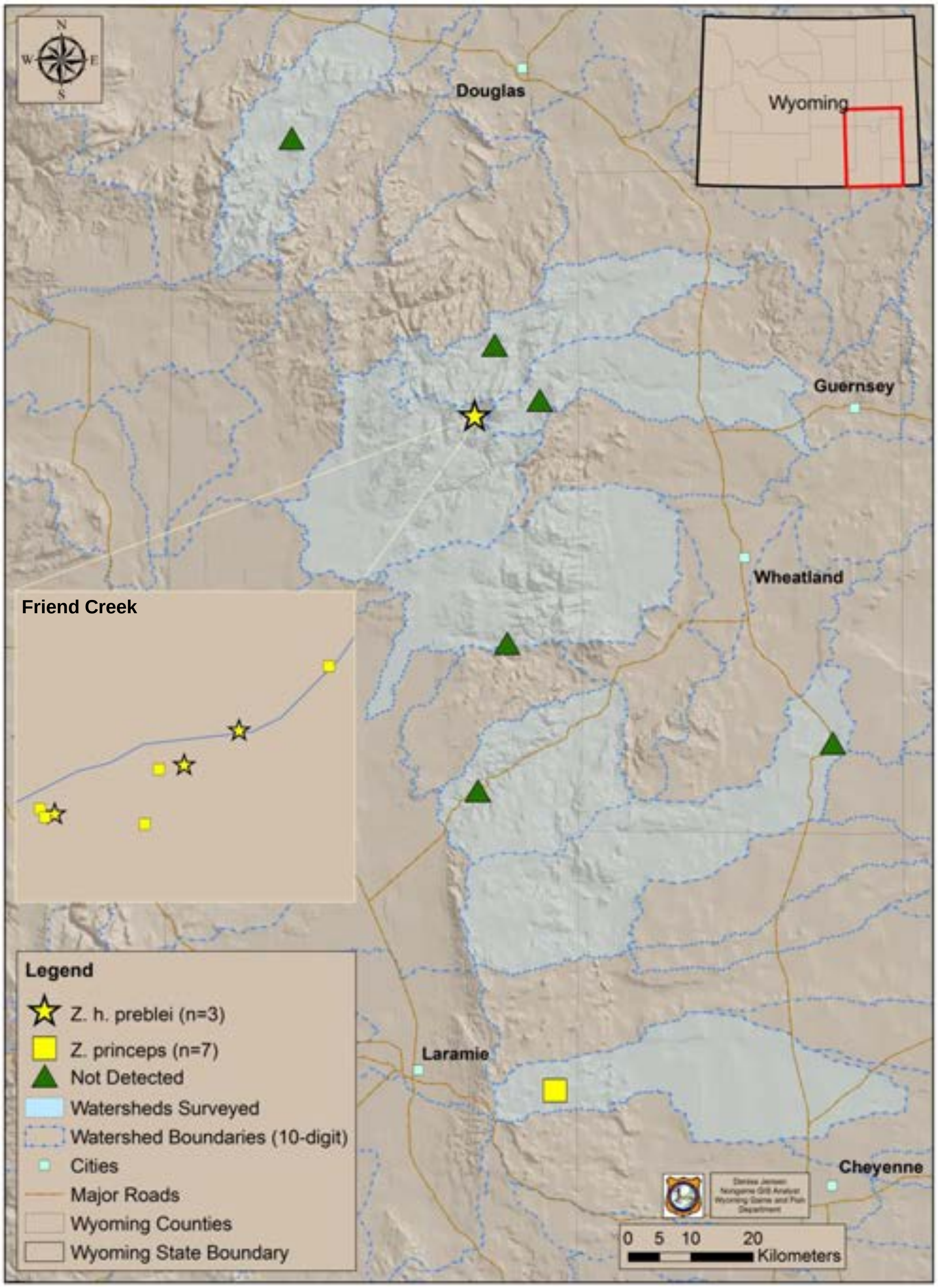

Figure 2. Trapping locations and 10-digit Hydrologic Unit Code watershed boundaries for all sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming from June-August 2013. Locations of captures of Preble's meadow jumping mice are designated by yellow stars; locations of captures of western jumping mice (*Z. princeps*) are designated by yellow squares; and sites where jumping mice were not detected are designated by dark green triangles. Friend Creek, where both species were detected, is shown in the inset.

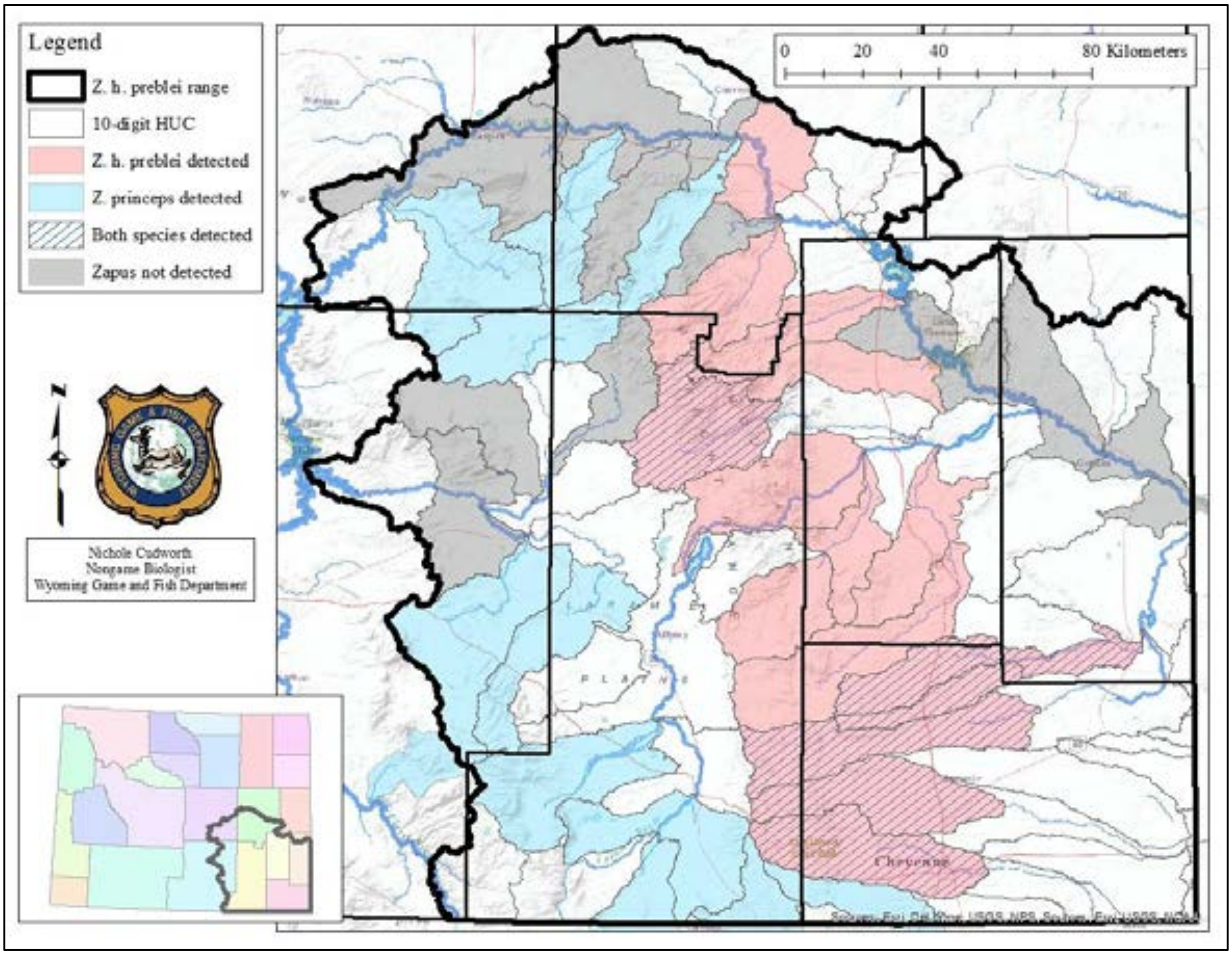

Figure 3. Trapping locations and 10-digit Hydrologic Unit Code (HUC) watershed boundaries for all sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming through 2013. HUCs where captures of Preble's meadow jumping mice were possible or confirmed are shown in red; HUCs where captures of western jumping mice (*Z. princeps*) were confirmed are shown in blue; HUCs where both species have been detected are designated by hash marks; and HUCs that have been surveyed but where jumping mice were not detected or species could not be confirmed are shown in gray. Taxonomic identification and location information from Bowe and Beauvais (2012).

GENETIC DIFFERENTIATION OF *ZAPUS SPP.* CAPTURED IN SOUTHEASTERN WYOMING, 2012

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need / Threatened Species – Preble's Meadow Jumping Mouse

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Nichole Cudworth, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

SUMMARY

In 2012, the Wyoming Game and Fish Department conducted surveys along the North Platte River and the western edge of the Laramie Range in Wyoming to document presence and distribution of Preble's meadow jumping mice (*Zapus hudsonius preblei*; Preble's; Cudworth and Grenier 2013). We captured one jumping mouse twice along the North Laramie River, which represented the lowest elevation survey site along the river thus far. We collected genetic samples (i.e., blood and tissue; Cudworth and Grenier 2013), and submitted samples to the lab of Dr. Tim King, US Geological Survey (USGS), to conduct nuclear and mtDNA genetic analysis following protocol outlined by King et al. (2006). Nuclear and mtDNA variation were identical for each genome and positively identified the sample as a western jumping mouse (*Z. princeps*). Although Preble's have been captured at higher elevations in this drainage, none have yet been detected farther west than the eastern edge of the Laramie Mountains (Wyoming Game and Fish Department unpublished report). Consequently, this finding conforms to previous observations that the Laramie Mountains may represent the westernmost extent of Preble's in the state.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming Governor's Endangered Species Account funds, for which the Department is extremely grateful. We also wish to thank I. Abernethy with the Wyoming Natural Diversity Database for submitting genetic samples, and Dr. T. King from the USGS for his assistance with genetic analyses.

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SPOTLIGHTING FOR BLACK-FOOTED FERRETS (*MUSTELA NIGRIPES*) IN THE SHIRLEY BASIN/MEDICINE BOW MANAGEMENT AREA

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need / Endangered Species – Black-footed Ferret

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funds
Wyoming State Legislature General Fund Appropriations

PROJECTION DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Jesse Boulerice, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

The black-footed ferret (*Mustela nigripes*) faces numerous challenges to recovery. Diseases remain the biggest threat to the persistence of the black-footed ferret in Shirley Basin, Wyoming. Releases of black-footed ferrets were terminated in 1994 as a result of sylvatic plague and disease epizootics, which reduced abundance of its prey, the white-tailed prairie dog (*Cynomys leucurus*) within Primary Management Zone 1. During this period, the reintroduced population was characterized by slow population growth. However, the black-footed ferret survived this bottleneck, and the population increased exponentially from 2000-2006 before transitioning to a logistical growth rate from 2006-2010. In 2013, we surveyed a portion of the Shirley Basin prairie dog complex as part of our annual commitment to recovery of the species and to monitor the reintroduced population. Similar to previous years, we spotlighted and captured black-footed ferrets in August and September 2013. We then compared estimates of abundance for the black-footed ferret and results of serological tests for diseases to data collected in previous years. We collected blood samples from 11 of 18 captured black-footed ferrets. All black-footed ferrets were negative for tularemia (*Francisella tularemia*) and canine distemper. We determined the minimum number alive to be 39 individuals, based on a summation of discrete observations for black-footed ferrets in 2013. This represents a drastic decrease in abundance since 2010. We believe low recruitment of prairie dogs during 2011-2012 primarily due to unusual weather experienced within the region were the cause of the decline. Although this decline is substantial, we expect the population of black-footed ferrets to rebound quickly in response to increasing abundance of prairie dogs.

INTRODUCTION

In 1991, Shirley Basin, Wyoming was selected as the first reintroduction site for black-footed ferrets (*Mustela nigripes*; ferret). Shirley Basin was selected for reintroduction due to its extensive complex of white-tailed prairie dogs (*Cynomys leucurus*; prairie dog) and the high level of support from private landowners in the area. Between 1991 and 1994, 228 ferrets were released in Shirley Basin. Releases were terminated in 1994 as a result of sylvatic plague and canine distemper epizootics, which decreased abundance of prairie dogs within Primary Management Zone 1. During this period, the reintroduced ferret population was characterized by slow population growth. Few (i.e., ≤20) ferrets were located annually prior to 2000. However, spotlight surveys were conducted between 2003 and 2006. During this period, we estimated an annual growth rate of 35% (Grenier et al. 2007). Survey results documented an increasing population of ferrets within the Shirley Basin/Medicine Bow prairie dog complex (Grenier et al. 2006a). Because prairie dog distribution had increased in other portions of Shirley Basin where ferrets were believed to be absent, an additional 250 ferrets were released into areas north and south of Shirley Basin during the fall and winter of 2005, 2006, and 2007 (Grenier et al. 2006b, Schell and Grenier 2007).

Primary monitoring interests have remained focused on a small portion of the prairie dog complex totaling about 8,000 ha (Grenier 2008). By 2006 the population had grown rapidly within the study area to 229 (95% CI: 169-289; Grenier et al. 2009). Estimates from 2008 (240; 95% CI: 176-303) and 2010 (203; 95% CI: 137-270) suggested that population growth had begun to taper off, as rate of growth appeared to transition from an exponential to a logistical pattern (Van Fleet and Grenier 2009, 2011). This report quantifies results of summer spotlight surveys in 2013. We compare estimates of abundance and serology results to previous years. We discuss the implications of our findings for recovery of the ferret in Shirley Basin, Wyoming.

METHODS

We conducted spotlight surveys in 2013 within the same area we surveyed in 2006, 2008, and 2010. We selected specific survey routes based on available resources, personnel, and the interspersion of two-track and other roads within prairie dog colonies. We contacted all landowners for permission to trespass prior to the initiation of surveys. Due to a low number of captures, we did not use closed population models to estimate abundance of ferrets as in previous years. Instead, we estimated minimum number alive (MNA) by summing all discrete observations of ferrets following guidelines outlined in Grenier (2008). We subdivided prairie dog colonies into sampling plots based on accessibility and assigned them to two strata based on abundance of ferrets. Sampling plots accessible only by foot were approximately 121 ha in size, while those accessible by vehicle were approximately twice as large (i.e., approximately 242 ha). Actual size of the survey plots varied due to size and shape of the prairie dog colony as well as other geographical boundaries (Grenier 2008). We did not survey colonies <61 ha (Fig. 1). We allocated survey effort to each strata proportionally and sampled 24 plots (Fig. 2; Grenier 2008).

We surveyed from 2000-2300 hrs and 0100-0600 hrs in blocks of 3 consecutive nights (Grenier 2008, Grenier et al. 2009). To locate ferrets, we drove vehicles equipped with roofmounted spotlights (Model RM 240 Blitz, Lightforce Professional Lighting Systems, Orofino, ID) along existing roads. Field personnel used a backpack spotlight unit (Walkabout Kit, Lightforce Professional Lighting Systems, Orofino, ID) to traverse portions of the colony that could not be surveyed from a vehicle.

After we located ferrets, we used an unbaited live trap to attempt to capture observed individuals (Sheets 1972). We checked traps hourly throughout the night, and removed all traps at sunrise. We transported captured ferrets to a mobile processing trailer, where we used isoflurane gas to anesthetize individuals (Kreeger et al. 1998). Ferrets were assigned to juvenile or adult age classes by palpation of the sagittal crest, examination of dentition and tooth wear, and reproductive status (Thorne et al. 1985). We marked ferrets with passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) and hair dye (Grenier 2008). We collected blood samples when possible. Following a brief recovery period, we returned the ferret to the burrow from which it was captured. We sent blood samples to the Wyoming Game and Fish Department (Department) Wildlife Veterinary Laboratory to test for the presence of tularemia (*Francisella tularemia*) and canine distemper virus (CDV) antibodies.

RESULTS

We spent 671 person•hrs, during 9 nights, spotlighting for ferrets in August and September (Table 1). We recorded 72 observations of ferrets and determined the MNA to be 39 individuals (Table 2). This amounted to a discrete ferret approximately every 17.2 person•hrs. We detected ≥13 litters.

We captured 18 ferrets, comprised of 6 males and 12 females. One female was previously captured in 2010, while all other ferrets were captured for the first time in 2013. Juveniles comprised 33% of our captures in 2013. We collected blood samples from 11 of the 18 ferrets captured. All blood samples were negative for all pathogens. We detected no abnormalities and very few (i.e., ≤10) ectoparasites (i.e., fleas and ticks) on most ferrets we handled in 2013. Capture details for all ferrets captured in 2013 are summarized in Table 3.

DISCUSSION

Abundance of ferrets has decreased dramatically since last surveyed in 2010 (Fig. 3). Overall, we detected about ½ as many individuals and litters than in previous years. MNA for 2010 was 91, while it was only 39 in 2013. Notably, despite this decrease, all ferrets appeared to be in good physical and reproductive condition. We failed to detect any physical abnormalities among captured ferrets, and serology results suggested that infectious deceases had little impact on this population in 2013. We hypothesize that the decline is a result of poor recruitment of prairie dogs in 2011 and 2012, rather than poor health of individual ferrets. Weather had been unusual and severe for Shirley Basin in 2011-2012. Spring of 2011 was extremely cold and wet. Local landowners reported seeing fewer juvenile prairie dogs in 2011 during the summer. The following year was reported to be one of the worst drought years in recent memory, with most prairie dogs estivating for the majority of the summer. We observed few prairie dogs above ground between June and September 2013. Burrows were often plugged and dilapidated, resembling post-epizootic conditions. However, conditions in 2013 appeared to return to normal, and we observed many prairie dogs, including both juvenile and adults, during our surveys. We also observed that nearly all burrows were well-maintained by prairie dogs and few had no prairie dog scat nearby. These observations suggest that conditions had improved since 2013. Given the capacity for high reproductive output by ferrets, we expect abundance of ferrets to increase quickly as conditions continue to improve (Grenier et al. 2007). The stochastic events that have influenced the reported decline highlight the fragility of these reintroduced populations. Our results suggest that other phenomenon besides diseases can cause rapid declines in abundance of ferrets.

ACKNOWLEDGEMENTS

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Table 1. Survey effort expended while spotlighting for black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming during the summer of 2013. A total of 671.05 hours of spotlighting was accomplished by vehicle and on foot through white-tailed prairie dog (*Cynomys leucurus*) towns.

Survey type	Number of hrs surveyed			
	Aug. 20-22	Aug. 27-29	Sep. 3-5	Total
Vehicle	99.85	45.45	103.8	249.1
Foot	103.75	119.6	197.1	420.45
Total	202.6	166.55	301.9	671.05

Table 2. Capture details for 18 black-footed ferrets (*Mustela nigripes*) captured in Shirley Basin, Wyoming, 2013. Blood samples were taken from 11 of the captured black-footed ferrets. * indicates individual recaptured from 2010.

Capture no.	Transponder no. – head	Capture date	Colony no.	Observer	Stud book no.	Sex	Age	Weight (g)
1	050 834 075	8/20/2013	556-8	J. Coyle	SB1201	M	A	1019
2	050 830 116	8/21/2013	556-6	B. Kimbel	SB1202	F	A	730
3	050 829 555	8/22/2013	556-8	J. Coyle	SB1204	F	A	628
4	050 832 115	8/22/2013	556-6	B. Kimbel	SB1203	F	A	689
5	050 833 627	8/22/2013	556-10	C. Helmke	SB1205	F	A	720
6	050 830 035	8/27/2013	559-2	A. Sutphin	SB1207	F	A	687
7	050 513 615	8/28/2013	559-3	A. Sutphin	SB1208	F	A	745
8	050 828 876	8/29/2013	559-2	B. Dow	SB1301	M	J	762
9	050 818 521	8/29/2013	559-3	J. Boulerice	SB1209	F	A	721
10	050 543 324	9/3/2013	520-1	M. Grenier	SB1210	F	A	718
11	050 533 639	9/3/2013	520-2	J. Boulerice	SB1302	M	J	890
12	050 523 083	9/4/2013	527-2	G. Frost	SB1212	F	A	673
13	050 516 319	9/4/2013	556-4	E. Maichel	SB1213	M	A	951
14	050 383 335	9/4/2013	520-1	M. Grenier	SB1303	M	J	889
15	050 519 547	9/4/2013	527-2	G. Frost	SB1205	F	J	759
16	050 534 842	9/4/2013	519-1	C. Helmke	SB1304	M	J	818
17	050 527 781	9/5/2013	527-1	N. Cudworth	SB1306	F	J	746
18*	095 817 022	9/5/2013	520-1	J. White	SB1001	F	A	664

Table 3. Complete list of all black-footed ferrets (*Mustela nigripes*) observed in Shirley Basin, Wyoming 2013. Discrete observations were determined based on guidelines outlined in Grenier (2008).

Date	Time	Colony	Observer	UTME	UTMN	Discrete
8/20/2013	02:50	556-8	J. Coyle	0413271	4665375	1
8/20/2013	22:05	553	D. Brady	0414247	4667680	1
8/20/2013	22:05	553	D. Brady	0414247	4667680	1
8/20/2013	22:05	553	D. Brady	0414247	4667680	1
8/21/2013	01:05	556-8	J. Coyle	0413313	4664431	0
8/21/2013	03:50	556-6	B. Kimbel	0411766	4666676	1
8/21/2013	04:10	556-6	B. Kimbel	0411888	4666949	0
8/21/2013	05:50	556-6	B. Kimbel	0411888	4666949	0
8/22/2013	02:50	556-6	B. Kimbel	0412077	4666407	0
8/22/2013	03:13	556-1	C. Helmke	0413291	4664417	1
8/22/2013	03:30	556-6	B. Kimbel	0411842	4666896	0
8/22/2013	04:15	556-6	B. Kimbel	0411744	4666690	1
8/22/2013	04:33	556-8	J. Coyle	0413167	4665102	1
8/22/2013	04:39	556-8	J. Coyle	0413147	4665081	1
8/22/2013	21:40	556-6	B. Kimbel	0411842	4666896	1
8/22/2013	23:00	556-8	J. Coyle	0413313	4664431	0
8/22/2013	23:53	556-1	C. Helmke	0413291	4664417	1
8/22/2013	23:53	556-1	C. Helmke	0413299	4664399	0
8/27/2013	02:25	559-2	A. Sutphin	0410577	4659858	1
8/27/2013	02:34	559-1	J. Trabal	0410070	4662438	1
8/27/2013	02:42	559-2	B. Dow	0410619	4659942	0
8/27/2013	03:05	559-2	J. Boulerice	0411417	4660386	1
8/27/2013	03:05	559-2	J. Boulerice	0411417	4660386	1
8/27/2013	04:00	559-2	A. Sutphin	0411083	4660185	1
8/27/2013	04:10	559-2	B. Dow	0411113	4660156	0
8/27/2013	04:10	559-2	B. Dow	0411123	4660136	0
8/27/2013	04:56	559-2	J. Boulerice	0411352	4660494	1
8/27/2013	05:30	555-1	E. Cressall	0410055	4670923	1
8/27/2013	22:35	559-2	B. Dow	0410531	4659780	1
8/28/2013	02:35	559-3	A. Sutphin	0410668	4659745	1
8/28/2013	02:40	559-3	B. Dow	0411087	4659760	1
8/28/2013	02:50	559-2	A. Sutphin	0411123	4660134	0
8/28/2013	03:30	559-2	J. Boulerice	0411417	4660306	0
8/28/2013	03:30	559-2	J. Boulerice	0411423	4660390	0
8/28/2013	03:30	559-2	J. Boulerice	0411424	4660383	0
8/28/2013	05:15	559-3	A. Sutphin	0410526	4659767	0
8/28/2013	22:40	559-3	B. Dow	0411057	4659373	0
8/29/2013	02:45	559-2	B. Dow	0410532	4659793	1
8/29/2013	04:00	559-3	J. Boulerice	0411424	4660383	0
8/29/2013	04:20	559-3	A. Sutphin	0411121	4660135	0
8/29/2013	20:30	559-3	A. Sutphin	0410526	4659767	0

Table 3. Continued.

Date	Time	Colony	Observer	UTME	UTMN	Discrete
8/29/2013	20:50	559-3	A. Sutphin	0411084	4660039	0
9/3/2013	02:30	520-2	J. Boulerice	0399442	4668438	1
9/3/2013	02:37	527-1	N. Cudworth	0396754	4672830	0
9/3/2013	03:02	520	M. Grenier	0401279	4667077	1
9/3/2013	03:17	527-1	N. Cudworth	0397654	4672973	1
9/3/2013	03:20	520-2	J. Boulerice	0400410	4667634	1
9/3/2013	03:20	520-2	J. Boulerice	0400410	4667634	1
9/3/2013	06:00	519	C. Helmke	0402372	4670146	1
9/3/2013	21:10	527-2	G. Frost	0440031	4671644	1
9/3/2013	21:20	527-2	G. Frost	0440031	4671644	1
9/3/2013	21:20	527-2	G. Frost	0440031	4671644	0
9/4/2013	02:10	527-2	G. Frost	0440031	4671644	1
9/4/2013	03:40	529	T. Pridemore	0400011	4672923	1
9/4/2013	05:05	556-4	E. Maichel	0399403	4669506	1
9/4/2013	05:10	519	C. Helmke	0402358	4670146	0
9/4/2013	05:30	529	T. Pridemore	0402015	4672659	1
9/4/2013	20:20	520	M. Grenier	0401659	4667159	1
9/4/2013	20:45	527-2	G. Frost	0440031	4671644	1
9/4/2013	21:40	521	M. Spencer	0400067	4665724	1
9/4/2013	22:30	519	C. Helmke	0402372	4670146	0
9/5/2013	02:18	527-1	N. Cudworth	0397654	4673973	1
9/5/2013	03:20	556-4	E. Maichel	0399086	4669451	0
9/5/2013	04:10	519	M. Karsch	0402242	4670250	0
9/5/2013	04:15	520-1	J. White	0401125	4666986	0
9/5/2013	05:00	520-1	J. White	0401519	4667632	0
9/5/2013	21:45	527-2	G. Frost	0400310	4671644	0
9/5/2013	21:45	527-2	G. Frost	0400310	4671644	0
9/5/2013	21:45	527-2	G. Frost	0400310	4671644	0
9/5/2013	21:45	527-2	G. Frost	0400310	4671644	0
9/5/2013	22:45	520-1	J. White	0401276	4666986	1

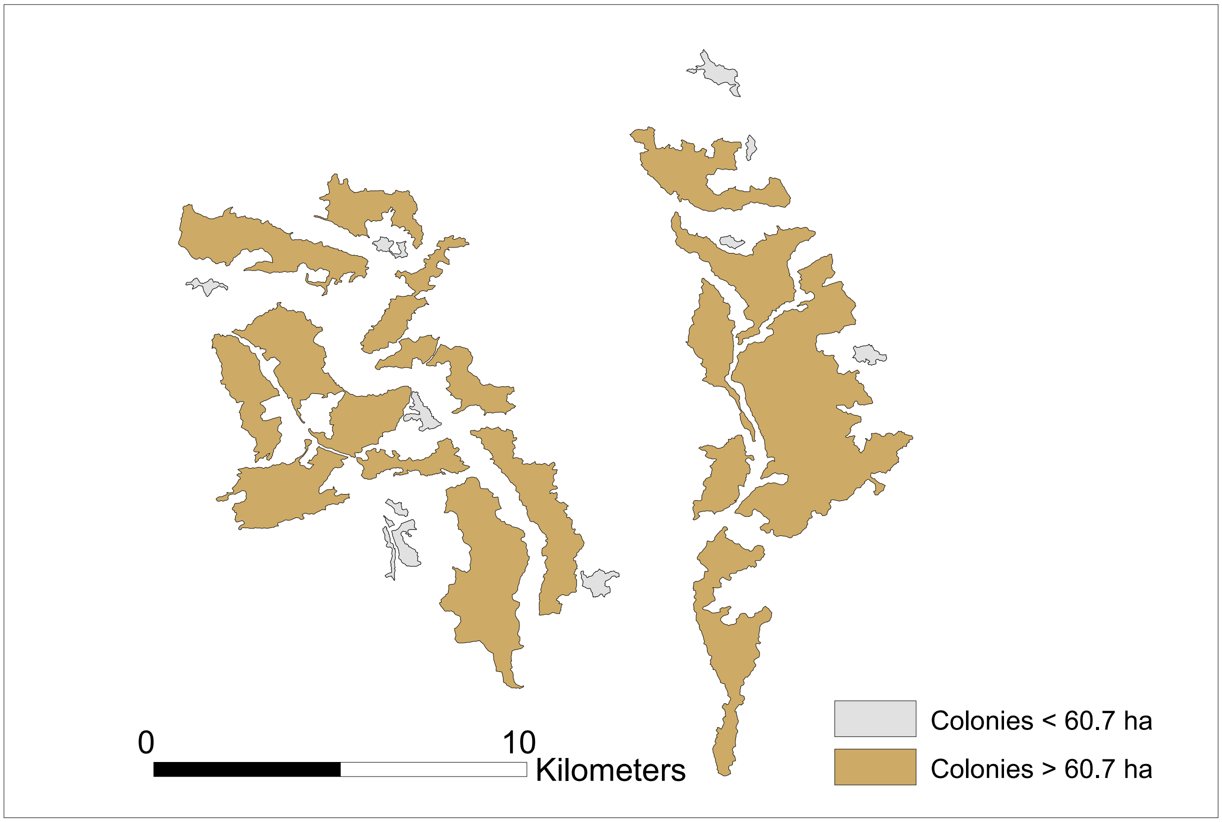

Figure 1. Spatial arrangement of white-tailed prairie dog (*Cynomys leucurus*) colonies that were spotlighted for black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming, 2013. Colonies ≤61 ha in size were not surveyed. Not all colonies surveyed contribute to the estimate of minimum number alive.

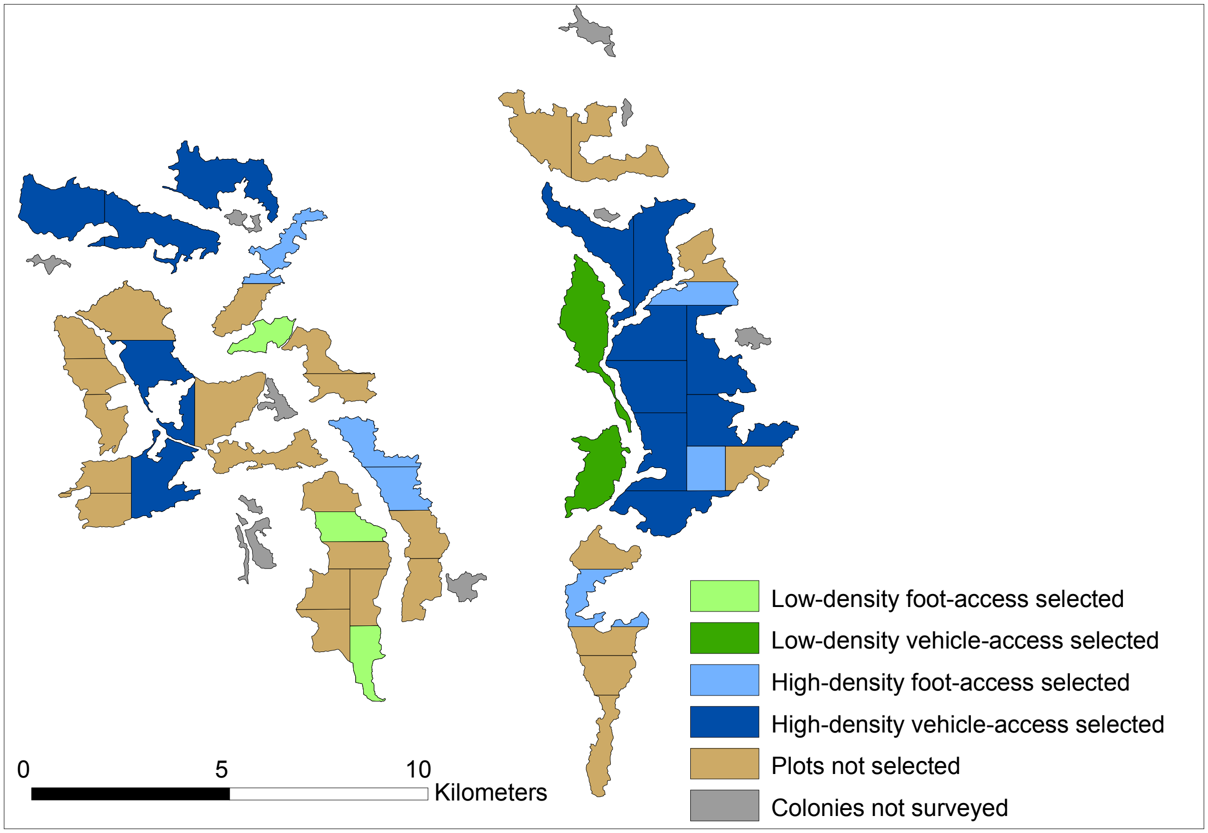

Figure 2. Distribution of survey plots that were spotlighted for the presence of black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming 2013. Colonies ≤61 ha in size were not surveyed, and no inference to these colonies is made.

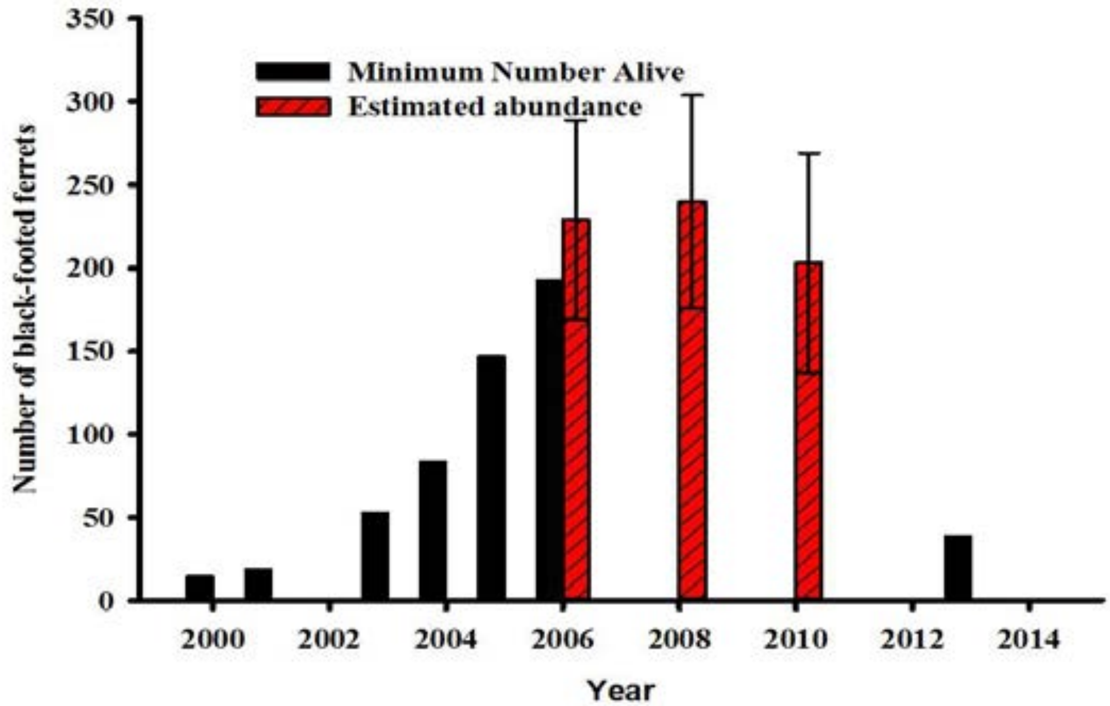

Figure 3. Abundance of black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming, 2000-2013. In 2006, abundance was estimated at 229 (95% CI: 169-289), in 2008 at 240 (95% CI: 176-303), and in 2010 at 203 (95% CI: 137-270). In 2013, abundance was based on minimum number alive as number of captured ferrets was too low to estimate abundance. Abundance surveys were not conducted in 2002, 2007, 2009, 2011, or 2012.

SPECIES OF GREATEST CONSERVATION NEED – BIRDS

MONITORING AND MANAGEMENT OF THE ROCKY MOUNTAIN POPULATION OF TRUMPETER SWANS (*CYGNUS BUCCINATOR*) IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Trumpeter Swan

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Funds
United States Fish and Wildlife Service Cooperative Agreements

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Susan Patla, Nongame Biologist

ABSTRACT

Since the late 1980s, the Wyoming Game and Fish Department has been actively involved in monitoring and managing Trumpeter Swans (*Cygnus buccinator*). The Trumpeter Swan is one of the rarest avian species that nests in Wyoming and is classified as a Species of Greatest Conservation Need with Native Species Status of 2 by the Wyoming Game and Fish Department. Year-round resident Trumpeter Swans in Wyoming comprise part of the historic Tri-State population that nests in the Greater Yellowstone Area. Monitoring efforts for this species are coordinated with the US Fish and Wildlife Service, Pacific Flyway Council, and the state agencies in Idaho and Montana. We completed four survey flights during 2013 and winter 2014 to collect census data on total number of adults and young in summer and winter and to document occupancy and productivity of all known nest sites. In the 2013 fall survey, we documented an increase in resident adult and cygnet Trumpeter Swans in Wyoming outside of Yellowstone National Park compared to the previous year (n = 153 adults, 52 cygnets), which is a record high for the State. We also documented a record high number of occupied nest sites (n = 51), which is the largest number since we initiated surveys in the 1980s. In February 2014, we counted slightly fewer swans wintering in Wyoming (n = 989), compared to the previous 3 winters when numbers ranged >1,000 swans. Forty seven percent of wintering swans were located in the Snake River drainage. Growth of the resident population of Trumpeter Swans can be attributed to the Wyoming Game and Fish Department's range expansion efforts beginning in the late 1980s in the Salt and Green River Basins. We remain concerned over the slow decline of swan numbers and productivity in the core Snake River area. To accommodate the growing

number of nesting swans in the Green River Basin, we initiated a wetland habitat program in 2004 that focuses on cooperating with landowners to develop shallow-water wetland ponds that provide additional summer habitat for swans and other wildlife species. Work has been completed on 5 private ranches, and >20 ha of shallow wetland habitat have been created in Sublette County. Funding for this work has been obtained by the Bureau of Land Management Wyoming Landscape Conservation Initiative, Wyoming Wildlife and Natural Resource Trust, Natural Resources Conservation Service, and Fish and Wildlife Service Partner's Program. The success of this swan-focused wetland program has helped to stimulate other wetland-related projects in the Green River area. The Department is currently administrating a standard North American Wetlands Conservation Act grant proposal developed with The Conservation Fund and other partners to obtain one million dollars for conservation easements and wetland habitat projects in the Green River Basin. Another project started in 2012 was the first basin-wide wetland assessment funded by the Environmental Protection Agency states program in Wyoming for the Green River Basin. A final report and analysis will be completed in 2015 by The Nature Conservancy of Wyoming for this assessment.

INTRODUCTION

The Trumpeter Swan (*Cygnus buccinator*; swan) is designated as a Species of Greatest Conservation Need in Wyoming with Native Species Status ranking 2 (WGFD 2010). Although swans were never listed under the Endangered Species Act of 1973, they have been a focal management species for federal and state agencies in the Greater Yellowstone Area (GYA) since the establishment of Red Rock Lakes National Wildlife Refuge in Montana in 1932. This refuge was created to conserve approximately 70 swans in the GYA, which were believed to be the last remaining Trumpeter Swans in the world. Due to conservation efforts, the number of swans in the GYA increased to >600 by the 1950s (USFWS 1998). However, the population has fluctuated since that time, and total number of adult birds in the GYA is currently <500 (Olson 2013b). This non-migratory segment of the population remains of concern even though Trumpeter Swan populations in Alaska, interior Canada, and the mid-western states have been increasing (Groves 2012).

The Pacific Flyway Council coordinates management of this population and has designated swans that nest and reside year-round in the GYA, including western Wyoming, as the Tri-State Area Flocks (TSAF). The TSAF are managed as part of the US segment of the Rocky Mountain Population (RMP) of swans, which includes those that nest in interior Canada and migrate south to over-winter in the GYA (USFWS 1998). The Wyoming Game and Fish Department (Department) coordinates with the US Fish and Wildlife Service (USFWS) Mountain-Prairie Region Migratory Bird Office and the states of Idaho and Montana to census the number of mature swans and young of the year (i.e., cygnets) in the TSAF. Since the late 1980s, the Department has worked to expand summer and winter distribution of swans in Wyoming (Patla and Oakleaf 2004). These efforts have established a new nesting population in the Green River Basin. Since 2004, the Department has cooperated with willing landowners to restore and create summer habitat in the Upper Green River Basin to accommodate this expanding resident flock (Patla and Lockman 2004, Lockman 2005).

The Department is a member of the Greater Yellowstone Trumpeter Swan Working Group, which consists of state and federal agencies, non-government organizations, and interested citizens. The working group meets annually in the fall to review and discuss productivity trends as well as to coordinate management actions. Wyoming also coordinates with the Pacific Flyway RMP Trumpeter Swan Study Sub-Committee. This report summarizes management activities and monitoring data for swans in Wyoming for the 2013 nesting season and the 2013-2014 winter season.

METHODS

We conducted four fixed-wing airplane surveys to collect data on swans in western Wyoming. We used the same pilot and Scout airplane from Sky Aviation, Worland, to fly all surveys. Flying elevation averaged 30-70 m above ground level depending on terrain and surface winds; flight speed varied between 135-160 kph. During the survey, the observer counted white birds (i.e., adults and sub-adults) and gray cygnets. We surveyed spring habitat use areas on 1 and 2 April and nest sites on 17 June to determine occupancy and again on 15 July to count number of young hatched (i.e., cygnets). The fall and winter surveys were coordinated by USFWS in the Tri-State area of Wyoming, Montana, and Idaho. We flew the Wyoming portion of the fall survey on 11 and 16 September 2013 and the winter survey on 2 and 10 February 2014. Additional data were obtained through site-specific ground surveys, reports provided by federal agencies, and observations from the public. We presented survey results and participated in the Pacific Flyway Trumpeter Swan Sub-Committee meetings in July 2013 and also participated in the Greater Yellowstone Trumpeter Swan Working Group meeting from 13-14 November 2013 in West Yellowstone, Montana. The USFWS Mountain-Prairie Region Migratory Bird Office produced two reports summarizing results for the coordinated RMP surveys that included data collected in Wyoming (Olson 2013b, 2014).

RESULTS

During February 2014, we counted a total of 958 swans wintering in the Pacific Flyway portion of Wyoming outside of Yellowstone National Park (YNP), which represents an 11% decrease over the previous year and the first time in 4 years that total winter swan numbers in Wyoming dipped below 1,000 (Table 1, Fig. 1). The largest percentage of wintering swans occurred in the Snake River (48%) and the Green River (31%) drainages (Table 1). An additional 47 swans were documented wintering in the Central Flyway portion of Wyoming including Bull and Dinwoody Lakes (Fig. 1). The number of swans wintering in the Pacific Flyway area in Wyoming increased 7.0% per year between 1972 and 2012 ($P < 0.01$; Olson 2013a). Increase in wintering birds is largely the result of continued growth of the migrant interior Canada nesting population.

In fall 2013, we counted a record high number of white swans (adults and subadults) in Wyoming outside of YNP ($n = 153$; Table 2). This represents a 7% increase in adults from the previous survey year. The number of swans in Wyoming (1993-2012) has increased by 2.1% per year ($P < 0.01$) for white birds and 7.6% ($P < 0.001$) for cygnets (Olson 2013b). However, in the traditional Snake River core area (1999-2013), the number of swans appears to be declining over the past 14 years (-0.5%). Conversely, in the Green River expansion area the number of swans has increased by 10.6% ($P < 0.001$) over the past 14 years (Olson 2013b). Overall, the total TSAF fall count of white birds represented an 18% increase from the previous year and the highest count since 1989. Number of cygnets, however, decreased 38.2% from 178 in 2012 to 100 in 2013. The TSAF have shown a slight annual increase of 1.9% for white birds ($P < 0.01$) and a slight increase in cygnets (+3.4%, $P = 0.03$) between 1993 and 2012 (Olson 2013b).

The number of nest sites occupied in 2013 in Wyoming outside of YNP ($n = 51$) represented a new record for Wyoming and greatly exceeded the 10-year mean (Table 3, Fig. 2). The number of nesting pairs in 2013 also represents a record high ($n = 34$). The number of young hatched and fledged in Wyoming outside YNP in 2013 exceeded the 10-year averages for 2003-2012 (Table 3). Of the 51 sites occupied in 2013, 67% of pairs initiated nesting, 56% hatched young, and 39% fledged at least one young. Overall, swans in the Green River Basin accounted for 61% of occupied sites and 69% of fledged young (Table 4). For the first time, a pair of swans raised five cygnets in the Wind River drainage north of Lander (Fig. 2). In the Snake River core area, 47% of cygnets that hatched did not fledge, compared to 36% of hatched young that did not fledge in the Green River. This trend of greater cygnet survivorship in the Green River expansion area has held for 6 out of the last 7 years.

Site-specific occupancy and productivity results for all known swan nest sites surveyed in Wyoming outside of YNP are presented in Appendix 1. A summary of productivity by management unit for the Snake and Green River drainages, 2002-2012, is presented in Table 5. Over this 11-year period, a total of 405 cygnets fledged, with 62% of the productivity occurring in the Green River expansion area. Cygnets were produced at 41 individual nest sites; 59% of these were in the Green River area. Only 53% of nest attempts in the Snake core resulted in fledged young compared to 72% in the Green. Swan productivity in both drainages was greatest on National Wildlife Refuges (NWR), which combined accounted for 51% of all cygnets produced: the National Elk Refuge ($n = 66$ young fledged) and Seedskadee NWR ($n = 139$ young fledged). Private land sites ($n = 12$) in the Green River area accounted for 38% of the total productivity in the expansion area. Of note are two nesting territories in the Snake core area, one on private land in the Buffalo Valley, and one at the Department's South Park Wildlife Habitat Management Area, that produced 28% of cygnets in that drainage.

Summary of mortality data from 1991-2013 are presented in Table 6. We documented 13 mortalities in Wyoming, which was less than half compared to the previous year. Necropsy results from the National Wildlife Health Lab and the state lab for 10 carcasses submitted this past summer and spring found that most of the necropsied swans died from heavy internal parasite loads including trematodes, nematodes, coccidian, and cestodes. One swan was also diagnosed with avian tuberculosis. A few samples were lost during shipment. Tissue samples were taken and frozen from all intact morbid swans for mercury analysis (requested by Biodiversity Research Institute) and possible future genetic work.

DISCUSSION

The 2013 nesting season was successful, with swan numbers and productivity in Wyoming outside of YNP reaching new historic highs. The number and productivity of Trumpeter Swans nesting in Wyoming outside of YNP has increased in recent years largely as a result of population growth in the Green River expansion area. We continue to document a slow decline in numbers of nesting pairs and low productivity of most nest sites in the Snake River core area. A total of 75% of the productivity in the Snake River core since 2002 has been from only 7 territories, 3 of which are on the National Elk Refuge. During this period of decline, we have documented a dramatic increase in the number of migrant swans from interior Canada wintering in the core area. Migratory swans may be reducing available forage needed by resident swans in winter and early spring. Generally, most migrant swans depart by the end of March or early April, leaving resident swans to forage on remaining aquatic vegetation until additional wetlands thaw and open. Especially in cold, late springs such as 2011, when the thaw in some locations was delayed until late May or early June, available aquatic vegetation is in short supply during the pre-nesting period. We hypothesize that the increase in the number of wintering swans negatively impacts resident pairs in the core area as a result of depleted foraging habitat that is in very limited supply during late winter and early spring. This idea is supported by results in 2007, which was one of the warmest springs on record in Wyoming. Wyoming swans in that summer produced a record number of young ($n = 31$) in the Snake River core area (Table 4). Access to supplemental food on private wetland ponds may be exacerbating the problem of increasing the number of swans in the Jackson area in winter by attracting and holding more swans. Recent efforts by the Wyoming Wetlands Society (WWS) to reduce the availability of forage for wild birds at the ponds where they hold captive swans in the Jackson area may have resulted in fewer swans wintering in Jackson this past winter. We will be monitoring the number of wintering birds in future years to see if this trend holds.

In contrast, although the number of swans wintering along the Green River south of Fontenelle Dam has been increasing annually since 2003 (Table 1) we are seeing exponential growth in resident swan numbers and increasing productivity in the Green River expansion area. This indicates that winter and early spring resources are adequate to support the resident nesting population in this drainage. Swans that winter along the Green River below Fontenelle Dam start to move north as soon as the river begins to thaw above the dam in early to mid-March. These swans have access to a much larger extent of new foraging habitat along the Green River corridor in the pre-nesting season compared to resident swans in the core area whose winter and summer habitat is concentrated in the valley of Jackson Hole.

Swans in Wyoming now comprise between 35-40% of the total TSAF and, therefore, constitute an important component of the current GYA resident population. Although, the success of the Green River range expansion program has resulted in increased numbers of swans in that area of the state, we remain concerned about declining numbers and productivity in the traditional core area, including YNP. We will continue to work with members of the Greater Yellowstone Trumpeter Swan Working Group and the Pacific Flyway to monitor this situation and work toward the development of management projects and joint research proposals to investigate the reasons for this decline and to manage for a viable nesting population in the core Snake River drainage. In 2013, YNP released three captive-raised yearlings and seven cygnets obtained from WWS to supplement their meager wild population (n = 14 in fall 2013). Monitoring the fate of these additional birds hopefully will determine what factors may be affecting swan survivorship and productivity in the park and in northwestern Wyoming (D. Smith, YNP wildlife biologist, pers. comm.). An additional five cygnets were released by USFWS and WWS on the Wind River Indian Reservation in September as the initial phase of a project to establish a nesting population in the Wind River drainage.

In future years, we will continue to focus management efforts on cooperative habitat projects with willing landowners to improve and restore wetland habitats in the Green River, Salt River, and Snake River drainages as opportunities arise (Patla and Lockman 2004, Lockman 2005, WGFD 2010). Given the increasing number and productivity of swans in the Green River Basin and possible long-term drought conditions, it is important that the Department continue to be a leader in habitat improvement projects for swans and other wildlife associated with shallow water wetland habitat. In 2013, swans used wetland sites developed by the Department as cooperative projects with landowners at four locations in the Pinedale area. Funding for these projects was obtained through the Wyoming Landscape Conservation Initiative, the Wyoming Wildlife and Natural Resource Trust, Natural Resources Conservation Service programs, and USFWS Partners Program. Construction is currently underway for two additional ponds on a ranch near Boulder. Planning work has also began on wetland and riparian restoration projects funded by a standard North American Wetlands Conservation Act grant which was awarded to the Department and the UFWS and 14 other partners for a total of $1 million for conservation easements and wetland habitat projects in the Upper Green River Basin. The development of this partnership and grant was possible through an Intermountain Joint Venture capacity grant award to The Conservation Fund and the Department. In 2012, we also obtained a state grant from the Environmental Protection Agency, in partnership with The Nature Conservancy (TNC) of Wyoming, to conduct the first basin-wide assessment of wetland habitat in the state for the Green River basin. Completion of this 2-year study will provide a more complete understanding of the types and condition of wetlands in the basin and help to focus future conservation and restoration work. We are also working with TNC and Wyoming Landscape Conservation Initiative to launch a study of wetland habitat used by the growing population of Trumpeter Swans in the Green River Basin to understand swan habitat selection and determine the extent of suitable habitat in the basin.

In summary, the future outlook for the resident Trumpeter Swan population in Wyoming is greatly improved compared to the status in the 1990s. We have increased number and distribution of swans in the state and also increased the amount of wetland habitat important for swans and many other species of waterfowl and wildlife. Certain risks, however, may be increasing for this species, some of which are likely related to climate change, including drought- and development-related habitat loss, new and increasing waterfowl diseases and parasites, expanding number of wintering swans, and growth in recreational water sports.

ACKNOWLEDGEMENTS

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Table 1. Number of Trumpeter Swan (*Cygnus buccinators*) adults and cygnets counted in Wyoming for the coordinated Tri-State winter survey in February, 2003-2014. Results are shown for specific survey areas in Wyoming where wintering swans have been found. Occasional swans observed in the Platte River drainage are not included. Data for the entire Tri-State Area, which includes portions of southwestern Montana and southeastern Idaho, can be obtained from D. Olson (2014).

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	146	254	49	35	16	500
2003	Cygnet	34	45	4	7	2	92
	Total	180	299	53	42	18	592
	Adult	149	307	61	94	0	611
2004	Cygnet	33	18	17	23	0	91
	Total	182	325	78	117	0	702
	Adult	124	367	61	102	31	685
2005	Cygnet	30	109	20	35	2	196
	Total	154	476	81	137	33	881
	Adult	121	413	100	124	18	776
2006	Cygnet	14	58	13	37	3	125
	Total	135	471	113	161	21	901
	Adult	144	420	116	158	6	844
2007	Cygnet	25	84	30	35	6	180
	Total	169	504	146	193	12	1024
	Adult	65	316	109	174	4	668
2008	Cygnet	7	63	30	43	6	149
	Total	72	379	139	217	10	817

Table 1. Continued.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	88	321	160	133	24	726
2009	Cygnet	2	63	27	8	12	112
	Total	90	384	187	141	36	838
2010	Adult	18	369	160	85	16	648
	Cygnet	5	56	30	12	8	111
	Total	23	425	190	97	24	759
2011	Adult	125	467	168	150	27	937
	Cygnet	42	138	51	32	8	271
	Total	167	605	219	182	35	1208
	Adult	51	488	210	109	27	885
2012	Cygnet	4	99	20	29	24	176
	Total	55	587	230	138	51	1061
	Adult	2	548	212	120	15	897
2013	Cygnet	0	120	30	20	8	178
	Total	2	668	242	140	23	1075
	Adult	24	411	261	123	41	860
2014	Cygnet	7	50	5	21	6	129
	Total	31	461	306	144	47	989

Table 2. Fall survey results for the Tri-State Area flocks of the Rocky Mountain Population of Trumpeter Swan (*Cygnus buccinator*) that are resident year-round in states of Idaho, Montana, and Wyoming, 2005-2013 (Olson 2013b). YNP represents Yellowstone National Park. [a] In 2013, YNP released captive raised swans: 3 yearlings released on 15 June on Delusion Lake, 3 cygnets on September 11 on the Yellowstone River (Alum Creek confluence), and 3 cygnets on Tern Lake on 13 September. These are included in the totals below.

Year	Age group	Montana	Idaho	Wyoming YNP [a]	Wyoming outside YNP	Tri-State total
	Adult	112	136	18	89	355
2005	Cygnet	40	22	1	35	98
	Total	152	158	19	124	453
	Adult	117	132	14	114	377
2006	Cygnet	17	39	0	26	82
	Total	134	171	14	140	459
	Adult	157	113	10	103	383
2007	Cygnet	41	15	0	59	115
	Total	198	128	10	162	498
	Adult	140	112	6	121	379
2008	Cygnet	7	5	2	34	48
	Total	147	117	8	155	427
	Adult	138	122	4	97	361
2009	Cygnet	21	21	0	33	75
	Total	159	143	4	130	436
	Adult	129	101	2	143	375
2010	Cygnet	30	29	0	48	107
	Total	159	130	2	191	482
	Adult	123	98	9	124	354
2011	Cygnet	40	12	0	37	89
	Total	163	110	9	161	443
	Adult	129	97	12	143	381
2012	Cygnet	96	30	4	48	178
	Total	163	127	16	191	559
	Adult	208	80	17	153	458
2013	Cygnet	26	28	7	52	113
	Total	234	108	24	205	571

Table 3. Occupancy and productivity data for Trumpeter Swans (*Cygnus buccinator*) nesting in Wyoming outside of Yellowstone National Park, 1991-2013. Shown are number of sites occupied, number of nesting pairs, number of pairs that hatched cygnets, number of pairs with fledged cygnets (i.e., mature young in September), total number of cygnets hatched, and number of cygnets fledged (counted in the fall survey) per year. The values in bold type are those that have been changed to reflect corrections in historic data. [a] Production data includes a site in the Green River drainage where eggs were collected and five 1-day-old young from Wyoming Wetlands Society's captive flock were grafted to a pair successfully in 2000, of which four fledged, and again in 2001, of which five fledged. Mean and standard deviation are shown for the 10-year period 2003-2012.

Year	Sites occupied (*n*)	Nesting pairs (*n*)	Pairs with hatchlings (*n*)	Pairs with fledglings (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)
1991	22	8	2	2	3	2
1992	29	10	5	3	17	9
1993	24	11	7	5	15	8
1994	20	13	8	5	29	18
1995	22	12	7	5	25	15
1996	**23**	**12**	**7**	4	**17**	**6**
1997	26	**14**	**6**	4	**19**	17
1998	**23**	18	10	7	26	15
1999	**21**	15	6	6	19	12
2000 [a]	26	16	**11**	**10**	**42**	**31**
2001 [a]	28	17	**11**	**10**	**34**	**27**
2002	24	**11**	9	8	23	17
2003	26	18	13	11	42	35
2004	22	17	14	11	54	37
2005	24	16	11	10	38	35
2006	24	18	12	8	33	26
2007	35	26	20	18	74	59
2008	35	16	12	11	39	34
2009	32	24	15	11	50	33
2010	37	24	18	12	66	48
2011	44	25	18	15	51	38
2012	44	28	18	16	62	48
2013	51	34	29	20	86	52
Mean	**32.8**	**21.2**	**15.1**	**12.3**	**50.9**	**39.3**
(SD)	(8.1)	(4.6)	(3.2)	(3.1)	(13.3)	(9.6)

Table 4. Comparison of Trumpeter Swan (*Cygnus buccinator*) nest-site occupancy and productivity data for core and expansion areas in Wyoming outside of Yellowstone National Park, 2007-2013. Expansion areas include drainages where Wyoming Game and Fish Department worked to expand both summer and winter distribution by translocation of wild swans or release of captive-raised swans from 1986-2003 (Patla and Oakleaf 2004). Core area is where swans nested in the Snake River drainage and its tributaries prior to range expansion efforts. Number of young fledged refers to the number of mature young counted on the September aerial survey conducted annually. Successful pair refers to those nesting pairs that hatched young.

Drainage and year	Occupied sites (*n*)	Nesting pairs (*n*)	Broods hatched (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)	Individuals hatched per successful pair ($\bar{x}$)
Snake River Core						
2007	17	11	9	37	31	4.11
2008	15	7	4	13	13	3.25
2009	14	10	6	21	12	2.33
2010	15	8	6	24	12	4.00
2011	18	10	7	22	14	3.14
2012	18	9	6	18	9	3.00
2013	19	12	11	30	16	2.72
Green River Expansion						
2007	16	13	11	37	28	3.36
2008	18	9	8	26	21	2.62
2009	18	14	9	29	21	2.08
2010	21	15	12	42	36	3.50
2011	24	14	10	27	23	2.70
2012	24	16	12	44	39	3.67
2013	31	22	18	56	36	3.11
Salt River Expansion						
2007	2	1	0	0	0	0.00
2008	1	0	0	0	0	0.00
2009	1	1	0	0	0	0.00
2010	1	1	0	0	0	0.00
2011	1	1	1	2	1	2.00
2012	1	1	0	0	0	0.00
2013	1	Unk.	0	0	0	0.00

Table 5. Summary of Trumpeter Swan (*Cygnus buccinator*) nest-site productivity by drainage and management unit 2002-2012, Wyoming. Shown per management unit are the number of nest attempts, total number of times that nests hatched and fledged young, total number of young hatched and fledged, and number of territories that fledged young over this 11 year period. Fledged young were those observed during the annual fall survey flight in mid-September. Key for the management unit abbreviations: CTNF – Caribou-Targhee National Forest, BLM – Bureau of Land Management, BTNF – Bridger Teton National Forest, NER – National Elk Refuge, Private – sites on private land, SNWR – Seedskadee National Wildlife Refuge, WGFD SP – Wyoming Game and Fish Department South Park Wildlife Habitat Management Area.

Drainage	Management unit	# nest attempts (*n*)	Total times that nests hatched young (*n*)	Total times that nests fledged young (*n*)	Total young hatched (*n*)	Total young fledged (*n*)	# nesting territories fledged young (*n*)
Snake River	CTNF	16	12	5	38	16	1
	BTNF	6	4	3	13	7	2
	GTNP	27	16	8	42	22	6
	NER	36	26	24	73	66	6
	Private	9	9	8	28	25	1
	WGFD SP	4	4	4	19	19	1
	Total	98	71	52	213	155	17
Green River	BLM	5	4	4	11	11	1
	BTNF	11	7	3	23	6	3
	Private	49	37	34	113	94	12
	SNWR	44	39	38	169	139	8
	Total	109	87	79	316	250	24

Table 6. Summary of Trumpeter Swan (*Cygnus buccinator*) annual mortalities in Wyoming, showing age class and probable cause of death, 1991 through 15 April 2013. Mortality of cygnets includes only those lost following fledge counts in September, so does not include brood reduction during the nesting season. [a] Mortality total for years 1991-1995 is not broken out by individual years; the following years' data are recorded for 15 April through 14 April for each period, but also includes carcasses and remains found after snow melt in May. [b] Swans with all white plumage over one year of age; likely some yearlings are included in this group. [c] Age not determined for 11 reported mortalities this period; necropsy reports not completed on 14 specimens submitted to lab. [d] Summary statistics are calculated only for the years 1998-2013.

Year	Total mortality (*n*)	Adult mortalities[b] (*n*)	Yearling mortalities (*n*)	Cygnet mortalities (*n*)	Collision mortalities (*n*)	Predation mortalities (*n*)	Shot or trapping mortalities (*n*)	Infection/ parasite mortalities (*n*)	Unknown mortalities (*n*)
1991-1995[a]	38	21	0	17	12	4	10	1	11
1995-1996	11	9	0	2	5	0	2	0	4
1996-1997	8	3	0	5	4	0	0	0	4
1997-1998	5								
1998-1999	10	8	0	2	2	1	0	1	6
1999-2000	10	7	0	3	6	2	1	1	
2000-2001	34	18	4	12	6	5	0	0	23
2001-2002	14	8	3	3	3	2	0	0	9
2002-2003	12	6	2	4	1	1	2	0	8
2003-2004	38	21	7	10	3	5	0	5	25
2004-2005	9	3	2	4	0	6	0	0	3
2005-2006[c]	49	27		11	1	0	1	0	47
2006-2007	10	8	0	2	0	0	0	0	10
2007-2008	11	7	1	3	4	1	2	1	3
2008-2009	16	11	3	2	4	1	0	0	11
2009-2010	6	4	1	1	1	1	0	0	4
2010-2011	7	6	0	1	4	0	1	0	2
2011-2012	32	21	3	8	5	1	1	4	21
2012-2013	27	18	11	8	2		1		24
2012-2013	27	18	11	8	2		1		24
2013-2014	13	8	0	5	1		3	2	7
Total[d]	325	199	48	87	45	26	13	14	227

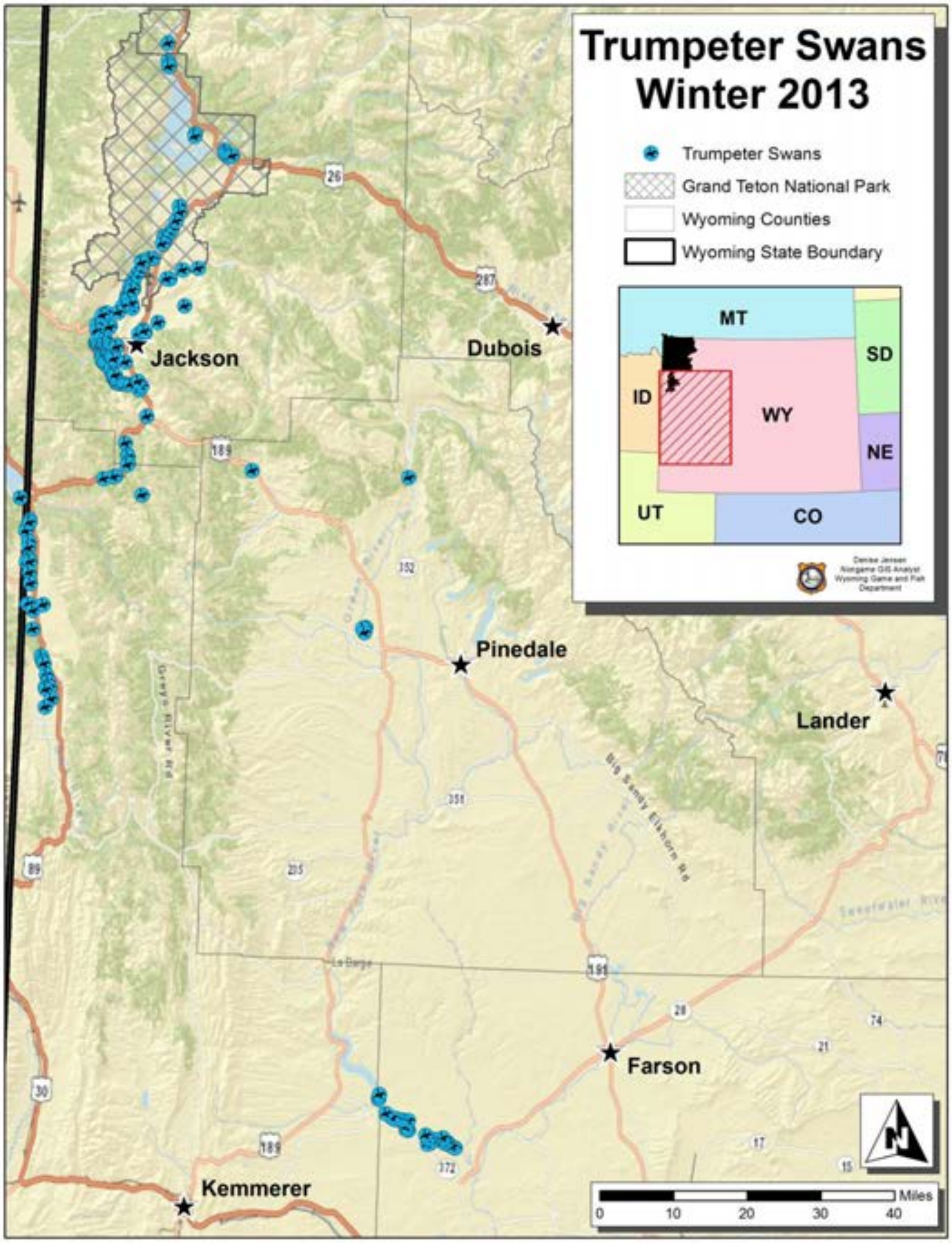

Figure 1. Locations of wintering Trumpeter Swans (*Cygnus buccinator*) in Wyoming documented during the annual winter aerial survey flown 2 February (Green River) and 10 February (Snake and Salt River drainages) 2014. Prior to management efforts, beginning in the late 1980s, to increase the distribution of swans in the Tri-State area, all swans wintered in the Jackson core area.

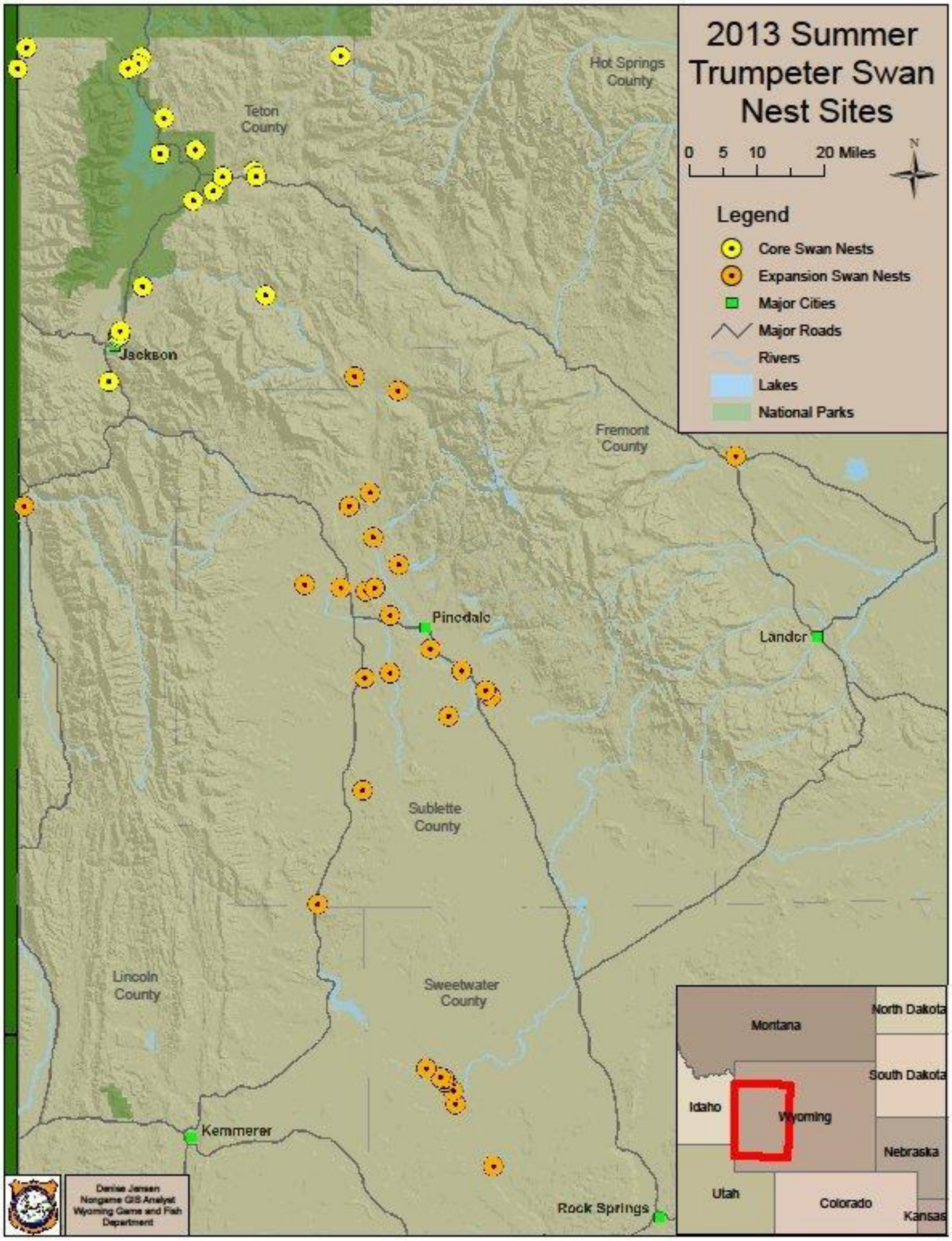

Figure 2. Locations of nest sites occupied by pairs of Trumpeter Swans (*Cygnus buccinator*) in Wyoming in the 2013 nesting season. Pairs did not lay eggs at all occupied sites. Shown are nests in the core Snake River area (yellow dots) and nests in the range expansion areas (orange dots). In a few cases, a single dot represents more than one occupied site for sites located in close proximity to each other.

Appendix 1. Annual summary of occupancy and production status for all known Trumpeter Swan (*Cygnus buccinator*) nests in Wyoming outside Yellowstone National Park, 2003-2013 by area. Sites include: CTNF – Caribou Targhee National Forest; GTNP – Grand Teton National Park; NER – National Elk Refuge; and Seedskadee NWR – National Wildlife Refuge. Key to the table codes includes: O – pair occupied site through nest period, did not attempt to nest, did not molt on site; OM – pair occupied territory through nest period, did not attempt to nest, molted on site; OL – pair occupied site late after nest initiation period; Nxy – pair nested, x = number of young hatched, y = number of mature young in September; OUID – pair reported on site but status not determined; NB – nonbreeding swans present, likely subadults; F – swans observed on fall (September) flight only; 1A – only one adult present; NS – not surveyed; --- – no swans observed all season.

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CTNF											
Ernest Lake	NB	---	NB	---	---	---	---	---	---	---	---
Bergman Marsh	NB	---	---	---	---	---	---	---	---	---	---
Indian Lake	N33	N55	N00	N10	N44	O	N40	N30	N30	N41	O
Widget Lake	F	---	---	---	---	---	---	---	---	---	---
Winegar Creek							N30	N20	N30	1A	N20
Fall River Slough					N00	---	---	---	---	---	---
Loon Lake	F	---	---	---	---	---	---	OL	---	---	---
Rock Lake	---	OL	OM	N00	---	O	---	---	---	---	---
Rock Lake slough								N41	---	---	---
Junco Lake	---	---	---	N00	---	---	O	---	---	---	---
Fish Lake	---	---	---	---	---	---	---	---	---	---	---
Squirrel Meadows	---	---	OL	---	---	---	---	---	---	---	---
Moose Lake	---	---	---	---	---	---	---	---	---	---	---
GTNP											
Upper Glade		N00	OM	---	---	---	---	---	---	---	---
Steamboat Mountain	---	N00	---	N43	O	O	OL	O	O	OL	N21
Glade Cliff Slough			N00	N10	O	N00	O	O	O	N11	O
Glade South	N10	N22	N00	O	O	---	---	---	---	---	N22
Flagg gravel pit ponds									---	---	O
Arizona Lake	---	OM	N20	N40	N00	N00	N30	N20	N20	N00	---
Emma Matilda	---	---	NB	NB	---	1A	OL	OL	OL	OL	O
Swan Lake	N00	N33	NB	OL	OM	N22	O	OM	N55	O	O

Appendix 1. Continued.

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GTNP (cont.)											
Christian Pond	---	---	---	---	---	---	---	---	---	---	---
Hedrick Pond	O	---	NB	1A	O	---	---	---	---	---	---
Elk Ranch	OM	OM	OM	OM	O	O	O	OL	OL	O	O
Spread Creek Ponds	---	---	---	---	---	---	---	---	---	---	N20
Polecat Slough	---	---	---	---	---	1A	1A	---	---	---	---
NER											
Highway Pond NER	N10	---	N00	---	N55	---	---	N00	---	---	---
NE Marsh NER	N33	N44	---	N32	NB	O	---	---	O		N22
Flat Cr. Island NER							N00	N10	N00	N00	N20
SE Marsh NER	N11	N43	O	N11	N42	N00	N11	---	O	N11	
Central Marsh NER	---	N22	N44	N33	N57	N33	O	N55	N00	N11	N22
Elk Jump Pond NER										N00	N00
Pierre's Ponds	N33	OM	O	OM	---	---	---	NB	O	---	---
Romney Ponds		OM	OL	NB	N44	N44	N43	NB	O	NB	1A
Bill's Bayou											OL
Jackson area											
Skyline/Puzzleface	OM	O	NB	---	---	---	---	NB	NB	NB	OL
WGF South Park	---	---	1A	OL	OM	OM	N44	N66	N44	N55	N43
Buffalo Valley											
Pinto/Halfmoon	O	N31	N55	N33	N66	N44	N54	OM	N11	N00	N44
Halfmoon BV									N44	----	OL
Blackrock slough										N60	N60
Tracy Lake						OL	OL	OL	OL	NB	NB
Lily Lake	N20	---	---	---	---	---	---	---	---	---	---
Teton Wilderness											
Enos Lake	N44	---	---	NB	NB	NB-3	---	NB	NB	NB	1A
Atlantic Cr.	---	---	---	---	---	---	nc	OUID	O	N00	N22
Salt River											
Kibby/Salt R Cove	N00	N00	NB	---	---	---	---	---	---	---	---

Appendix 1. Continued.

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Salt River (cont.)											
Alpine Wetland North	NB	NB	NB	NB	N00	---	NB	NB	NB	NB	NB
Alpine Wetland South					NB	O	N00	N00	N21	N00	O
Jacknife Creek area										O	---
Gros Ventre River											
Lower Slide Lake		---		---	---	---	---	NB	NB	---	NB
Upper Slide Lake	OM	N11	N22	N00	OM	OM	OM	OM	O	O	O
Grizzly L pothole	---	---	---	Dry	Dry		---	---	---	---	---
Burnt Fork	---	---	---	---	---	---	NB	---	---	---	---
Soda Lake	---	---	---	---	---	---	---	---	---	---	---
Green/New Fork Rivers											
Wagon Creek Lake	O	O	---	---	---	NB	---	---	---	---	---
Rock Crib	O	---	---	---	---	NB	---	---	---	---	---
Wagon Cr Pothole					N00	---	---	N42	O	O	---
Mosquito Lake	1A	OL	---	NB	N32	N00	N00	O	OL	O	O
Roaring Fork P.	---	---	---	---	---	---	---	---	---	---	---
Mud Lake	---	N50	N20	N20	N52	OE	---	OL	O	N00	O
Circle S slough								N00	---	NB	---
Jensen Pond, Green R										O	---
Carney oxbow		N55	N22	N00	N44	N00	N00	N22	N00	O	O
Carney pond							N30	---	---	---	---
Q Y Bar Reservoir					O	O	---	---	---	---	---
O Bar Y pond new 2012										N44	N33
Marsh Creek Pothole					N22	---	---	---	---	---	---
Kendall Wetland	N00	N00	NB	NB	OL	N11	N33	OM	O	N44	N00
Blatt Res Willow Cr										NB	O
Kitchen Main	N54	N44	N22	N33	N54	N53	N11	N22	N32	N43	N00
Kitchen Middle	NB	NB	OM	OM	OM	O	N22	N55	N43	---	---
40 Rod Cr slough								F	NB	NB	N20
Vichory Reservoir										NB	N11

Appendix 1. Continued.

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Green/New Fork Rivers (cont.)											
Webb Draw								F	N00	N10	N22
McCroft Lane										N00	---
Fayette New Fork				NB	N33	N40	N00	---	N33	N55	N52
Swift New Fork						N54	OL	N33	OL	NB	NB
Barden Slough	N00	OM	OM	OM	---		---	---	---	---	---
Swift Reservoir	NB	NB	---	OL	OL	NB	NB	OL	O	N21	N33
EF Hunt Club/FH									N11	N21	N33
Jensen Slough N Fork						OL	O	N22	O	N21	O
Sommers Green R										O	N30
Cottonwood Cr mouth										NB	---
Rimfire Rendezvous										NB	NB
Rimfire Sophia										OL	NB
Soaphole BLM pond										NB	N44
Muddy Cr, n B. Piney										NB	---
Ferry Island					N22	N33	N00	N44	OL	N22	N22
Shafer Slough	NB	---	---	NB	---	---	NB	NB	---	NB	---
Reardon Draw									N11	NB	---
Voorhees Pond	---	---	---	---	---	OL	---	N00	O	O	N40
LaBarge Cr Pond									O	----	---
Big Sandy Reservoir	---	---	---	NS	---	nc	---	---	---	---	---
Eden Res.								1A	1A	NB2	---
Farson area								N22	O	O	---
Seedskadee NWR											
Hamp Unit		N33	N44	N53	O	N00	N00	N42	N42	N00	N22
Hawley 1	N44	N60	N65	N54	N22	N33	N43	NB	O	N55	O
Hawley 2	N44	N54	N00	N66	N33	N66	N44	N55	N44	N66	N44
Hawley 2 S								N43	N33	---	N33
Hawley 3	N43	---	N33	---	NB	NB	---	NB	O	---	---
Hawley 5							N33	NB	NB	---	---

Appendix 1. Continued.

Site	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seedskadee NWR (cont.)											
Hawley 6	N44	N65	N77	N00	NB	NB	---	N44	N22	N55	N22
Sage Pools					N31	N33	N75	N42	N22	N77	N55
Other Wyoming											
Swamp Lake, Cody	1A	---	---	---	---	NC	NC	NC	---	---	nc
Trail Lake, Dubois			OM	OM	---	---	---	---	---	---	---
Dinwoody Lake								F	---	---	---
Lake Julia								O	1A	---	---
Martens Pond									O	---	N55
Colony eastern WY	NB	NB	NS	NS	---	---	NC	NC	OL	NB	---

WYOMING COMMON LOON (*GAVIA IMMER*) MONITORING SUMMARY REPORT, 2013

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Common Loon

FUNDING SOURCE: United States National Park Service
Wyoming Governor's Big Game License Coalition
Ricketts Conservation Foundation

PROJECT DURATION: 1 June 2012 – 30 September 2017

PERIOD COVERED: 28 May 2013 – 30 September 2013

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ABSTRACT

Since 1987, Yellowstone National Park and the Wyoming Game and Fish Department have been monitoring occupancy and productivity of Common Loon (*Gavia immer*) nest areas. In 2013, Biodiversity Research Institute expanded on this effort through increased monitoring of pairs throughout the nesting season and began to capture and band adult loons at a few sites. In total, we surveyed 69 lakes and documented 14 territorial pairs, 11 of which nested to hatch 13 chicks; 11 of those chicks survived to fledge. Biodiversity Research Institute located 9 of the 11 active nest sites in 2013, plus 3 nests used in previous years. We using diurnal capture methods to capture and band 2 loons and placed a geolocator on a leg band for determining wintering grounds. Blood mercury levels were low for these birds (<3 ppm).

Compared to historic counts of 21 pairs, the Wyoming loon population has declined. It is still uncertain exactly what has caused the decline and exactly what threats to nesting and survivorship may impact any recovery, but the by-catch of adult loons from gillnetting efforts on Yellowstone Lake is a concern. Productivity in the past two years has been well above the 0.48 chicks surviving per territorial pair required for population stability. The stability of the Wyoming loon population is critical, as it is isolated from neighboring populations in Montana, Idaho, and Washington by >322 km. Compared to the few other disjunct loon populations across the species range, the Wyoming population is the largest and most isolated.

Possible threats to the population include habitat loss due to long-term drought, direct human disturbance at nest sites, water level fluctuations, contaminants (such as lead and mercury), and invasive aquatic plant and animal species. A few loons have been lost as by-catch in gillnets from the effort in recent years to control lake trout on Yellowstone Lake. In 2013, one loon was caught in August and another in October. The Yellowstone National Park Fisheries and Aquatic Sciences Department estimates that on average <1 loon is caught per year as a result of gillnetting. It is uncertain if these by-catch loons are from the local population or migrants. Samples for genetic analysis were taken from the two captured live loons and the two deceased by-catch loons, but results are not yet available.

To continue assessing common loon demographics, movements, population trends, and threats in 2014, Biodiversity Research Institute recommends the following: 1) continue comprehensive monitoring of pairs, nesting, and unpaired adults, 2) increase capture and banding of adults and juveniles, 3) assess habitat quality by using established habitat ranking models, 4) assess threats to nesting through the use of nest cameras and identify potential for nest rafts, and 5) investigate the issue of loon bycatch on Yellowstone Lake and identify adjustments to gillnetting operations to avoid avian bycatch.

INTRODUCTION

The Common Loon (*Gavia immer*) is a highly charismatic and iconic species of North America that has come to symbolize wild areas. Loons, however, have been able to acclimate to human disturbance in portions of their breeding range, but generally active management and outreach actions are needed to offset adverse impacts from people. In the western US, loons historically nested as far south as northern California, southern Idaho, and central Wyoming (Evers 2007). Currently, there are 105 territorial pairs in the western US. Most of these western breeding pairs are located in Montana (72 pairs, 68.6%). Washington, Wyoming, and Idaho have 17 (16.2%), 14 (13.3%) and 2 (2.0%) territorial pairs, respectively.

Analysis of historical data and monitoring in 2012 confirmed that the Wyoming breeding loon population is small, disjunct, and declining. This population consists of loons in Yellowstone National Park (YNP) the Caribou-Targhee National Forest (CTNF), Grand Teton National Park (GTNP), and the Bridger-Teton National Forest (BTNF). Annual monitoring efforts across the region have counted the number of adults and large chicks since the late 1980s. The Wyoming State Wildlife Action Plan classifies the Common Loon as a Tier 1 Species of Greatest Conservation Need. Common Loons have a traditional "K-selected" life history pattern (i.e., long-lived, low fecundity, and low annual adult mortality rate), so significant changes in its breeding population are symptomatic of chronic stressors (Evers 2007, Evers et al. 2010). Therefore, this species is viewed as a biologically valuable indicator of aquatic integrity (Evers 2006). In 2013, Biodiversity Research Institute (BRI) completed the most comprehensive loon monitoring effort to date throughout northwestern Wyoming.

This 2013 project was initiated using funding from the National Park Service and the Wyoming Governor's Big Game License Coalition. Supported by a grant from the Ricketts Conservation Foundation, BRI biologists, working with state collaborators, will be addressing three major conservation components over the next five years: 1) population assessments through surveys and habitat evaluations, 2) creating specialized outreach and conservation initiatives, 3) compiling comprehensive nationwide loon health assessments, and 4) identifying research needs and restoration options, including classic and novel strategies.

Although loons generally prefer lakes >24 ha with clear water, an abundance of small fish, numerous small islands, and an irregular shoreline that creates coves, they can be found in a wide variety of freshwater aquatic habitats. Lake size and configuration are important determinants for loon density. Habitat heterogeneity is particularly difficult to quantify and typically requires an evaluation for what constitutes "high" versus "low" quality. Loon habitat use patterns generally follow that of Pulliam and Danielson's (1991) ideal pre-emptive distribution model, where an individual selects the best available site and prevents other individuals from occupying that site.

Water clarity is an important lake characteristic for breeding loon success. Loons are visual underwater predators, and clear water is crucial for foraging efficiency. A Michigan study documented that the time adult loons spent foraging in turbid water was significantly greater than in clear water (Gostomski and Evers 1998). Water clarity can be measured with a Secchi Disk or with specially designed probes and instruments. Secchi Disk readings of ≤1.5 m alter loon foraging behavior (Barr 1986). Loons prefer foraging in clear waters of littoral zones; they tend to avoid deeper parts of large lakes. Breeding adults and their young generally forage in relatively shallow areas <5 m and within 50 to 150 m from the shoreline (Strong and Bissonette 1989, Ruggles 1994). Preferred prey species that are 10 to 15 cm long, such as yellow perch (*Perca flavescens*), are found in this zone (Barr 1996).

Loons nest in close proximity to the water's edge and tend to select small islands, floating bog mats, and marshy hummocks. Loons prefer to nest on small islands, primarily the lee side (Olson and Marshall 1952, Sutcliffe 1980, Titus and Van Druff 1981, Yonge 1981, Dahmer 1986, Jung 1987). Floating sphagnum bog mats afford particularly high nesting success (Reiser 1988) because they can move with water level fluctuations related to natural and anthropogenic influences. Marsh and mainland sites are of lower preference and most likely occur in response to lack of islands, shoreline development (Alvo 1981, Christenson 1981, McIntyre 1988), and high conspecific densities.

Nest sites are generally located ≤1.2 m from the water's edge, although water level draw-downs can extend their limits, and >15-m pathways have been documented (J. Fair, pers. com.). Available submergent and emergent materials are used to build nest structures. Common Loons select nest sites with steep drop-offs that allow for underwater approaches and exits (Olson and Marshall 1952, Christenson 1981, McIntyre 1988, Ruggles 1994); however Sutcliffe (1980) and Valley (1987) did not find this to be a predictor of site location. Strong et al. (1987) found between-year reuse of nest sites by loons to be 78-88%. Changes in nest locations were more frequent after nest failures and reuse occurred more often after successful nesting.

Chick rearing areas or nurseries share much of the same attributes as foraging areas. They are typically in shallow water close to shore, with prey size classes suitable for feeding young. These areas experience less prevailing wind and waves that could otherwise separate chicks from adults. Chicks hide among shoreline vegetation in response to threats or when left unattended (Yonge 1981, Strong and Bissonette 1989, Ruggles 1994).

Common Loons have been well-studied across North America, particularly in the northeast. From long-term data across different populations, Evers (2007) and Mitro et al. (2008) showed for a Common Loon population to remain stable, a pair needs to fledge about one chick every other year (0.48 chicks surviving per territorial pair). Loons are poor colonizers of unoccupied habitat. Dispersal of individuals is limited, and, therefore, loons are slow in re-colonizing new areas. Loons returning to freshwater lakes for the first time show an average dispersal of 13 km from their natal lakes; however dispersal ≥92 km has been documented (Evers et al. 2000). Intra-season movements are much more limited, with an average of 4 km, and no records of dispersal beyond 20 km (Evers 2001). Females are much more likely to disperse farther than males, and new territories are more likely to be established near former territories. Across North America, both sexes exhibit a high degree of territory fidelity with 80% of males and 82% of females returning to the same lake or territory in successive years (Evers 2007).

Our objectives for 2013 were to: 1) monitor existing loon territories and identify new loon pairs and unpaired adults in the study area, 2) determine reproductive success (number of young fledged per territorial pair) of loons breeding in Wyoming, 3) locate nest sites of breeding loons, 4) delineate territorial boundaries and habitat use throughout the region, and 5) assess threats to reproductive success and adult survival.

The study is being conducted in the northwest portion of Wyoming, which lies within the Greater Yellowstone Ecosystem. This area includes YNP, GTNP, and parts of the CTNF and BTNF. The landscape is characterized at higher elevations by lodgepole pine (*Pinus contorta*) and mixed conifer forests and alpine meadows, with sagebrush (*Artemisia* spp.) steppe and grasslands occuring at lower elevations. Many lakes in the region exist between altitudes of 1,829 and 2,438 m, the largest of which are Yellowstone Lake and Jackson Lake. Northwest Wyoming is a major vacation destination in North America, with YNP alone drawing >3 million visitors annually. The majority of visitation occurs in the summer months.

METHODS

Lakes with known loon presence from 2012 monitoring were the primary focus of our surveys and were visited as soon as conditions and logistics allowed. Secondly, historically occupied lakes were surveyed to confirm continued absence or recolonization. Lastly, surveys were conducted on lakes in the region not known to have historical loon presence. Identifying lakes not currently occupied allows for better tracking of any population expansion and colonization of lakes.

Survey methods were consistent with those reported by Evers (2007). Lakes were often surveyed from shore, but canoes or kayaks were used if available or when an island nest-site needed to be accessed. Yellowstone Lake was surveyed from shore, canoe, and motorboat. We used 10× binoculars and a 15-45× spotting scope to survey all lakes.

If a loon was observed, it was determined to either be a single adult or part of a territorial pair. Territorial loon pairs were identified according to observed territorial behavior such as close physical association, defensive posturing, and vocalizing along territorial borders within a lake. Territories are areas of a lake(s) used by pairs for feeding, resting, breeding, nesting, and chick rearing, and are protected against incursion by other loons (and sometimes waterfowl) for a ≥4weeks. Territory types were determined to be occupying a single lake (whole lake territory), part of a larger lake (partial lake territory), or utilizing more than one lake (multiple lake territory). Territories are used as a unit of reference in describing loon breeding activity.

We searched lakes with active nesting pairs in 2013 or nesting in previous years for nest sites. For each nest found, we recorded the location (island, marsh, or shoreline) and nest type (bowl, scrape, or hummock) and took photos taken. We used Google Earth to obtain approximate GPS coordinates of each nest.

We obtained information on breeding loons from the greatest distance possible to minimize impacts on nesting and brooding activities. Since nesting evidence may be obscured by vegetation, it was often necessary to search for nest evidence by foot. In these cases, we performed nest searches by walking the perimeter of the available nesting habitat in loon territories. We used a Supercub plane flown at low altitudes to conduct aerial surveys throughout the season to further track loon presence and reproduction, but more importantly to survey inaccessible lakes due to bear management area restrictions, snow conditions, or remoteness.

We delineated loon territories according to observed territorial behavior by a loon pair such as close physical association, defensive posturing, and vocalizing along territorial borders within a given lake. Nesting pairs were defined as those where the female laid ≥1 egg, while successful pairs hatched ≥1 chick. Unsuccessful nesting attempts were categorized as a fail if conclusive evidence of nest failure could be determined. Possible causes of nest failure included: avian predation, mammalian predation, water level fluctuations (rise/fall), human disturbance, loon disturbance, never hatched, or unknown (e.g., loon on nest, then egg missing and loon off nest).

For successful nests, we recorded chicks hatched as those that hatched completely out of their eggs. We define the terms chicks hatched and chicks surviving as loon young ≤6 weeks post-hatching. The term fledged young refers to loon young >6 weeks of age. Loon chicks surviving >6 weeks of age are assumed to have fledged.

We used diurnal (floating mist net) and nocturnal (night-lighting) techniques to attempt to capture Common Loons in the CTNF and BTNF. Diurnal capture involved stretching a mist net between two parallel floating PVC pipes and using loon decoys and loon recordings or vocalizations to lure loons into the netted area. A loon is entangled when it swims underwater into or dives from above into the net. Nocturnal capture is traditionally attempted with loon pairs with young chicks and requires using spotlights and recordings or vocalizations to approach loons close enough for them to be netted with a large dip net. We weighted each bird captured and obtained bill and tarsus measurements. In addition, we drew blood for genetics and mercury analysis. We attached an aluminum USFWS band with ID number and colored band to one leg and placed two colored bands on the other. For each bird, we attached a geolocator (LOTEK Wireless LAT 2000 Series, Model LAT 2900) to a colored band to determine migration paths and wintering grounds. These devices record sunlight levels over time that can be used to calculate the bird's approximate location (latitude and longitude). Because they need to be retrieved so this data can be downloaded, birds that received a geolocator must be re-captured the following year.

RESULTS

A total of 69 lakes were surveyed in the Greater Yellowstone Ecosystem for Common Loons from 28 May-30 September 2013 (Fig. 1). A total of 14 territorial pairs (TP) were identified. Of these, 11 (79%) nested (NP). Thirteen chicks hatched (CH) from the nesting pairs, and 11 (85%) survived to fledge (CS). Nesting propensity (NP/TP) was 0.79, while hatching success (CH/NP) was 1.18. Chick survivorship (CS/CH) was 0.85. Overall loon productivity (CS/TP) for the region was 0.79 (Table 1).

In addition to observing loon pairs during our surveys, we also detected eight unpaired adults (UA). Some lakes within the study area were surveyed for loon presence and habitat suitability for the first time in 2013, and, while no new pairs were identified, some unoccupied potential habitat exists. Similarly, lakes surveyed in Wyoming outside of the study area where loons were known to exist did not result in any new pairs. No loons were observed on the northern border of YNP in southern Montana.

In 2013, half of the successful loon nests hatched between 14-30 June. The other half successfully hatched between 1-7 July (Table 2). Based on these hatch dates, the back-calculated date for egg laying (28-day incubation) for the earlier hatches was mid-May, likely soon after ice-out. Pairs that hatched chicks sooner were consistently found at lower elevations and further south (Fig. 2). It is possible that loons may be staging on open water on Yellowstone Lake, Jackson Lake, and other iced-out lakes south of territories prior to arriving at their breeding lakes.

Late-season monitoring showed that adults with chicks surviving departed their breeding lakes in mid-September, while pairs without chicks left in mid-August. Chicks were leaving their lakes around 11-12 weeks of age, and the Cygnet Lakes chicks were observed flying at 10 weeks of age.

Late in the summer and into fall when pairs typically begin to leave their lakes and socialize, loons were seen on Yellowstone and Jackson Lakes alone, in loose pairs, and in small groups. Mary Bay and the Southeast Arm of Yellowstone Lake were found to have loose aggregations of five and eight loons respectively. Single or pairs of loons were seen along the northwestern and northern shores of Yellowstone Lake. Loons were also seen on Jackson Lake, particularly around the areas of Leek's Marina and the Jackson Lake dam, including what appeared to be the male and chick from Arizona Lake around the islands near Leek's Marina.

Three loons were caught and subsequently drowned in gillnets in Yellowstone Lake between 2012-2013 (one loon in 2012; two in 2013). In 2013, post-mortem examinations were performed on two of these bycatch loons by wildlife veterinarian Dr. Michelle Kneeland. The first loon examined was a subadult (second year), which was extracted from a gillnet on 20 August 2013 in Yellowstone Lake's South Arm. Pathologic findings were consistent with drowning as a result of net entanglement (presumptive cause of death). The second carcass necropsied was an adult caught in agillnet on Yellowstone Lake (area unspecified) the previous season on 5 November 2012. Again, pathologic findings were consistent with drowning as a result of net entanglement. Wing, tarsus, and bill measurements were recorded for both birds, and samples of feathers, liver, gizzard contents, and body fluid were collected.

In the national forests, we used the diurnal method to capture two loons; the female from Loon Lake (CTNF) and the female from Arizona Lake (BTNF; Table 3). Nocturnal capture efforts were unsuccessful largely due to a late start in the season (older chicks are defended less by their parents, making capture more difficult).

Loon pairs utilizing the grouping of Winegar, Junco, and Fish Lakes as a territory have sometimes been monitored and counted in findings by both YNP and the Wyoming Game and Fish Department. In reviewing the historical nesting data and habitat use in 2012 and 2013, it was determined that loons have had more presence and nesting on Fish Lake and Junco Lake than Winegar Lake. As a result the Winegar/Junco/Fish territory will be counted as a Wyoming territory (rather than YNP) in the BRI database.

YNP hosted eight territorial pairs in 2013 and seven unpaired adults. Of these pairs, six nested (75%), and all nests were successful at hatching at least one chick (100%). A total of eight chicks hatched (Table 4), and all fledged. Loon productivity for YNP was 1.00. Territorial pairs were found on the following lakes: Wolf Lake, Cygnet Lakes, Shoshone Lake East, Riddle Lake, South Delusion Lake, Yellowstone Lake – South Arm, Lewis Lake, and Buela Lake. The Cygnet and Buela pairs both fledged two chicks, and the only pairs that did not nest were on Lewis Lake and Shoshone East (Fig. 3).

The majority of the region's unpaired adults were observed in YNP. These birds were often seen away from established territories and engaging established pair members in or near their territories, particularly the Wolf Lake pair on Grebe and Ice Lake. Single loons or loosely associating adults were seen during surveys or reported by YNP staff on Lake of the Woods, Cascade Lake, Shoshone Lake West, Delusion Lake, Lewis Lake, Heart Lake, and Yellowstone Lake in the areas of Mary Bay, Pumice Point, and Gull Drive. Due to time of year of some sightings, infrequent sightings, or proximity to other sightings of unpaired adults, the conservative estimate for unpaired adults in YNP is seven. In addition to unpaired adults, three sub-adult (2^{nd} year) loons were recorded. One immature was seen consistently on Buela Lake and was tolerated by the loon pair, indicating that it may have been a previous offspring of the pair. In Mary Bay on Yellowstone Lake, two sub-adults were seen throughout the summer, often together and occasionally associating with single adults. Since there are no established territories near Mary Bay, it is suspected that these sub-adults are utilizing Mary Bay as a foraging and socializing area.

The area outside of YNP consisting of CTNF, BTNF, and GTNP hosted six territorial pairs in 2013 (Fig. 4). Five of these pairs nested (83.3%), with four of those pairs successfully hatching at least one chick for a total of five chicks. The Winegar/Junco/Fish pair never nested, and the Loon Lake pair nested but failed (unknown cause) after approximately two weeks. The Bergman Reservoir pair in CTNF hatched two chicks that died shortly after. A single chick each hatched on Arizona Lake, Indian Lake, and Emma Matilda Lake, and all three survived, resulting in overall productivity of 0.50 for the loons outside YNP (Table 5). Single adults were observed or reported throughout the summer on Lower Slide Lake, Bradley Lake, Leigh Lake, and Jackson Lake, and are conservatively assumed to all be sightings of the same unpaired adult moving around. Infrequent reports and sightings of single adults in the area of the Loon Lake, Indian Lake, and Bergman Lake pairs made it difficult to assign any unpaired adults to the area. Additional unpaired adults may be present on Jackson Lake, but could not be confirmed due to a lack of survey coverage.

In total, 12 nest locations have been identified for the Wyoming population (Table 6). Most nests in the region are shoreline nests; however, some of the most productive nests are on islands or sedge islands. Nest types ranged from built up or crude bowls to depressions created by resting atop grassy hummocks. Most nesting pairs held whole or multi-lake territories with only Yellowstone Lake – South Arm being a partial lake territory.

DISCUSSION

From 1989-2006, the number of loon pairs in YNP remained steady, averaging 15 pairs per year during this time, then declined sharply in 2007. The pair count in YNP decreased from nine pairs in 2012 to eight pairs in 2013 due to the Winegar/Junco/Fish territory reassignment to Wyoming. Some territories changed location between 2012 and 2013. Pairs were absent on Delusion Lake and the South East Arm, but were present on Shoshone Lake and South Delusion Lake, which were unoccupied in 2012. The pair count is still below historic counts of 17 territorial pairs prior to 2006 (Fig. 5). In 2011, zero chicks survived to fledge in YNP. Surveys were only conducted for some territories from 2007-2011, and no surveys were conducted in 2008.

From 1989-2012, productivity fluctuated regularly with an average of 0.48 (Fig. 6). For the second year in a row, productivity has been >0.48, with 1.11 in 2012 and 0.89 in 2013.

The territorial pair count outside of YNP exceeded four pairs for the first time since 1990 (Fig. 7). This was largely attributed to the new pair establishing a territory on Bergman Reservoir, which is habitat usually utilized by the Indian Lake pair. Productivity of 0.60 in 2013 was above the threshold of 0.48, but below average historic productivity of 0.93 (Fig. 8). These pairs outside of YNP have consistently produced >0.48 and may be a source area for the regional population. No data exist for these territories in 2011.

The count of 14 territorial pairs across the study area observed in 2013 is an increase from 13 pairs in 2012 (Fig. 9). Compared to average productivity from 1989-2012 of 0.51, breeding pairs fared well in 2013, with a high regional productivity of 0.79 (Fig. 10). The 2013 breeding success, along with 1.00 in 2012, are the highest measures of productivity in nearly 25 years. It is difficult to compare 2013 with more recent data due to lapses in monitoring from 2008-2011.

The results from the 2013 breeding season confirm that a decline in loon pairs in the region has occurred. While 14 pairs is an increase from 2012, it is still below the historic average of >20 pairs. The decline was most pronounced when the population decreased from 21 pairs in 2006 to 14 pairs in 2007. This may have been driven in part by poor productivity from 2002-2006 ($\bar{X}$ = 0.32), particularly 2000-2005 ($\bar{X}$ = 0.27). The stability of the Wyoming loon population is critical, as it is entirely isolated from neighboring populations in Montana, Idaho, and Washington by >322 km (Fig. 11). Of the few disjunct loon populations across the species range, the Wyoming population is the largest and most isolated. A contraction of the Wyoming population occurred recently as pairs have failed to occupy traditional breeding lakes in northern YNP and the western portion of the study area (Fig. 1). Surveys completed by BRI north of YNP indicate that suitable, yet unoccupied, habitat exists (Anderson et al. 2013), so loons in this study area have not moved north. The trend in the number of territorial pairs from 2007-2011 is somewhat unclear due to occasional shortfalls in monitoring and a change in how data were collected and recorded in YNP from 2007 onward. More recent pair counts for 2012 and 2013 are accurate and differ greatly from pair counts prior to 2007.

Unpaired adult numbers and movements can give additional insight into the dynamics of the population decline. The eight unpaired adults observed throughout the region in 2013 constitute 22% of the total adult population. In YNP, 7 of the 25 total adults are unpaired (28% of the population). Based on previous monitoring efforts across North America, unpaired adults generally constitute 15-20% of the adult population (Hanson et al. 2002, Taylor and Vogel 2003, Evers 2007). It is possible that the death of one member of a pair is leaving the remaining member unpaired. These newly unpaired loons may attempt to acquire a mate, abandon their territories, and spend time attempting to take over a territory or establish a new one (Piper et al. 2000, Evers 2001). Unpaired adults were not well tracked prior to 2012, so this explanation is speculative.

Over the past two years, some threats to loons in Wyoming have been identified that need to be researched further. These threats include but are not limited to human disturbance, fluctuating water levels, habitat loss due to emergent vegetation, declines in cutthroat trout (*Oncorhynchus clarki*) populations, and a possible change in foraging strategies by Bald Eagles (*Haliaeetus leucocephalus*) to target more avian prey. The extent and severity of these threats is currently unknown, and other threats to the population likely exist.

As with many other loon populations in across the US, human disturbance can have serious impacts of all levels on loon reproduction (Vermeer 1973, Titus and Van Druff 1981, McIntyre 1988, Kaplan 2003). With the currently occupied loon habitat in Wyoming, there is the inherent benefit of almost entirely undeveloped shorelines and absence of lake residents, but human disturbance via shoreline activities and water use by Parks and National Forests visitors is of concern. Across the region, many territories have either shoreline access to the nest-site area or allow boating in the territory (Table 7). Interestingly, many of the region's most productive loon territories have limited human access. Humans approaching a nest by foot or boat can disturb nesting loons and cause them to flush off a nest, which, in turn, exposes eggs to temperature fluctations, predation, or nest abandonment (Titus and Van Druff 1981, McIntyre 1988). During brooding, human disturbance (particularly via boats), can interrupt the proper feeding and care of chicks, separate chicks from adults, or cause parents to abandon their chicks.

Common Loons typically build their nest ≤1.2 m from the water's edge, which makes them susceptible to fluctuating water levels. A water-level rise can flood a nest, while a large drop in water levels can strand a nest (Fair 1979), resulting in significantly negative impacts on nesting (DeSorbo and Evers 2002). The Jackson Lake impoundment may be an ecological trap by offering quality habitat but poor nesting due to fluctuating water levels. Bergman Reservoir experiences a complete draw down by the end of August that would prevent any fledged chick(s) from leaving the lake. While most other lakes in the study area have natural water-level regimes, a change in climate may negatively impact loons through altered hydrology in the region. For some lakes, emergent vegetation may be an issue by reducing or entirely eliminating open water, including Obsidian Lake, Horseshoe Lake, Robinson Lake, Indian Lake, Lake of the Woods, Cygnet Lakes, South Delusion Lake, and Tanager Lake.

Loons tend to feed primarily in the littoral zone and prefer fish around 10-15 cm but will take smaller prey and fish ≤30 cm (Ruggles 1994, Barr 1996). In Wyoming, the cutthroat trout may be a preferred prey species due to smaller sizes and foraging location. The decline in cutthroat trout in response to invasive lake trout (*Salvelinus namaycush*) may impact the preferred prey base of loons. Similarly, eagles may alter foraging strategies to target greater than usual numbers of avian prey including goslings, cygnets, and loon chicks, in response to the declines in cutthroat trout (D. Smith, pers. comm.). It is suspected that an eagle at Riddle Lake has learned this strategy and has been killed Trumpeter Swan (*Cygnus buccinator*) cygnets hatched there.

Common Loons have been killed by net entanglement and subsequent drowning as a result of gillnetting activities on Yellowstone Lake. Beginning in 1996, gillnets have been used to control the invasive lake trout population on Yellowstone Lake (Martinez et al. 2009). Efforts were intensified starting in 2001 and have increased annually since then (Bigelow et al. 2003). In 2011, YNP began hiring commercial netters for full seasons of lake-trout control, and in that year, 26,777 units of effort were put forth (1 unit of effort = 100 m of gillnet set over 1 night; Koel et al. 2012).

Loons can become entangled in nets as they are attracted to fish activity and enter the net area. Nets set in deep areas will drown loons, while shallow set nets allow loons to struggle at the surface (Evers 1994, Evers 2007). Common Loons are a regular occurrence as by-catch in marine gillnetting operations as well (Forsell 1999, Warden 2010).

We could not determine if the recent by-catch birds in 2012 and 2013 were from Wyoming's breeding population, as they were unbanded, and two were killed in the fall. Any mortalities that occur within the breeding season (May-August) are likely local birds. Loons killed in the fall may be southward migrants from Montana, Saskatchewan, or other populations that may use the Greater Yellowstone Ecosystem as a flyway or stopover during migration (Yates et al. 2002). While official counts of loon by-catch are being tallied by the fisheries department at YNP, early estimates report an average of less than one loon is caught each year (D. Smith, pers. comm.).

Data from banding and breeding season observations show that the Wyoming loon population, like other western populations, does appear to be different in morphology and brooding behavior than eastern loon populations. Weight and morphometrics of females caught in 2013 confirm that these loons are smaller-sized than loons in the Midwest and eastern portions of the US. This smaller size potentially drives some behavioral differences as well. In response to danger, Wyoming loons often stash chicks among shoreline vegetation rather than actively defend them on open water as is common in eastern populations (pers. obs.). While loon pairs responded to threats with typical posturing and tremolos, Wyoming male loons appeared to rarely "yodel" in situations we would expect them to. Yodeling is a vocalization produced by males in territorial behavior or in response to danger and is thought to be an indication of size and willingness to escalate a fight (Mager et al. 2007, Mager et al. 2010). Throughout the 2013 monitoring season, yodeling was rarely observed during intrusions by conspecifics and Bald Eagles, nocturnal capture efforts, or when decoys were deployed with recorded yodels broadcast during diurnal capture.

Blood mercury levels were below the observed effect level (<3.0 ppm Hg) for both loons caught in 2013. The Loon Lake female, which nested but failed, did show slightly elevated mercury in its feathers (20.265 mg/g), indicating mercury exposure on wintering grounds or during a stopover on spring migration. Evers et al. (2008) found that adverse effect thresholds for adult loons are at 40.0 mg/g in feathers and 3.0 mg/g in blood. The data from the geolocator deployed on the Loon Lake female may provide insight into areas where mercury exposure is occurring.

It was unexpected for Wyoming loon pairs and chicks to leave their territories by or before mid-September, with chicks flying by 11-12 weeks of age. Loons were not observed leaving the lakes, so this conservative estimate is based on absences. Parents typically leave their breeding lakes before chicks, which may stay until the lakes start to freeze. Peak migration for adult loons is late-October through early-November. Many of these smaller lakes may not host enough fish to support continued loon foraging, as a pair with two chicks is estimated to consume 423 kg of fish in a single breeding cycle (Barr 1996). There may also be a social component to these differences in seasonal movements.

Through monitoring and historic data analysis in 2012 and 2013 we are beginning to better understand the status of loons in Wyoming. Pair counts have declined from a high of 21 pairs in 2006 to 14 pairs in 2013. Changing climate and altered hydrology impact water levels and threatens loon nesting success through flooding or stranding nests or encroachment by emergent vegetation. The decline in cutthroat trout populations may alter the prey base for loons in Yellowstone Lake. Bald Eagles, in response to declining cutthroat trout, may be switching their foraging strategies to target juvenile birds including goslings, cygnets, and loon chicks. Lake recreation and shoreline activities of visitors to the region may have an impact on loons particularly through nesting disturbance on easily accessible lakes. These threats and the potential by-catch of local loons on Yellowstone Lake need to be investigated further. Building a robust data set on loon presence, productivity, and habitat use in the area, as well as banding more individuals over time, will be critical in understanding changes in this population.

In conjunction with the members of the Wyoming Common Loon Working group, we should continue monitoring the pairs, unpaired adults, and reproductive success of the Wyoming loon population for 2014. Focus should be concentrated on locating nest-sites not found in 2013. Early season (May) and late season (September) monitoring can track the phenology of this breeding population and identify causes for possible early nest failures and late-season movements of pairs and chicks. Increased monitoring across Yellowstone Lake throughout the breeding season will identify patterns of loon habitat use and movements. Personnel should also increase monitoring at Jackson Lake to identify possible pairing and habitat use by unpaired adults.

The continued capture and banding of adults and chicks will build genetic, morphometric, mercury, and overall health profiles for this population. Deploying more geolocators will increase recapture of banded birds and downloading of logged data for determining wintering grounds. Banding of the Wyoming population, particularly loons on Yellowstone Lake and other lakes in that area, will increase understanding of causes of loon mortality.

BRI has developed a ranking matrix for assessing the quality of loon breeding habitat. Data should be obtained for completing this ranking system. Nesting areas and nest sites should also be investigated through trail camera technology for determining nesting threats and levels of human disturbance. Lakes should continue to be evaluated for potential use of floating nest rafts, particularly on lakes with quality habitat and loon presence but with fluctuating water levels. The use of recording devices to analyze yodels and other loon calls should be attempted over the coming seasons to determine differences in calls and behavior ecology between Wyoming loons and loons from other parts of North America.

BRI would like to collaborate with the YNP fisheries department to investigate loon by-catch from gillnetting activities on Yellowstone Lake and identify possible adjustments in operations to avoid loon and other avian by-catch. Loon carcasses retrieved can be necropsied to collect additional samples and information on loons utilizing Yellowstone Lake and other habitat through the study area.

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Table 1. Common Loon (*Gavia immer*) monitoring results from Wyoming and Yellowstone National Park, 2013.

Demographics	Total
Territorial pairs (TP)	14
Nesting pairs (NP)	11
Chicks hatched (CH)	13
Chicks surviving (CS)	11
Unpaired adults (UA)	8
Nesting propensity (NP/TP)	0.79
Hatching success (CH/NP)	1.18
Chick survivorship (CS/CH)	0.85
Productivity (CS/TP)	0.79
% population unpaired	22%

Table 2. Lake elevations (m) and hatch dates of nesting pairs of Common Loons (*Gavia immer*) in Wyoming and Yellowstone National Park, 2013.

Nesting pairs (north – south)	Elevation	Hatch date
Wolf Lake	2,443	5 July 2013
Cygnet Lakes	2,532	1 July 2013
Riddle Lake	2,416	5 July 2013
S. Delusion Lake	2,391	1 July2013
Yellowstone Lake – South Arm	2,361	15 July 2013
Beula Lake	2,261	15 June 2013
Indian Lake	1,957	14 June 2013
Bergman Reservoir	1,950	30 June 2013
Arizona Lake	2,124	20 June 2013
Emma Matilda Lake	2,099	15 June 2013

Table 3. Capture and banding data from female Common Loons (*Gavia immer*) caught at Loon Lake, Caribou-Targhee National Forest, and Arizona Lake, Bridger-Teton National Forest, Wyoming, 2013.

Banding data and morphometrics	Loon Lake	Arizona Lake
Band ID #	1118-15936	1118-15937
Band combination	L: White/Blue R: White/Silver	L: White Stripe/Red R: Red Stripe/Silver
Mercury	Blood: 1.195 mg/kg Feather: 20.265 mg/kg	Blood: 1.570 mg/kg Feather: 5.526 mg/kg
Genetics	Awaiting results	Awaiting results
Weight (g)	3050	2750
Culmen (mm)	52.4	56.0
Length (mm)	68.3	72.0
Width (mm)	14.1	12.4
Depth (mm)	21.5	22.0
Bill overlap (mm)	+ 3.9	+ 6.4
Tarsus (mm)	L: 21.2 R: 21.7	L: 22.6 R: 21.6

Table 4. Monitoring results for Common Loons (*Gavia immer*) for Yellowstone National Park, 2013.

Demographics	Total
Territorial pairs (TP)	8
Nesting pairs (NP)	6
Chicks hatched (CH)	8
Chicks surviving (CS)	8
Nesting propensity (TP/NP)	0.75
Hatching success (CH/NP)	1.33
Chick survivorship (CS/CH)	1.00
Productivity (CS/TP)	1.00

Table 5. Monitoring results of Common Loons (*Gavia immer*) in Wyoming (Caribou-Targhee National Forest, Grand Teton National Park, and Bridger-Teton National Forest), 2013.

Demographics	Total
Territorial pairs (TP)	6
Nesting pairs (NP)	5
Chicks hatched (CH)	5
Chicks surviving (CS)	3
Nesting propensity (TP/NP)	0.83
Hatching success (CH/NP)	1.00
Chick survivorship (CS/CH)	0.60
Productivity (CS/TP)	0.50

Table 6. Known nest-sites and types of Common Loons (*Gavia immer*) by territory in Yellowstone National Park and Wyoming, 2013.

Territory	Nest location	Nest type	Active or historic	Territory type
Emma Matilda Lake	Shore	Bowl	Active	Whole
Arizona Lake	Marsh	Scrape	Active	Multi
Buela Lake	Marsh	Hummock	Active	Multi
Winegar Lake	Shore	Bowl	Historic	Multi
Loon Lake	Marsh	Bowl	Active	Whole
Indian Lake	Island	Scrape	Active	Whole
Bergman Reservoir	Island	Bowl	Active	Whole
Lewis Lake	Shore	Bowl	Historic	Whole
Riddle Lake	Island	Scrape	Active	Whole
South Arm	Island	Bowl	Historic	Partial
Cygnet Lakes	Island	Bowl	Active	Whole
Wolf Lake	Shore	Hummock	Active	Multi

Table 7. Human disturbance at territories of Common Loons (*Gavia immer*) in Wyoming, 2013.

Territory name	Shoreline access to nest area	Boating allowed in territory
Wolf/Grebe/Cascade	yes	no
Cygnet Lakes	yes	no
Shoshone Lake East	yes	yes
Delusion Lake	no	no
South Delusion Lake	no	no
Riddle Lake	no	no
Lewis Lake	yes	yes
Yellowstone Lake – South Arm	yes	yes
Yellowstone Lake – SE Arm	no	yes
Heart Lake	yes	yes
Winegar/Junco/Fish	yes	no
Beula Lake	yes	no
Loon Lake	no	yes
Indian Lake	no	no
Bergman Reservoir	yes	yes
Arizona Lake	no	no
Emma Matilda Lake	yes	no

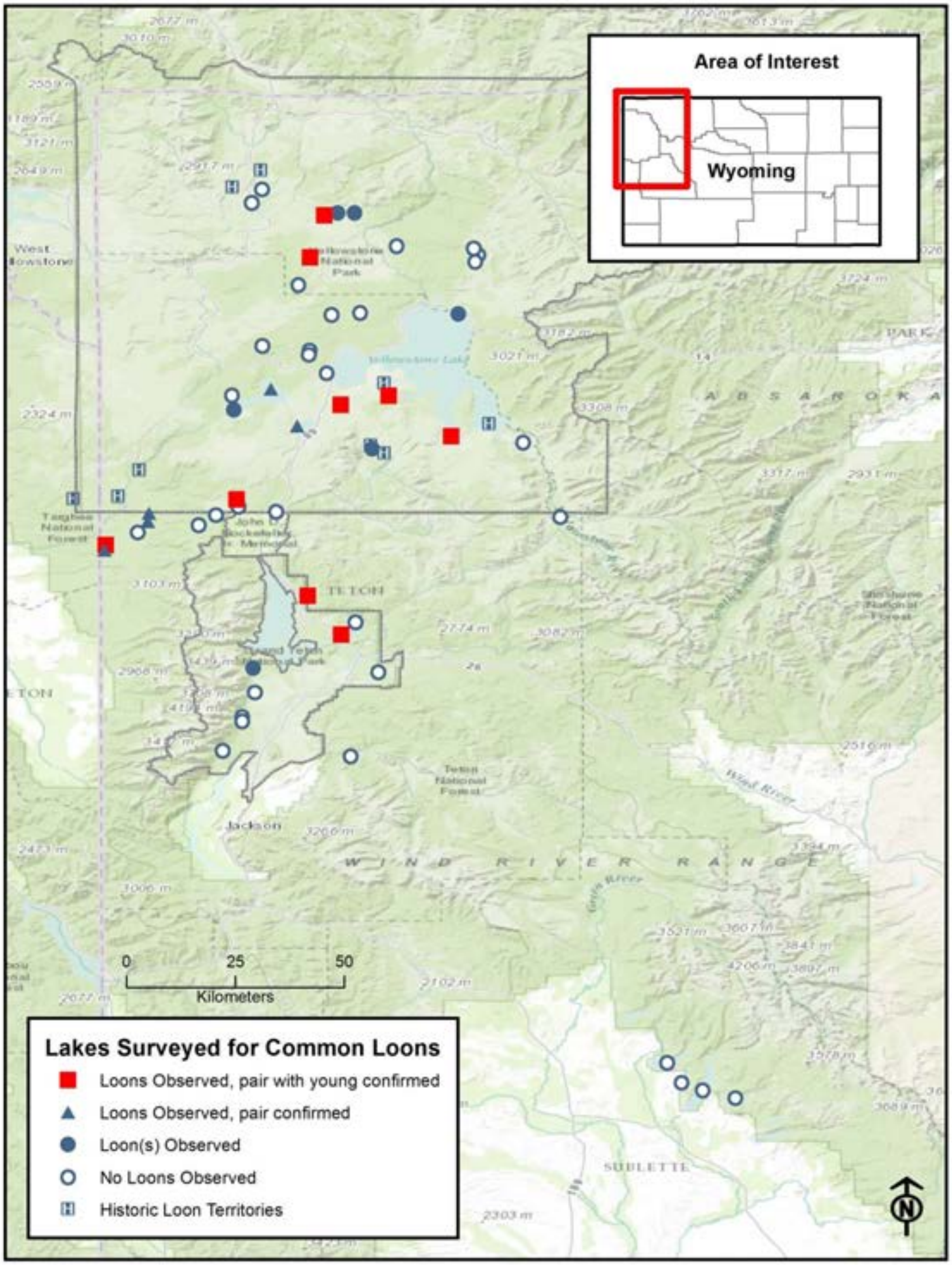

Figure 1. Presence of Common Loons (*Gavia immer*) lakes surveyed in Wyoming and Yellowstone National Park, 2013.

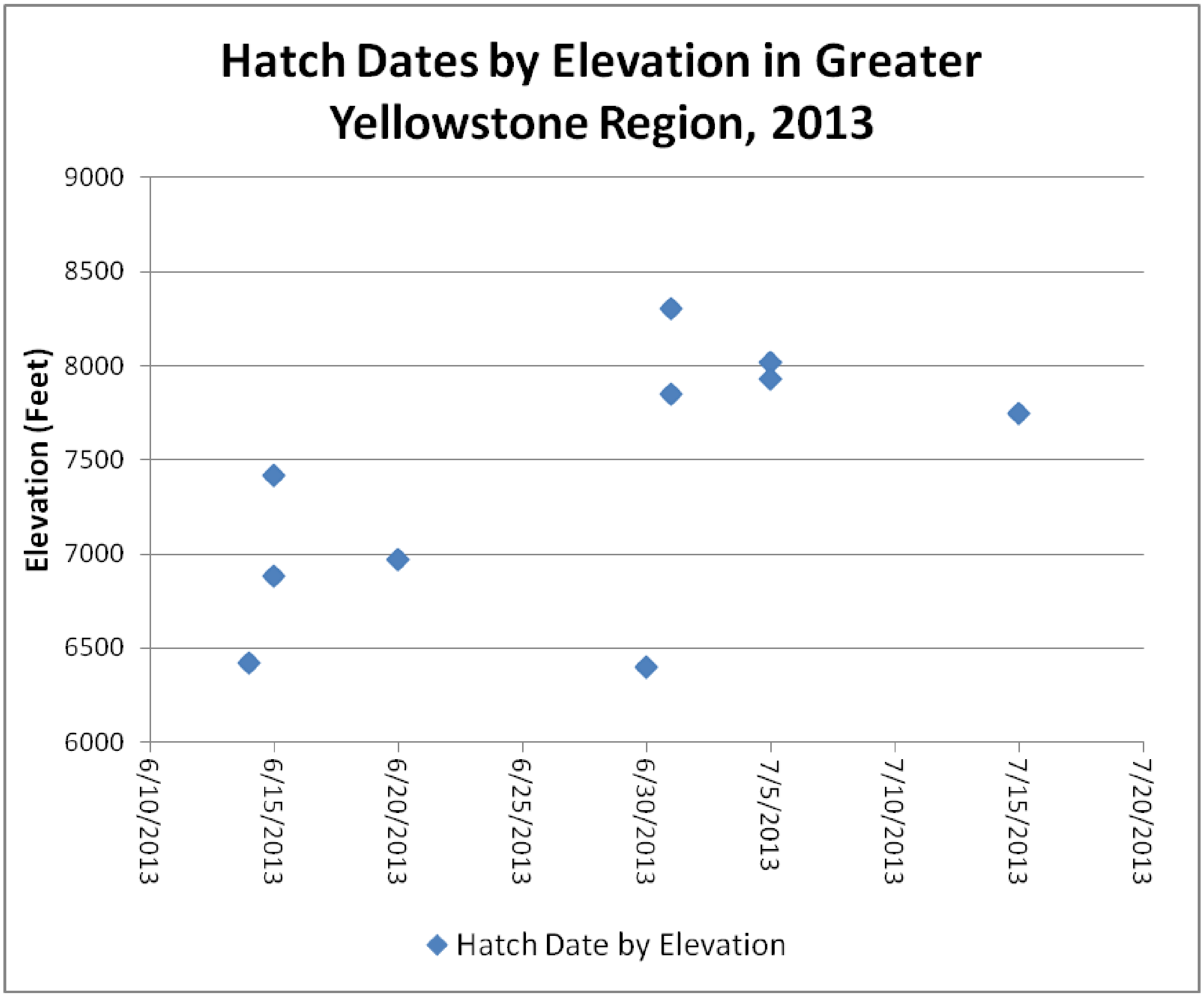

Figure 2. Hatch dates and nesting-lake elevations (ft) for Common Loons (*Gavia immer*) in Wyoming and Yellowstone National Park, 2013.

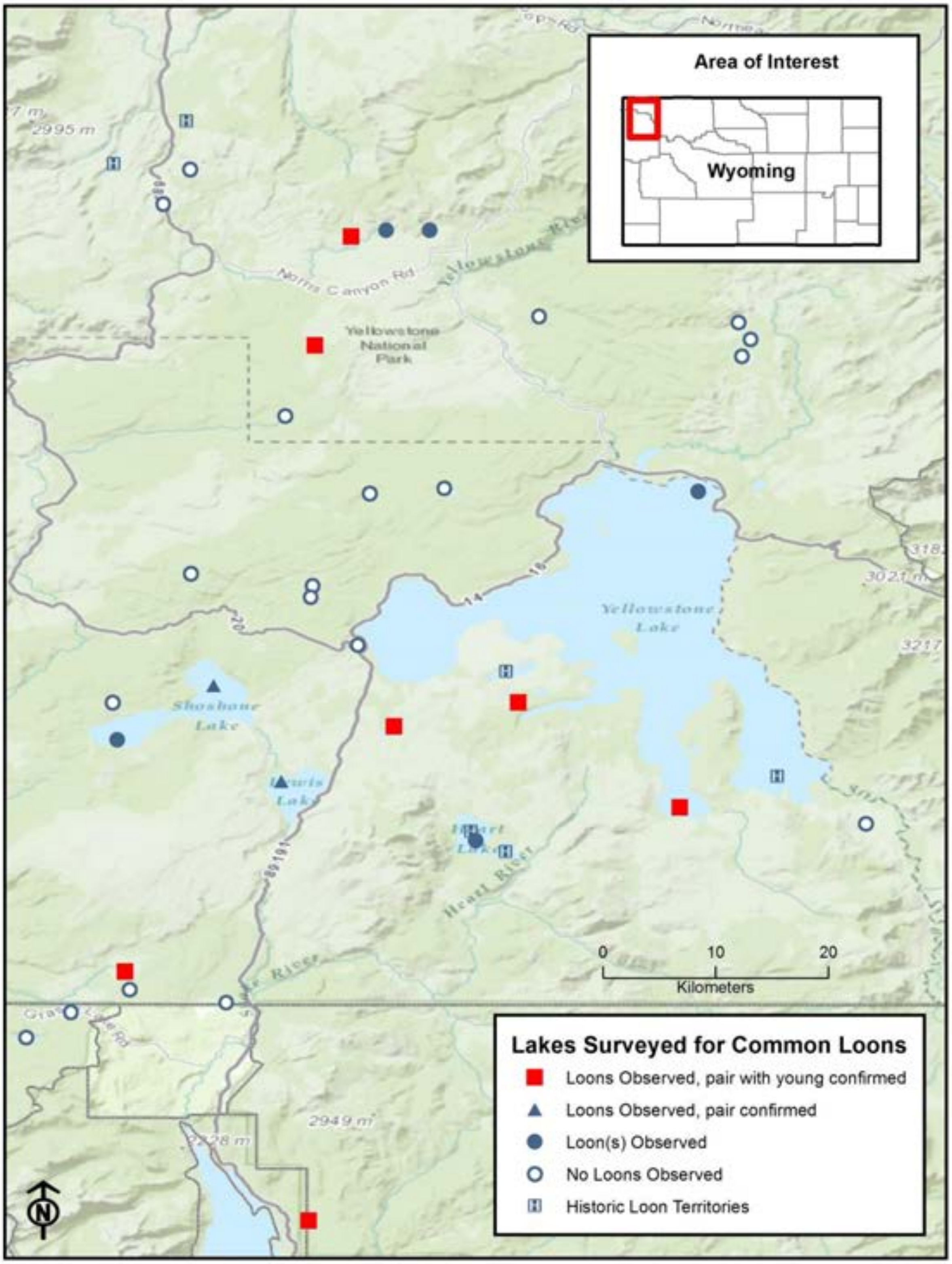

Figure 3. Population of Common Loons (*Gavia immer*) in Yellowstone National Park, 2013.

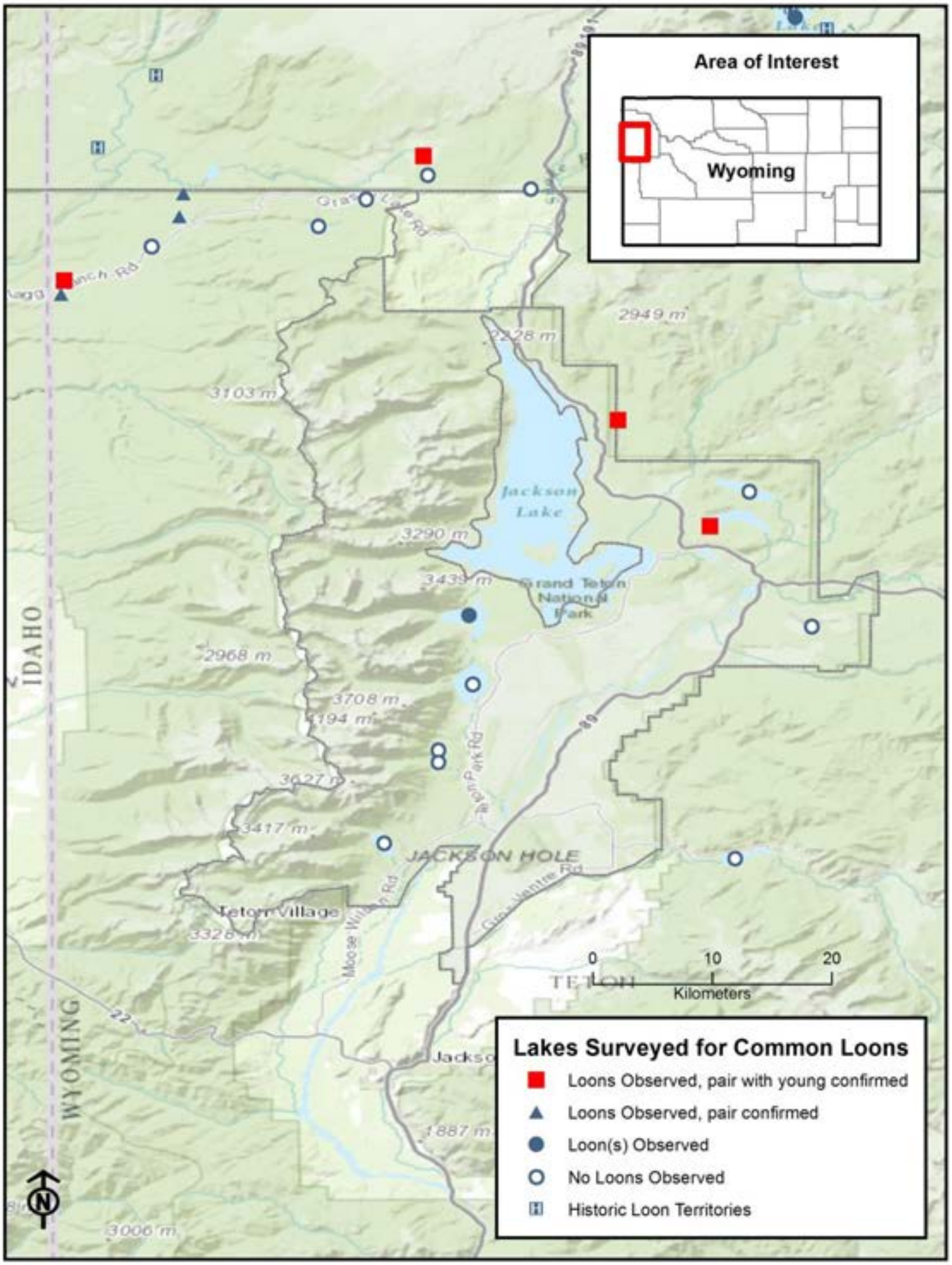

Figure 4. Presence of Common Loons (*Gavia immer*) in Wyoming (Caribou-Targhee National Forest, Grand Teton National Park, and Bridger-Teton National Forest), 2013.

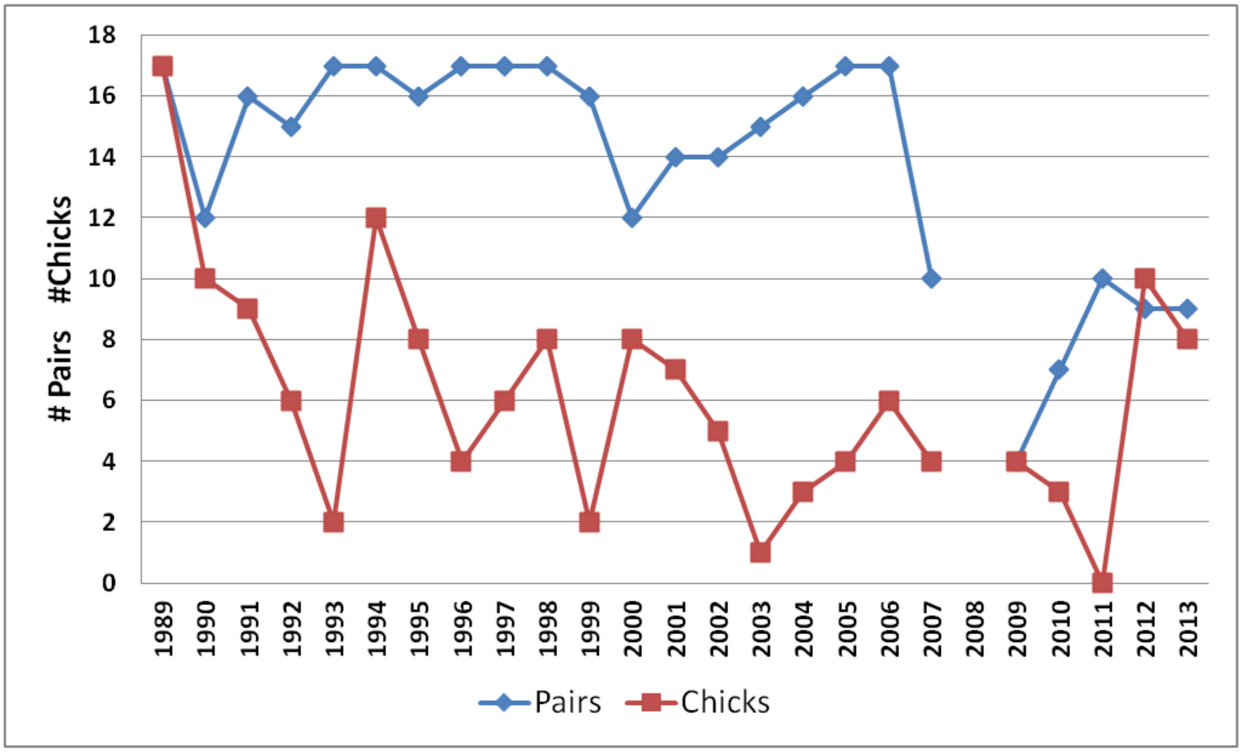

Figure 5. Number of territorial pairs and chicks surviving of Common Loons (*Gavia immer*) in Yellowstone National Park, 2013.

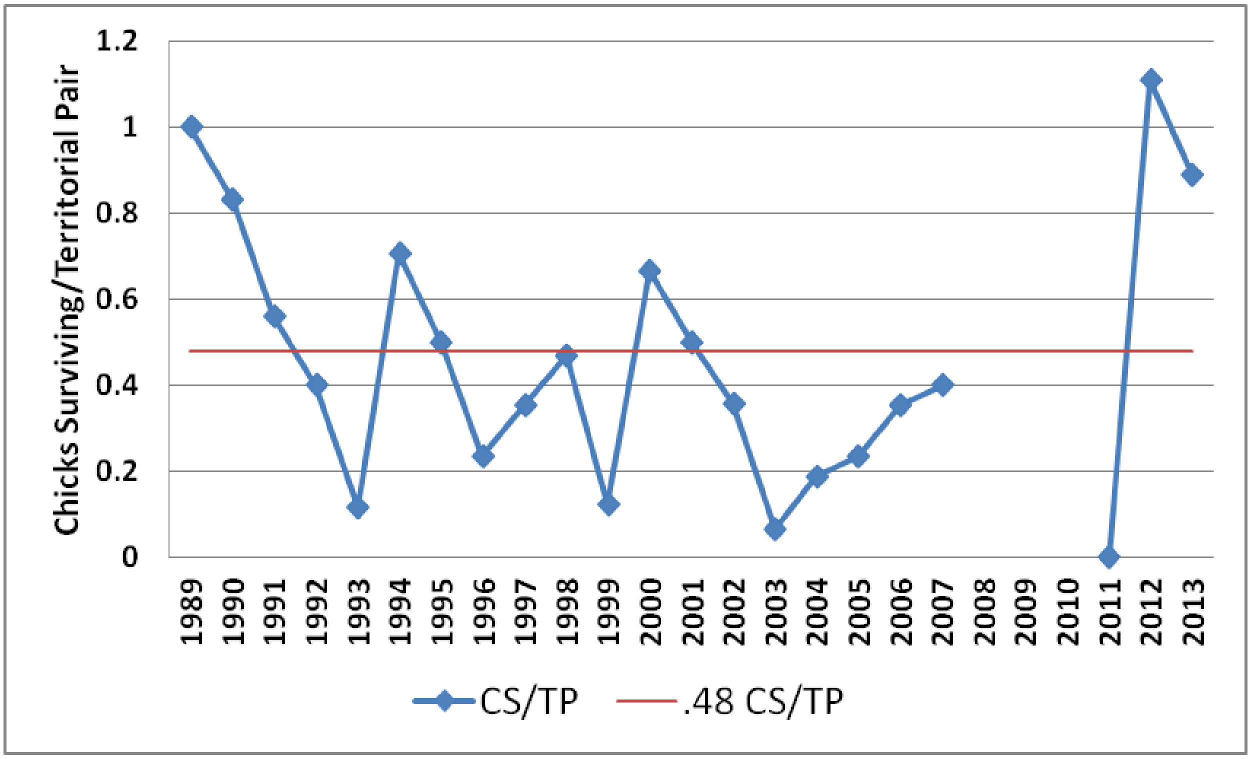

Figure 6. Territorial pairs (TP) and chicks surviving (CS) of Common Loons (*Gavia immer*) in Yellowstone National Park, 2013. Red line indicates the estimated productivity needed to sustain loon populations (0.48 CS/TP).

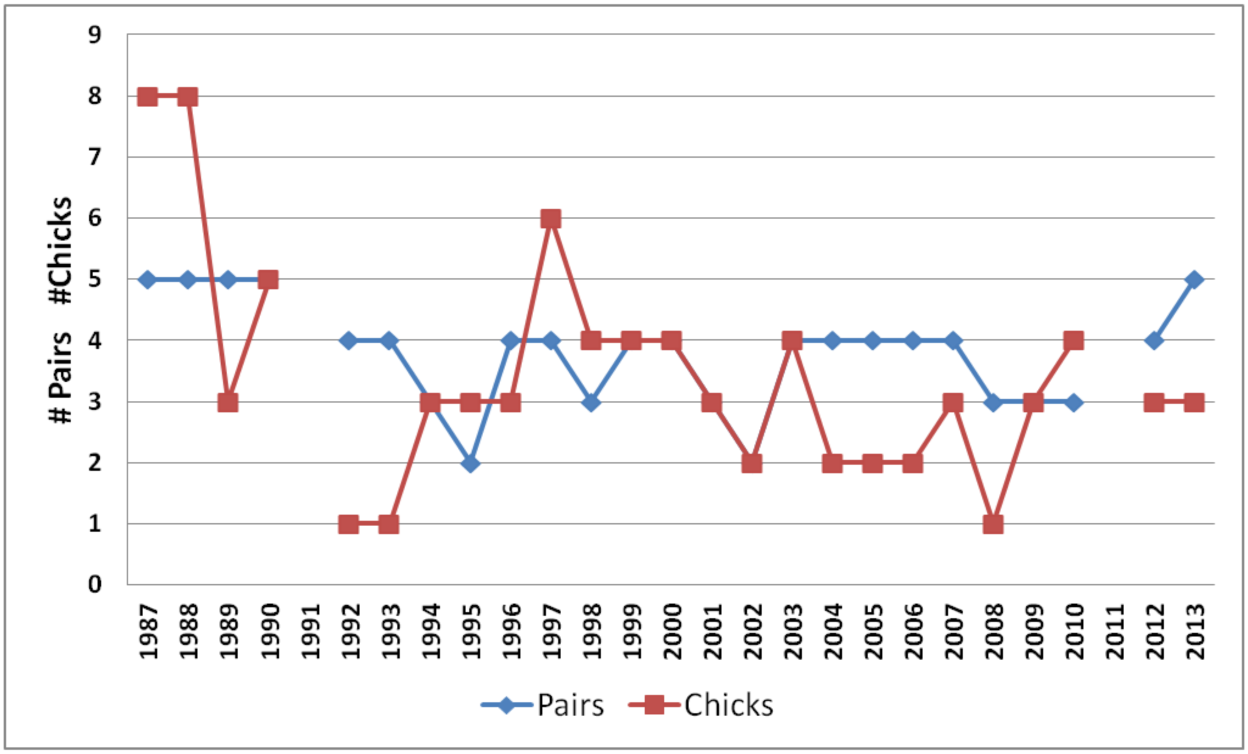

Figure 7. Territorial pairs and chicks surviving of Common Loons (*Gavia immer*) in Wyoming outside of Yellowstone National Park (Caribou-Targhee National Forest, Grand Teton National Park, and Bridger-Teton National Forest), 2013.

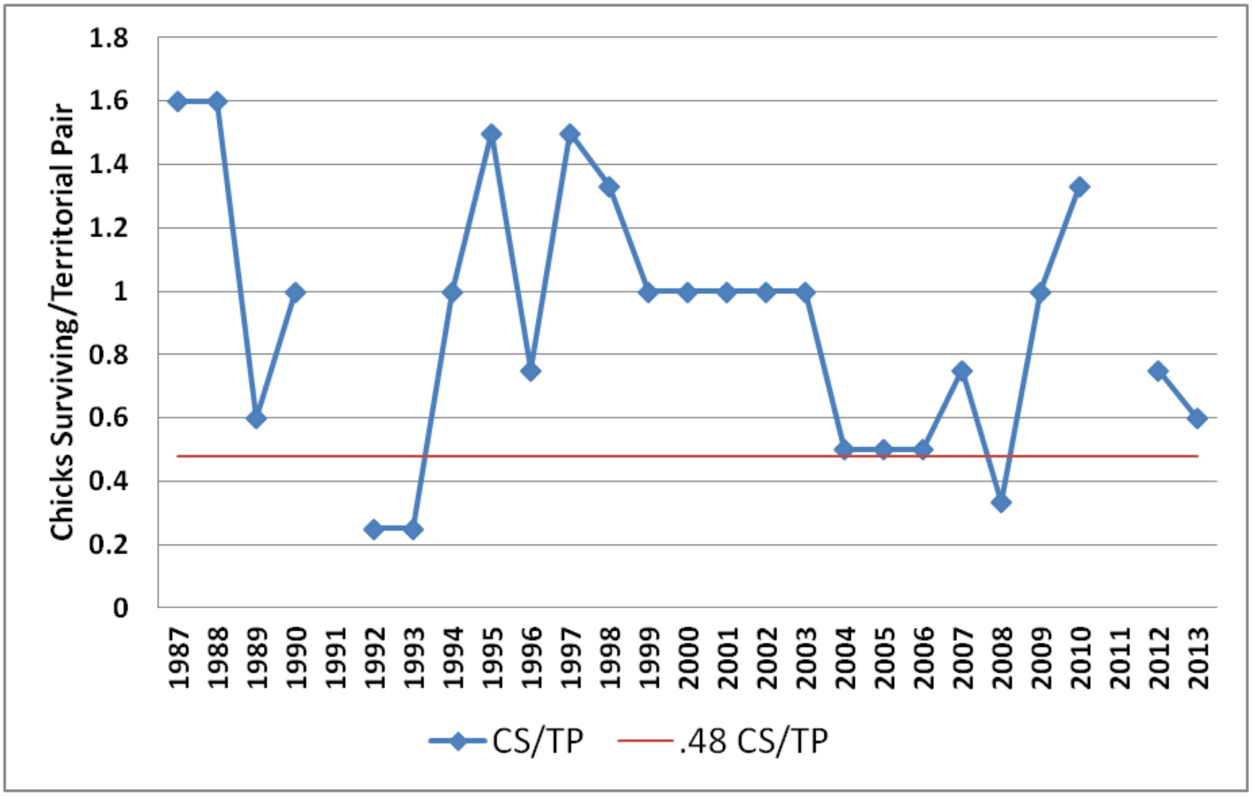

Figure 8. Productivity of Common Loons (*Gavia immer*), including number of chicks surviving (CS) per territorial pair (TP), in Wyoming (Caribou-Targhee National Forest, Grand Teton National Park, and Bridger-Teton National Forest), 2013. Red line indicates the rate needed to sustain loon populations (0.48 CS/TP).

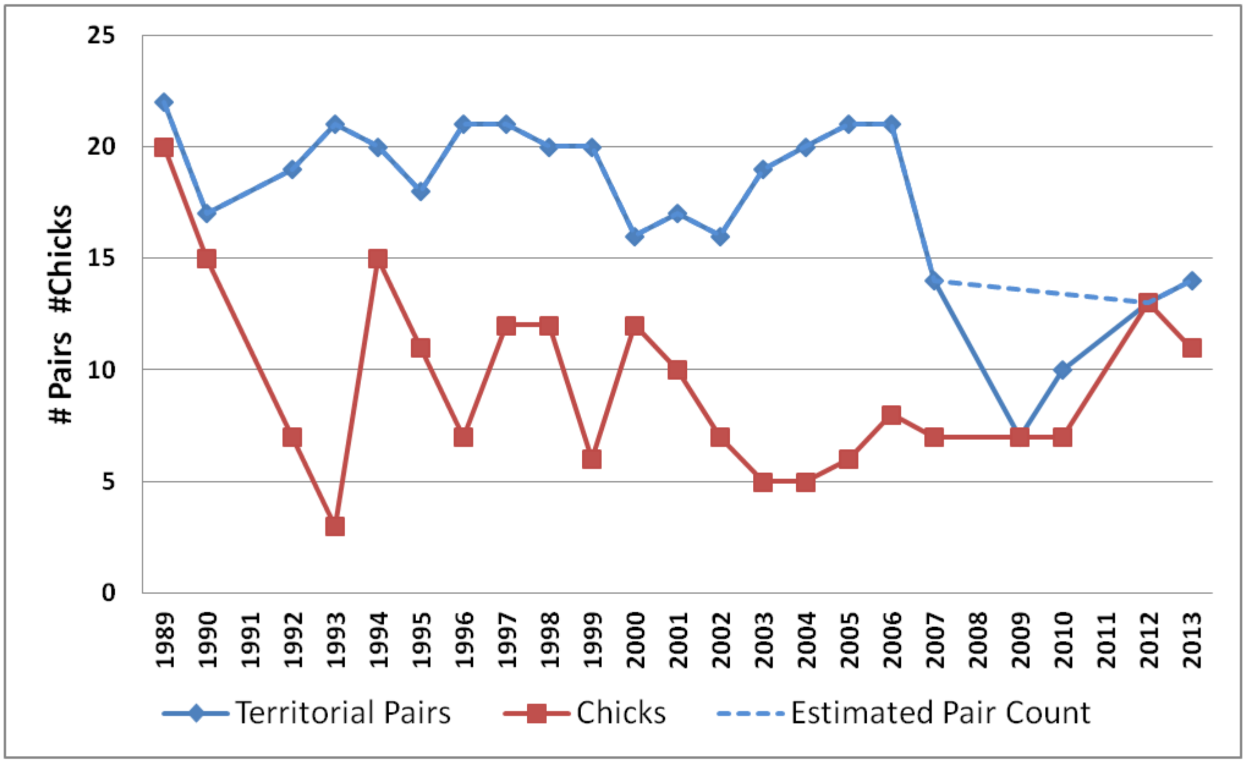

Figure 9. Territorial pairs and chicks surviving of Common Loons (*Gavia immer*) in Wyoming and Yellowstone National Park, 1989-2013. Seven pairs were recorded in 2009, but more were likely present in the study area.

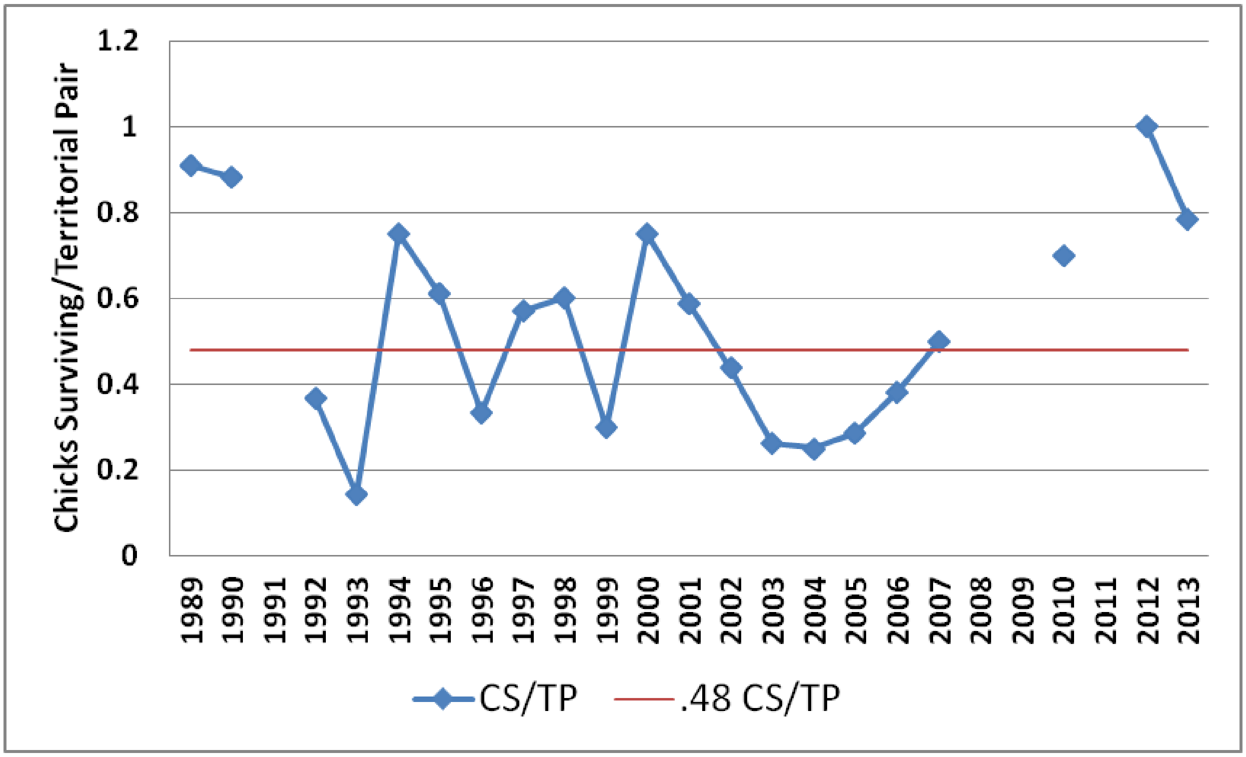

Figure 10. Productivity of Common Loons (*Gavia immer*), including number of chicks surviving (CS) per territorial pair (TP), in Wyoming and Yellowstone National Park, 1989-2013. Red line indicates the rate needed to sustain loon populations (0.48 CS/TP).

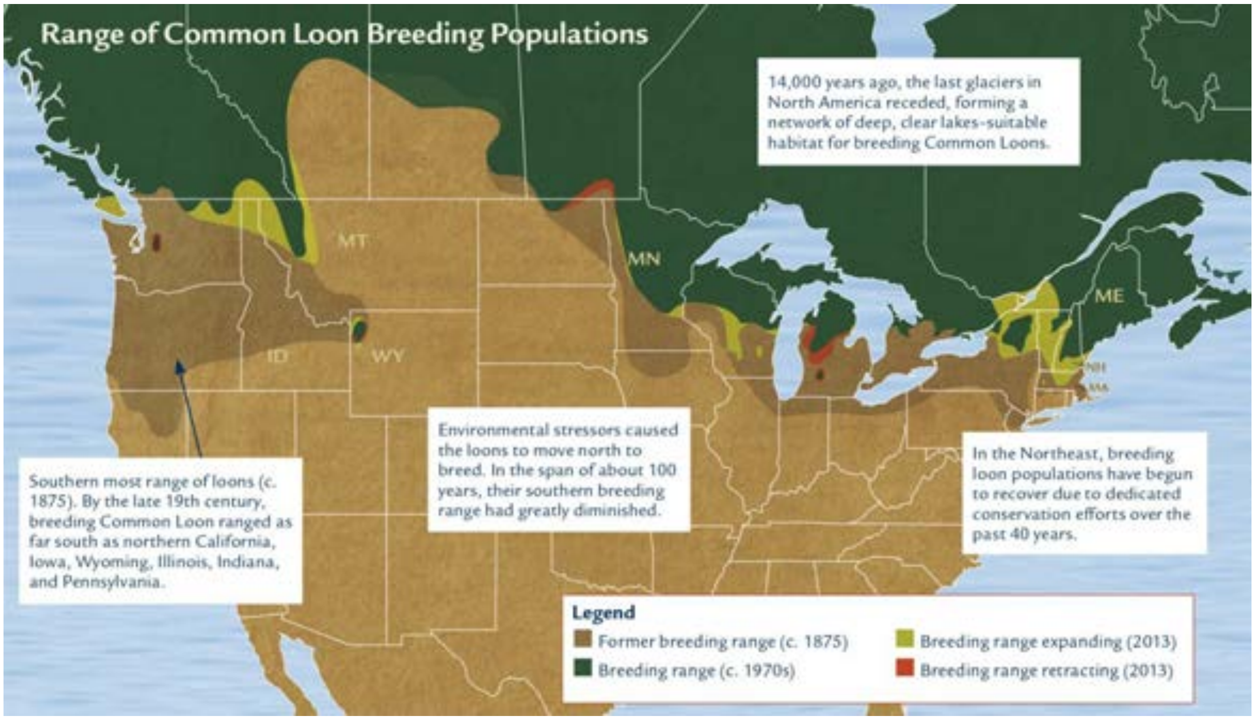

Figure 11. Common loon (*Gavia immer*) species range depicting isolated populations and range retractions and recoveries.

POPULATION TRENDS OF AMERICAN BITTERNS (*BOTAURUS LENTIGINOSUS*) AT COKEVILLE MEADOWS NATIONAL WILDLIFE REFUGE, WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – American Bittern

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Nichole Cudworth, Nongame Biologist

ABSTRACT

The American Bittern (*Botaurus lentiginosus*) is classified as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department because of severely limited wetland habitat necessary for reproduction and survival. Because of their secretive behavior, American Bitterns require a species-specific call-playback technique to document presence. In 2013, we used this survey technique to continue annual monitoring along five transects on the Cokeville Meadows National Wildlife Refuge in western Wyoming to estimate population trends over time. Although two transects demonstrated slightly declining populations, one other demonstrated an increase in American Bitterns we detected. We had insufficient data to develop a population trend for the fourth and fifth transects, but data suggest American Bitterns are likely increasing on at least one of these transects, as well. When sufficient data are accumulated for these transects, we will conduct population trend analyses on these data, as well. Although results should be interpreted cautiously until additional data can be accumulated and analyzed, current trends suggest habitat improvements are likely leading to increases in the number of nesting American Bitterns on the Cokeville Meadows National Wildlife Refuge.

INTRODUCTION

The American Bittern (*Botaurus lentiginosus*; bittern) is 1 of 12 species of colonial-nesting waterbirds that is classified as a Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (WGFD 2010). The bittern is a wetland-obligate species that prefers tall, emergent vegetation, and nests on a platform made of reeds, sedges, or cattails that is suspended approximately 6 cm over the water surface (Gibbs et al. 1992, Desgranges et al. 2006, Dechant et al. 1999). Bitterns are typically found in large wetlands ≥3 ha in size and have been observed in wetlands up to 180 ha (Brown and Dinsmore 1986, Dechant et al. 1999). Stability of wetlands can be threatened by fluctuating water levels, changes in land use practices, and desiccation due to climate change (McMenamin et al. 2008, WGFD 2010), which may negatively impact bittern populations (Steen et al. 2006). Bitterns are entirely dependent upon marshes and wetlands for reproduction and survival. Although bitterns are found scattered throughout Wyoming's marshes, they are only known to breed in nine latilong degree blocks (Orabona et al. 2012). Bitterns are a summer resident in Wyoming and are classified as a Tier 2 SGCN with a Native Species Status of 3 (NSS3; WGFD 2010).

We have conducted surveys for colonial waterbirds a minimum of every three years to determine presence and index the number of nesting pairs at important breeding sites in Wyoming (Orabona 2010). However, bitterns are loosely colonial, secretive, and seldom detected during these surveys. Additionally, bitterns have been shown to co-occur with other species of waterbirds less often than would be expected (Bolenbaugh et al. 2011). Consequently, we use a species-specific survey to determine occupancy, abundance, and distribution of bitterns annually in breeding habitat in western Wyoming. Our objectives in 2013 were to continue annual surveys along four pre-defined transects and evaluate population trends, and survey a new transect that was established in 2012.

METHODS

We surveyed five transects for bitterns on the Cokeville Meadows National Wildlife Refuge (Refuge) in western Wyoming (total 13.2 km): Bartlett transect (2.0 km), Diamond transect (2.8 km), Peterson transect (3.2 km), Pixley transect (3.6 km), and Thornock transect (1.6 km). Transect location and length was based upon the amount of suitable bittern habitat present and known locations of bitterns from previous passive-listening surveys. We designed our survey methods following recommendations by the USFWS and USGS (1999) and Conway (2005). Detections of secretive marsh birds, including bitterns, have been shown to increase when surveys include a mixture of passive listening and call-playback techniques (Conway and Nadeau 2006). Consequently, we conducted annual surveys of bitterns during the breeding season between 13 May and 30 June when they were most vocal and responsive to this survey technique. We surveyed each transect once. All surveys were conducted between 1800 and 2200 hrs and 0530 to 0730 hrs to coincide with the peak of bittern vocalization activity; however, if individuals were heard calling before or after this timeframe, we adjusted surveys accordingly. We spaced our survey locations every 400 m along each transect. At each location, we initiated the survey by passively listening for bittern vocalizations for 5 min. We then played a recorded bittern call for 1 min and finished the survey by listening for a response for 1 min. We recorded all bitterns heard or seen during all phases of the survey, and marked the approximate location of each individual bittern on a transect map. We also noted other species observed or heard at each location.

For each transect, we tallied the total number of bitterns recorded for each survey. If more than one survey was conducted, we used data from the survey that detected the greatest number of bitterns for analyses, since individuals may not vocalize consistently among surveys. Survey techniques have varied since the first bittern-specific transects were established in 2004 (Orabona and Cudworth 2011); consequently, we only use data from surveys with consistent techniques (i.e., 2007 to present). Due to small sample sizes resulting from fluctuating water levels during some years, we only analyzed data for transects with a minimum of three years of survey data (i.e., Bartlett, Diamond, Peterson, and Thornock transects). For these transects, we conducted a regression analysis and report the slope and R^2 value of trend lines to investigate population trends.

RESULTS

We planned to survey all transects three times; however, we were only able to survey each transect once because of scheduling conflicts during the first two replicates. We detected bitterns on all five survey routes (Table 1). Detections of bitterns varied from a low of 0.9 individuals detected per km on the Peterson transect to a high of 6.9 individuals detected per km on the Thornock transect. Route locations and the number of bitterns we detected at each stop are depicted in Figure 1.

On the Bartlett transect, detections of bitterns have continued to decrease by 0.13 individuals per km per year (R^2=0.074; Fig. 2). We now have 4 years of data on the Diamond transect so have included it in the analysis. American Bittern detections on the Diamond transect appear stable (R^2=0.00; Fig. 3). Detections of bitterns on the Peterson transect increased by an average of 0.18 individuals per km per year (R^2=0.192; Fig. 4). The number of bitterns detected on the Thornock transect in 2013 was the similar to those in 2011 and 2012 numbers, but trend since 2007 has shown a very slight decrease of 0.20 individuals per km per year (R^2=0.045; Fig. 5). The Pixley transect has only been surveyed for 2 years, and was not included in these analyses.

DISCUSSION

In 2013, we were only able to conduct one replicate of each transect due to scheduling conflicts during the survey timeframe. On the Bartlett transect, we detected the highest number of bitterns since the survey was initiated in 2007. In 2012, the trendline on the Bartlett transect demonstrated a noticeable decline compared with results from previous years (Cudworth and Orabona 2012). Our results in 2013 show a large increase in detections that are more comparable to the first few years of the survey, although the trendline indicates a slight overall decline. The limited results on the Diamond transect indicates the number of bitterns has remained stable; however, the variation is weak (R^2=0.00). Although we detected the same number of bitterns in 2013 on the Peterson transect as in 2012, we detected fewer bitterns compared to 2010 and 2011. The number of bitterns we detected on the Thornock transect in 2013 was similar to 2007, 2008, 2011, and 2012, but was less than the highest numbers detected in 2009 and 2010. This decrease in bittern detections has had a disproportional impact on the trend for the Thornock transect, where we reported an increase of 1.51 individuals per km per year (R^2=0.73) in 2010 (Orabona and Cudworth 2011), to an increase of only 0.26 individuals per km per year (R^2=0.03) in 2011 (Cudworth and Orabona 2012), and a slight decrease of 0.13 bitterns per km (R^2=0.013) in 2012. The seasonal and annual fluctuation in number of bitterns we detected on these transects may simply be a response to local conditions, as results can fluctuate due to inconsistent spring weather or alternations in flood irrigation management. Bitterns nest only 6 cm above the water surface and are negatively impacted by rapid or even moderate flooding (Desgranges et. al 2006).

Our ability to survey these transects in previous years was impacted by unfavorable weather conditions, time constraints, available personnel, and access issues. However, on occasions when we surveyed the Diamond and Peterson transects prior to 2010, we detected few bitterns, which we hypothesized was due to a limited availability of nesting habitat. Since 2006, personnel at the Cokeville Meadows National Wildlife Refuge have actively improved habitat for bitterns using controlled flooding, which has expanded the amount of suitable habitat available to bitterns for nesting.

It is difficult to monitor trends of bitterns with only 4-7 years of data, so results should be interpreted with caution. Small sample sizes make these trends especially susceptible to stochastic fluctuations, as can be observed at some level for all transects, which can obscure overall trends. Taken as a whole, bittern detections appear to be increasing on the Refuge, likely reflecting the current habitat improvement and expansion projects in place. Our efforts to continue annual surveys for bitterns will increase the precision of trend analyses, allow for better trend estimation, and will help elucidate how habitat projects are influencing distribution and abundance of bitterns on the Cokeville Meadows National Wildlife Refuge.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would also like to express our appreciation to USFWS personnel at the Cokeville Meadows National Wildlife Refuge and Seedskadee National Wildlife Refuge for supporting our monitoring program and their continued efforts to improve wetland habitat at Cokeville Meadows to benefit this Species of Greatest Conservation Need. Finally, we thank Department Nongame GIS Analyst D. Jensen for assistance producing the survey map.

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Table 1. Total and number per km of American Bitterns (*Botaurus lentiginosus*) detected during surveys conducted June 2013 on the Cokeville Meadows National Wildlife Refuge, western Wyoming. Transect length for each route is reported in parentheses.

Bartlett transect (2.0 km)		Diamond transect (2.8 km)		Peterson transect (3.2 km)		Pixley transect (3.6 km)		Thornock transect (1.6 km)	
Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km
6	3	7	2.5	3	0.9	6	1.5	11	6.9

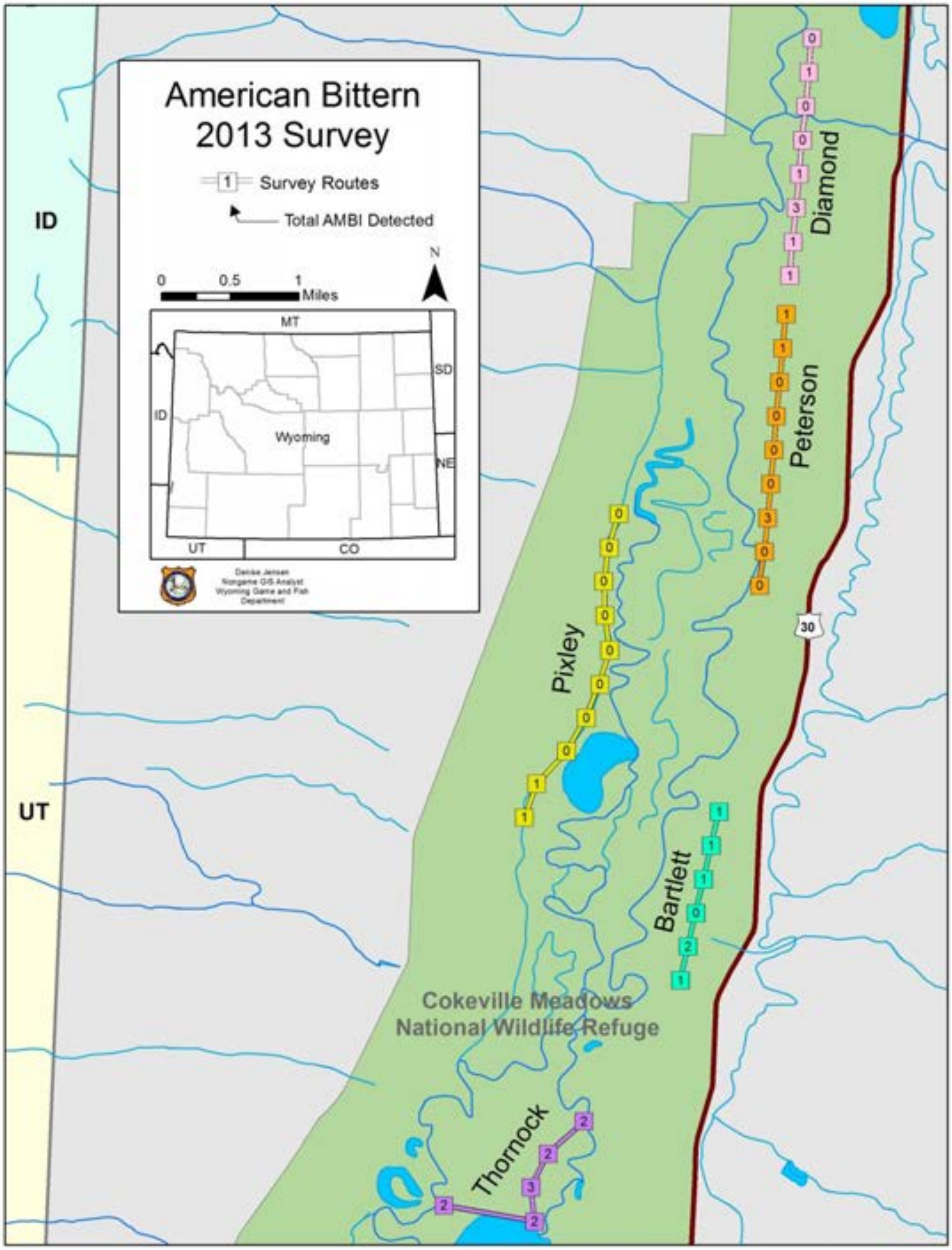

Figure 1. American Bittern (*Botaurus lentiginosus*) transect locations and numbers we detected during the 2013 surveys on the Cokeville Meadows National Wildlife Refuge. We have only conducted the Pixley transect for 2 years, so did not include this route in the data analysis.

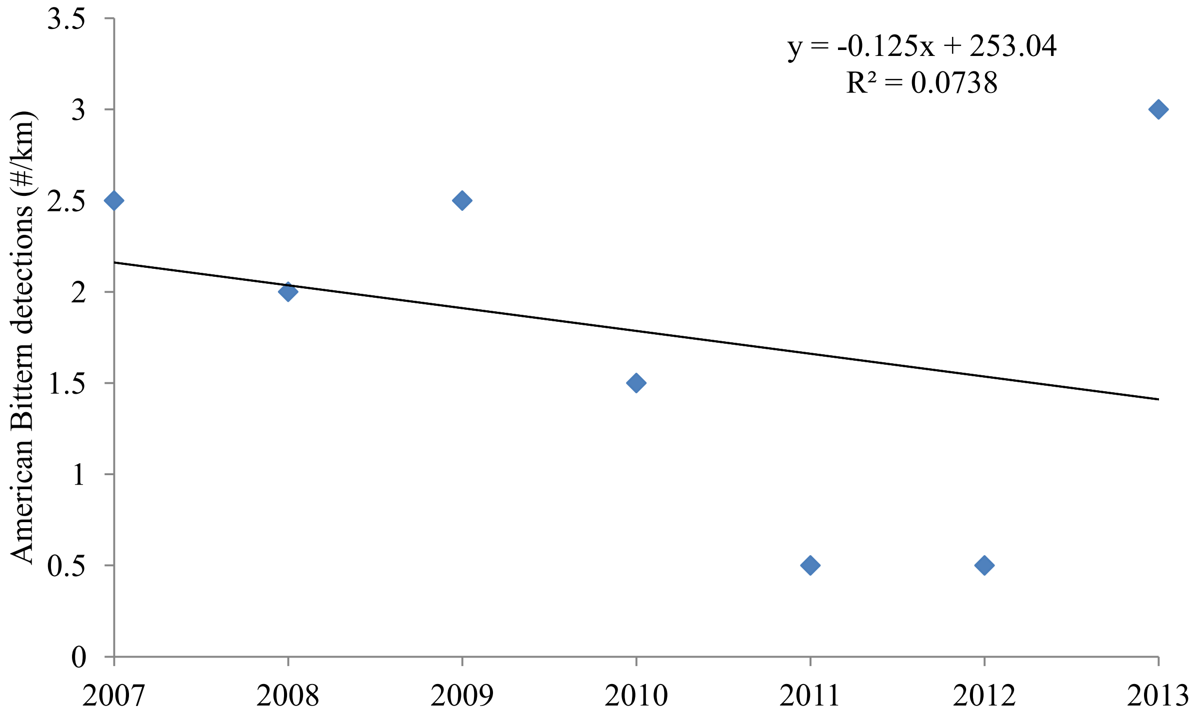

Figure 2. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Bartlett transect (2.0 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2007-2013. The trendline is shown for reference.

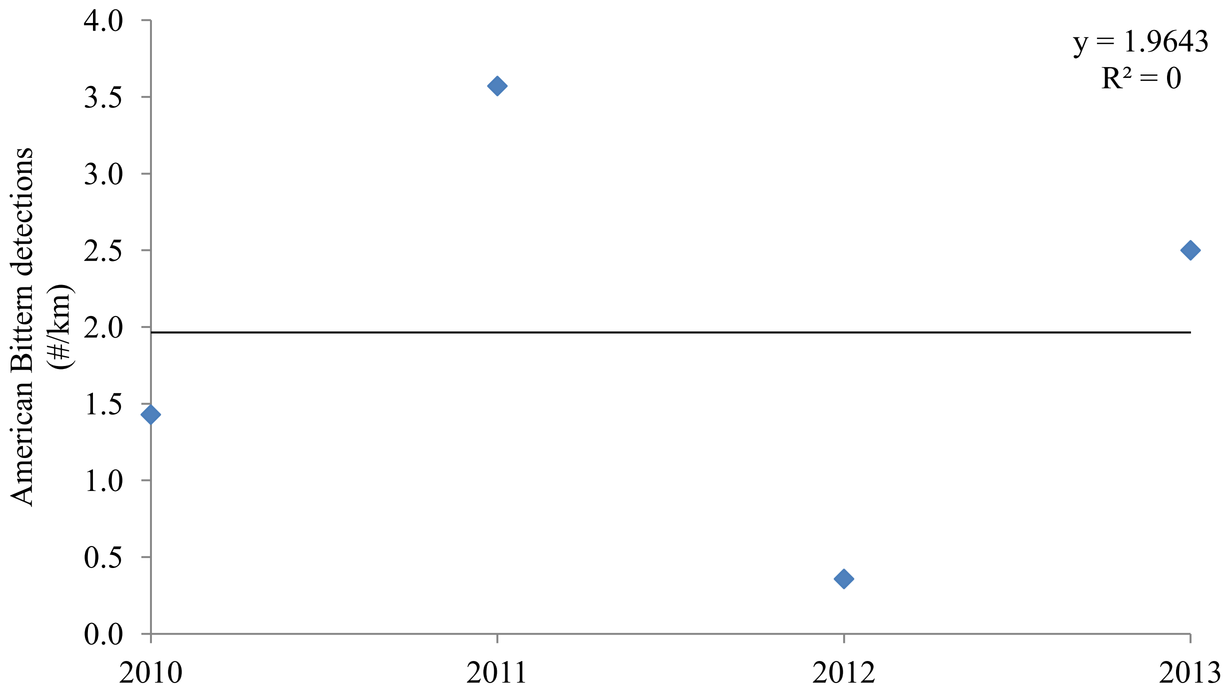

Figure 3. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Diamond transect (2.8 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2010-2013. The trendline is shown for reference.

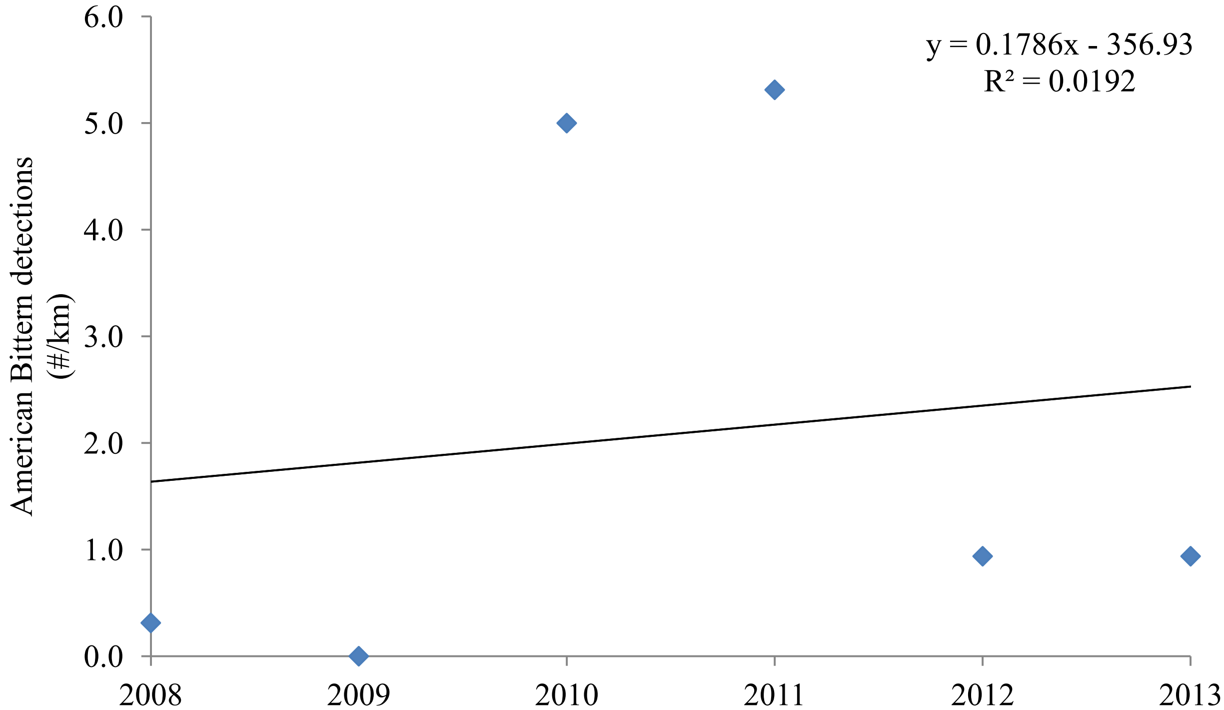

Figure 4. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Peterson transect (3.2 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2008-2013. The trendline is shown for reference.

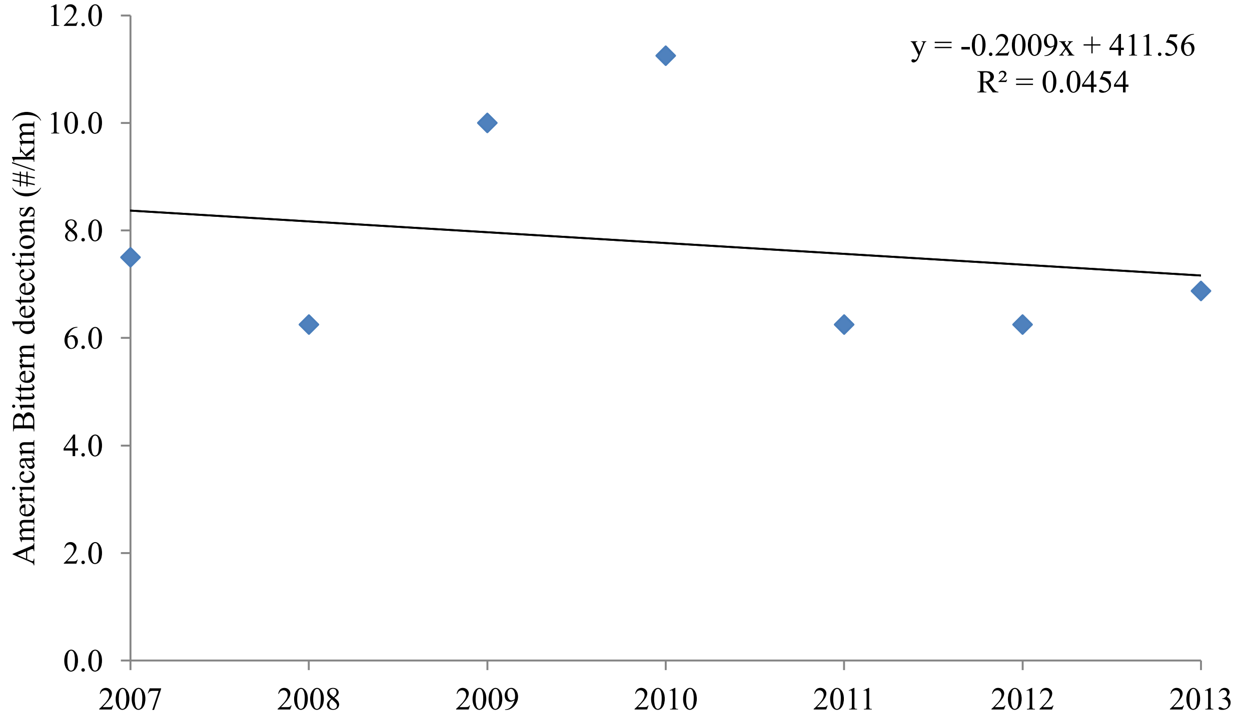

Figure 5. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Thornock transect (1.6 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2007-2013. The trendline is shown for reference.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) MONITORING IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

FUNDING SOURCE: United States Army Corp of Engineers
Bridger-Teton National Forest
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Susan Patla, Nongame Biologist
Bob Oakleaf, Nongame Coordinator (retired)

ABSTRACT

The Bald Eagle (*Haliaeetus leucocephalus*) occurs throughout most of North America from Alaska to central Mexico and winters generally throughout the breeding range except in the far north. It nests along major river drainages and lakes throughout Wyoming, with the most significant concentrations in Teton, Sublette, and Carbon counties, including a significant number of nesting pairs in Grand Teton and Yellowstone National Parks. We initiated monitoring for Bald Eagle statewide in 1978. The Bald Eagle, although no longer designated as a Threatened species under the Endangered Species Act, remains protected under the Bald and Golden Eagle Protection Act and is classified as a Species of Greatest Conservation Need with Native Species Status of 2 in Wyoming. We currently monitor the population of Bald Eagles that nest in the western portion of the state (i.e., Snake and Green River drainages) annually and obtain data when available from other areas of the state. We have detected ≥139 nest sites to date. However, we believe there is potential habitat for ≥200 territories to occur statewide. In 2013, we obtained occupancy data for 101 territories and productivity data for 67 nest sites. As in previous years, Bald Eagles occupied a high proportion (i.e., ≥83%) of nesting territories we monitored, and successful nests produced an average of 1.6 young per nest. We documented a total of 84 mature young from surveys in western Wyoming. Bald Eagles that nest in Wyoming and continue to show strong productivity still experience some site-specific risks due to increasing energy development, rural development, recreational activities, and environmental contaminants. We continue to receive and process numerous requests for information and management recommendations for Bald Eagle nest and roost sites.

INTRODUCTION

The Bald Eagle (*Haliaeetus leucocephalus*) nests along all major river systems in Wyoming, but the largest number of nesting pairs is found in northwestern Wyoming in the Greater Yellowstone Area (GYA) along the Snake River drainage and its tributaries. Bald Eagles in the northwestern part of the state have long been recognized as part of a distinct population that nests in the Rocky Mountain West. This genetically distinct population extends into Idaho and Montana (Swenson et al. 1986). Recovery of the species in Wyoming centered on the Jackson area beginning in the 1980s. The numerous territories located along the Snake River continue to serve as a source of Bald Eagles for other areas of the GYA and other parts of Wyoming (Harmata and Oakleaf 1992). Since 2000, we have also documented a substantial increase in the number of pairs that nest in the Green River Basin. Bald Eagles that nest in Wyoming continue to experience some site-specific risks from increasing energy development, rural development, recreational activities, and environmental contaminants. The US Fish and Wildlife Service (USFWS) released guidelines recently to assist developers of land-based wind-energy projects in identifying risks to wildlife species, including Bald Eagles (USFWS 2012).

The USFWS removed the Bald Eagle from protection under the Endangered Species Act in the western US in July 2007. However, the species continues to be protected under the Bald and Golden Eagle Protection Act. The Wyoming Game and Fish Department (Department) initiated monitoring for Bald Eagles statewide in 1978. Currently, program objectives include monitoring occupancy and productivity at nesting territories in the Snake River and Green River Basin, south to Seedskadee National Wildlife Refuge (NWR). Additional surveillance data are collected at a number of other sites around the state by Department personnel. We continue to receive numerous requests by other state and federal agencies and the public for information on status of nests of Bald Eagles and provide recommendations on mitigation measures to conserve nest sites in Wyoming. The Army Corp of Engineers (ACE) request data every year on the status of nest sites located adjacent to the Snake River dike system in the Jackson area to schedule maintenance projects. The ACE has provided funding support the last few years for aerial survey work. Management guidelines have been developed for nest sites for the GYA based on a long-term ecological study and provide valuable information for avoiding disturbance to nesting eagles (Greater Yellowstone Bald Eagle Working Group 1996). The Department is actively involved in reviewing new federal regulations through participation in the Central Flyway Nongame Technical Committee.

METHODS

We conducted aerial surveys at a majority of known Bald Eagle nest sites in western Wyoming to monitor nests for occupancy and productivity. Fixed-wing aircraft surveys were conducted in late March and early April to document the number of occupied sites with incubating adults and again in early June to determine number of mature young produced per site. During aerial surveys, we recorded the number of adult and young Bald Eagles observed, UTM coordinates of nests, condition of nests, species of nest tree, and photographed new sites. We also recorded locations of other Species of Greatest Conservation Need (WGFD 2010).

In 2013, we used a single observer and a Scout fixed-wing airplane that flew approximately 100-200 m above ground and at speeds of 120-160 kph to conduct aerial nest-occupancy surveys on 1-2 April and a productivity survey on 17 June. We collected additional data 25-26 April on the Pacific Flyway goose pair survey. We combined the productivity flight for eagles with a monitoring survey for Trumpeter Swan (*Cygnus buccinator*) to reduce overall survey costs. We surveyed all known nest sites along the main stem and tributaries of the Snake River, Gros Ventre River, Salt River, New Fork River, and the Green River from Green River Lakes to south of Seedskadee NWR.

Biologists from Grand Teton National Park, Seedskadee NWR, National Elk Refuge, the Department, and the USFWS contributed data from their respective monitoring efforts. A few volunteers in Jackson also surveyed specific territories on a regular basis. In other parts of the state, Regional Wildlife Biologists collected data for a subset of known nests that were visible from the ground. For ground-based surveys, observers used spotting scopes or binoculars from observation points that were sufficiently far away to prevent disturbance to nesting Bald Eagles. Survey duration was typically ≤2 hrs depending on visibility, behavior of adult birds, and status of the nest. Department personnel that conducted aerial surveys for waterfowl provided additional data. Some wildlife consultant companies provided nest observation data as well.

RESULTS

In 2013, we evaluated occupancy status of 101 nest sites. Data collected from nest sites in Yellowstone National Park and by private consultant groups in other parts of Wyoming are not summarized here; consequently, this report represents a minimum count of nesting Bald Eagles that occur statewide. Monitoring effort was greatest in western Wyoming where the majority of nests are known to occur.

Bald Eagles occupied 83% of sites surveyed. Table 1 presents productivity data for nest sites in western Wyoming that were monitored consistently through repeated aerial or ground surveys. The majority of occupied nests were found along the main stem of the Snake River (including Jackson Lake) and the Green River drainage (Table 1, Fig. 1). Overall, 78% of the territories checked for productivity in western Wyoming produced mature young. The number of mature young produced per successful nest was 1.62. Storms with strong winds resulted in the loss of two nests in April and May in the Snake River drainage. Overall, 11 nest sites failed in the Jackson area, most likely a result of late, cold snow storms that occurred in early April during the hatching period. No emergency dike work was required along the Snake River dike system in 2013.

DISCUSSION

The number of nesting pairs of Bald Eagles appears to have stabilized in the Snake River drainage in Wyoming, but the nesting population is still increasing slightly in the Green River Basin and likely at other locations in the state. Two new nesting territories sites were documented in 2013, one south of Seedskadee NWR along the Green River and one on the Hams

Fork. Two new nest sites found in the Snake River drainage in 2013 appeared to represent alternative sites for known territories rather than an increase in nesting pairs. Comparing productivity data for the Greater Yellowstone population collected from 1982-1995 to the current year indicates that current productivity, or the number young produced per occupied site, for 2013 is within the historic range (Greater Yellowstone Bald Eagle Working Group 1996). The Department provides data on nesting eagles for numerous requests every year from county, state, and federal agencies and private consultants for use in evaluating proposed projects and developing mitigation measures to protect nesting territories. In the future, additional surveys may be needed in areas where energy developments (i.e., oil, gas, and wind) occur or are proposed along major drainages or known migration routes and wintering areas. We hypothesize that in areas undergoing high levels of development along major river corridors, Bald Eagles could experience higher mortality rates, lower productivity, or loss of nest sites if adequate mitigation measures are not applied.

ACKNOWLEDGEMENTS

We greatly appreciate the efforts of the following individuals for providing data on nesting Bald Eagles in 2013: H. Obrien (Casper Region), D. Patla (volunteer), B. Bedrosian (Craighead Beringia South), E. Cole (National Elk Refuge), T. Koerner and B. Ahlers (Seedskadee NWR), W. Scherer and A. May (Grand Teton National Park), and B. Jones (Teton County). In addition, we wish to thank Dave Stinson of Sky Aviation who piloted the Bald Eagle nest surveys. We appreciate funding provided by the ACE (Walla Walla office) to help cover the cost for aerial surveys.

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Table 1. Summary of Bald Eagle (*Haliaeetus leucocephalus*) nesting data collected by the Nongame Section of Wyoming Game and Fish Department in Wyoming 2013. We present data by major drainages and geographic boundaries in Wyoming. [a] GYA Greater Yellowstone Area does not include data for 3 pairs in Lincoln County (Salt River) or data from Yellowstone National Park. [b] Aerial surveys from Green River Lakes to Fontenelle Dam; ground surveys on the Seedskadee National Wildlife Refuge. [c] Data only received from the Casper region. [d] Percentage of occupied territories checked for productivity that produced mature young. [e] Mature young is the number of fully feathered nestlings counted prior to fledging in June and July.

	Wyoming portion of GYA [a]	Green River [b]	Bear River	Salt River	Casper Region [c]	Statewide total
Territories checked for occupancy (*n*)	48	41	1	2	9	101
Territories occupied (*n*)	40	31	1	2	8	82
Percent of territories occupied	83%	80%	100%	100%	89%	83%
Territories surveyed for productivity (*n*)	38	19	0	2	8	67
Territories that produced young (*n*)	26	16		2	8	52
Percent of successful nests [d]	74%	84%		100%	100%	78%
Mature young produced [e] (*n*)	38	30		4	12	84
Mature young per successful nest ($\bar{x}$)	1.5	1.9		2.0	1.5	1.6

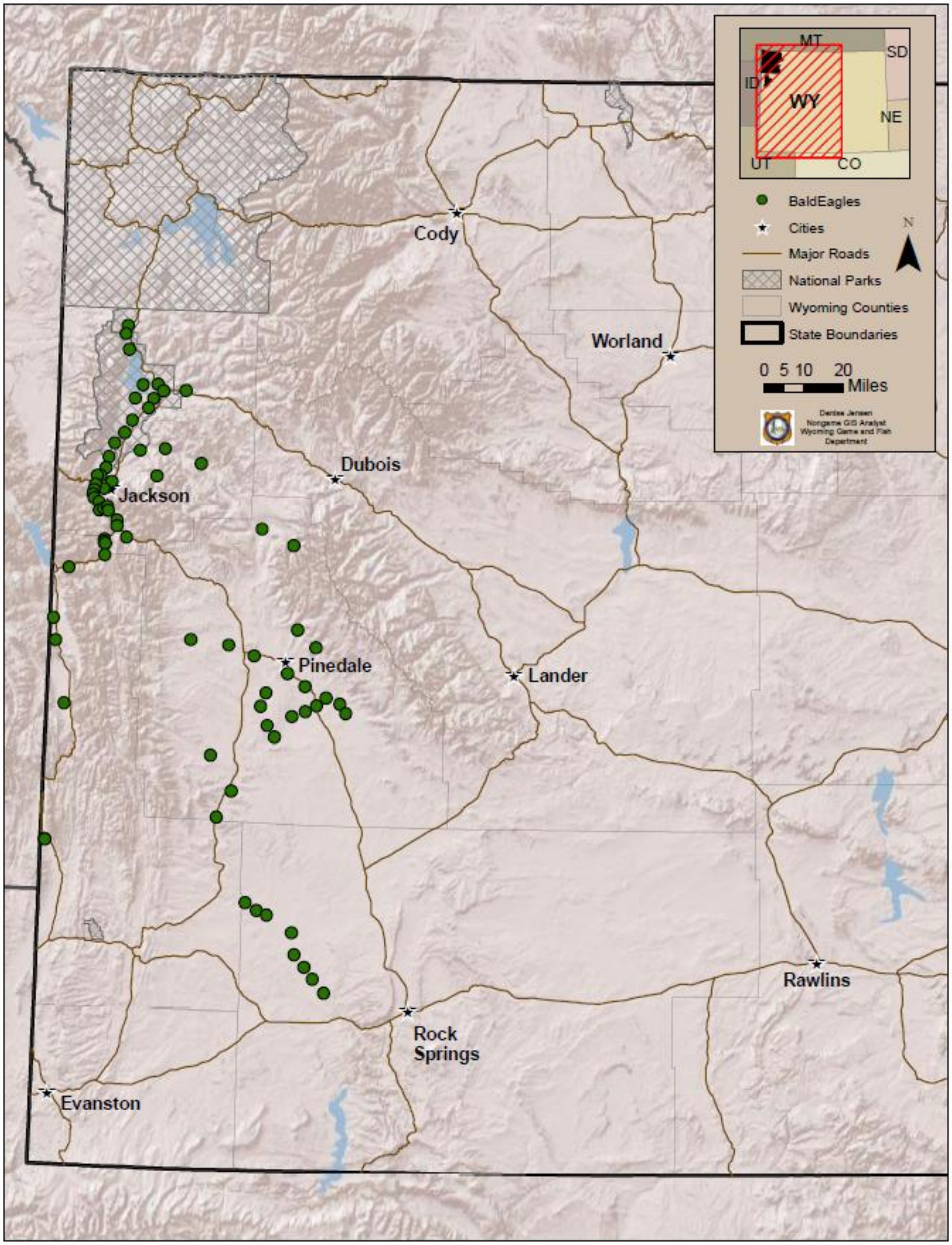

Figure 1. Map of Bald Eagle (*Haliaeetus leucocephalus*) nest sites occupied by nesting pairs monitored by the Wyoming Game and Fish Department in western Wyoming in 2013.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) AVOIDANCE OF NATURAL GAS INFRASTRUCTURE IN THE PINEDALE ANTICLINE PROJECT AREA

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

FUNDING SOURCE: Pinedale Anticline Project Area

PROJECT DURATION: January 2011 – November 2013

PERIOD COVERED: January 2011 – November 2013

PREPARED BY: Bryan Bedrosian, Craighead Beringia South
Ross Crandall, Craighead Beringia South
Susan Patla, Nongame Biologist

ABSTRACT

Activity and infrastructure related to oil and gas development in the western US has negatively influenced wildlife populations. In the anticline region of the Upper Green River Valley, natural gas development is continually increasing with the number of gas wells expected to double in the next decade. Negative impacts to species such as mule deer (*Odocoileus hemionus*) and Greater Sage-Grouse (*Centrocercus urophasianus*) are known but impacts to other species are less known and important to understanding the greater influence of this relatively new disturbance. We assessed movements made by five adult Bald Eagles (*Haliaeetus leucocephalus*) related to the infrastructure associated with natural gas extraction in and around the Pinedale Anticline Project Area. We found that migrant, over-wintering Bald Eagles avoided producing gas wells within the Pinedale Anticline Project Area. Additionally, one breeding eagle whose territory overlapped a natural gas field avoided producing well pads while raising young. Based on the location data, we found no evidence to suggest the other individuals breeding within our study area avoided producing well pads, but their breeding territories did not overlap the Pinedale Anticline Project Area or producing wells. To investigate whether Bald Eagles were choosing nest sites away from producing gas wells, we also tested nest-site selection relative to distance to producing wells. We found no evidence that Bald Eagles in and around the Pinedale Anticline Project Area were avoiding producing gas wells when choosing nest sites. Therefore, the lack of producing wells within two of the three nesting territories was unlikely due to eagles choosing territories away from natural gas infrastructure but likely a result of where the birds were captured. While nest sites may not be chosen based on proximity to wells, our results suggest when Bald Eagles are within an active gas field, they may avoid producing well pads. It is very important to note that our results and conclusions are limited due to small sample sizes. Our results are complicated by the apparent selection for proximity to producing well pads in the

remainder of our analyses. It is unclear whether these results indicate actual selection for proximity to well pads or whether the birds move about the landscape regardless of natural gas infrastructure despite model support for proximity to well pads. We assume the latter, since it is unlikely Bald Eagles would be receiving any benefits by being close to producing well pads and the fact that we found support for both attraction and avoidance. Regardless, our results suggest the possibility does exist for negative influences of natural gas development on Bald Eagles, particularly if the well pads are located within the areas of high use within a territory (e.g., riparian areas). To minimize the potential for negative impacts in the future, we recommend new gas wells be placed away from riparian areas, which are critical for the breeding and migratory segments of the population.

INTRODUCTION

The anticline region of the Green River Valley has been and will continue to receive high development pressure from energy extraction practices and the resulting infrastructure. As such, there is concern for sensitive wildlife species in this area, such as ungulates (Sawyer et al. 2009), Greater Sage-Grouse (*Centrocercus urophasianus*; Holloran et al. 2010), and Bald Eagles (*Haliaeetus luecocephalus)* due to anthropogenic changes including habitat alteration, loss, and increased disturbance levels. With >8,500 gas wells already drilled in the Green River Valley and an additional 10,000-15,000 forecasted over the next decade, the rate of anthropogenic change to this area will only increase. Although the physical footprint of oil and gas infrastructure comprises only a small portion of the valley, recent research has shown that the effects of this infrastructure on native wildlife species can be extensive (e.g., Holloran et al. 2010). Human modification and increased presence in the valley, especially in riparian corridors, may influence a variety of sensitive species. Listed as a Level I Priority Bird Species in Wyoming, the Bald Eagle remains sensitive to disturbance not only at nest sites but also at quality foraging areas year-round (Grubb and King 1991, Steidl and Anthony 2000). Reduction and mitigation of disturbance at both eagle nesting and annual use areas need to be a high priority for wildlife managers in the region. However, identifying critical annual Bald Eagle habitat is the first step in the process to understand what, if any, mitigation efforts are needed and what will be successful. By assessing landscape level habitat use of Bald Eagles using the Green River Valley, managers will be in a much better situation to promote the conservation of eagles, recommend mitigation of current developments, and help provide for sustainable development both in this region and elsewhere in the western US where a variety of energy development projects are being planned.

The main objective of this study is to investigate landscape habitat use of Bald Eagles in the Upper Green and New Fork River area near the Pinedale Anticline Project Area (PAPA) and examine the potential relationships of eagle habitat use, distribution, nest success, and mortality with the degree of anthropogenic landscape features associated with energy development. We investigated roost locations of breeding eagles near the project area, described migration habits of eagles wintering in this area, and investigated potential avoidance of wells within territories and across the study area.

METHODS

The primary study area consisted of the PAPA natural gas extraction field near Pinedale (Appendix A). The area encompasses roughly 80,100 ha, although we extended the boundaries of our study area slightly to account for the movements of the Bald Eagles. Within our extended study area, there were approximately 6,100 active well pads. Habitat types are primarily sagebrush (*Aretmisia* spp.) and grassland with the exception of the riparian areas, which are dominated by cottonwoods (*Populus* spp.). The Green River and the New Fork River were the primary waterways with eagle nests in close proximity. Bald Eagles on the study area primarily hunt for fish in the rivers, although we did notice during periods of high runoff, when the water was not conducive to fishing, adults appeared to rely primarily on terrestrial prey (pers. obs.) found near the riparian areas. Eagles utilize carrion during the winter months to augment live prey, and a large number of migrants also utilize the PAPA during the winter months, typically feeding on carrion during that time.

All captures were completed from January 2011 through the breeding season of 2012. We trapped adults either during the breeding season or by targeting locations near known nest sites in the pre-breeding season. During the breeding season, we used a floating fish snare (Cain and Hodges 1989) to capture adults. We floated stretches of both the New Fork and the Green Rivers with known Bald Eagle nests. When we approached a known nest site, we waited to see a perched adult, at which time we would deploy the floating fish snare. When a bird was captured, we immediately would gain control of the bird to minimize stress and the potential for injury. During the pre-breeding season, we trapped in known territories with road-killed ungulate carcasses and net launchers (Trapping Innovations, LLC, Kelly, WY, USA). We used behavioral clues (e.g., aggression or calling) to help determine if the target eagle was potentially a territorial breeder and fired the net launcher when the target bird was on the bait. Once an eagle was captured, we outfitted it with a 70-g solar-powered GPS/PTT transmitter (Microwave Telemetry, Columbia, MD, USA). The transmitters gathered approximately 15 relocation points per day for the life of the transmitter (ca. 2 years). All transmitters saved a location at midnight so we could assess potential avoidance of well pads during roosting. Transmitters were attached using a backpack style harness (Bedrosian and Craighead 2007). Data used for this report were gathered from the time of capture through November 2013.

To evaluate whether Bald Eagles were avoiding oil and gas development in the study area, we used a resource selection function (RSF) framework (Manly et al. 2002). We assessed the probability of use for all tracked individuals relative to a few basic covariates, including distance to producing well pads, by season. To assess probability of use, we first projected random points within the study area to represent unused, available locations. To define the boundaries of the area to project unused, available locations, we used 95% Kernel Density Estimators (KDE) estimated using locations from each bird that were within our extended study area for each year the bird was tracked. We used KDEs instead of Minimum Convex Polygons (MCP) due to the linear use of the landscape, specifically the rivers, by Bald Eagles. Upon visual observation of both home-range estimators, we determined the KDEs better represented seasonal territories than the MCPs. We used the adehabitatHR package in R (R Core Team 2013) to estimated KDEs. We projected an equal number of random points within each KDE that were used to build the KDE. Each randomly projected point within the KDEs represented unused, available locations. During the non-breeding season, we used any location from migrant eagles when they were in the study area to build KDEs. We only had enough locations for the two migratory Bald Eagles from the two non-breeding seasons during this study to build KDEs. We also clipped the KDE's from the non-breeding season to the PAPA boundary to test whether eagles were avoiding active well pads within the PAPA only. Once KDEs were clipped, we projected the same number of random number locations as there were used locations within the PAPA for each bird. There were only non-breeding season locations within the PAPA, and there were not enough roost points (n = 10) to test for avoidance of producing well pads within the PAPA during the non-breeding season for the migrants.

We projected random points within potential roosting habitat (i.e., trees) to define unused, available roost locations. We defined roosting habitat based on locations of roosts in riparian areas. We used a 30-m resolution Gap Analysis land cover layer and extracted the land-cover types that matched potential roost locations and used our new layer to randomly project available roosting habitat. We used the KDEs to clip the roost habitat layer to limit the amount of available habitat to actual territories for each individual. We projected an equal number of unused, available locations as there were for roost locations in each KDE for each year the eagle was tracked.

Our main question was whether Bald Eagles were avoiding producing gas wells, so we minimized the covariates we used to those that were critical to the models. Based on visual observation of the relocation information, we determined it would be essential to include a distance to water covariate to account for proximity to hunting areas and included this covariate in all models. Our next covariate, distance to nest, we only used for the breeding season analysis. We used distance to nest to account for central place foraging (Rosenberg and McKelvey 1999, Irwin et al. 2007), which is occurring by both adults when they come back to the nest to feed the young. The last covariate we used was distance to producing well pad. The Pinedale District BLM office provided us with the most current locations of all well pads within their region. We measured distance from producing well sites to each used and available location. Only wells that were producing during the study period were used. We assumed that the disturbance related to non-producing sites was minimal compared to producing sites. To estimate distances, we measured Euclidean distance using Spatial Analyst in ArcGIS 10.0 (ESRI Inc., Redlands, CA, USA).

We were also interested in determining whether Bald Eagles in and around the PAPA were avoiding producing well pads when choosing their nest sites. We followed methods we used for assessing avoidance by individuals where we had used nest sites and projected unused but potentially available nest sites. We used nest sites found by Wyoming Game and Fish Department and Hayden-Wing Associates by aerial surveys. The nests we used for this analysis were occupied during the study period. All occupied nests were ≤250 m from water and in riparian habitat. The average distance between nests was 7,175 m. We limited our projected, available nesting habitat to riparian areas ≤250 m from the rivers' edge and ≥3,588 m from the nearest occupied nest and other unused, available sites. The distance chosen, 3,588 m, is ½ the nearest neighbor distance, which we used to account for the territorial nature of Bald Eagles. We projected 10 random sites within habitat in and around the PAPA that fit these criteria.

We tested the influence of five covariates on the probability of nest-site selection by Bald Eagles. These were variables that have been shown to influence selection of nest sites by Bald Eagles in other parts of their range. The covariates included distance from nest site to road, total linear distance of roads within the territory, mean anthropogenic disturbance in the territory, total linear distance of river within the territory, and distance to producing well pads. The anthropogenic disturbance covariate was taken from a GIS layer produced by the Wyoming Game and Fish Department and accessed through the Wyoming GeoLibrary. The level of disturbance was based on a scale from 0 to 100, with 100 representing high anthropogenic disturbance, for each pixel in a 30-m resolution raster layer. The value for each pixel was based on weighted distance of the impact of various anthropogenic disturbances. We used a 1.8-km radius circle to delineate territories, which prevented overlap between all used and available territories and is near the upper end of the secondary management zone for the species (USFWS 1987). There were not enough producing well pads within the buffers to justify using total producing well pads as a covariate in our models.

We used logistic regression in a generalized linear model (GLM) and generalized linear mixed model (GLMM) framework test to the ability of our covariates to explain the probability of use on the landscape by Bald Eagles. When only a single bird was involved, we used GLM. When multiple birds were involved, we used a random intercept in a GLMM for each individual to account for unequal number of relocation points (Gillies et al. 2006). We split the analysis up into 4 major sections: 1) non-breeding season, 2) breeding season, 3) breeding season and roost, and 4) non-breeding season and roost. To test the importance of our distance to well covariate, we used a likelihood ratio test (LRT) to compare the fit of a full model containing the distance to well pad covariate to a reduced model containing all covariates except distance to well pad. We used a threshold of $P = 0.05$ to determine the importance of the distance to well pad covariate. The full models for the breeding season analysis included:

Pr(Use) = Distance to Water + Distance to Nest + Distance to Producing Well Pad

The full model for the non-breeding season included:

Pr(Use) = Distance to Water + Distance to Producing Well Pad

All covariates were screened for collinearity prior to the model building process by using Pearson's correlation coefficient with a threshold of $|r| > 0.6$ for assessing correlations. No covariates were correlated, so all were used. All covariates were scaled to improve model convergence. We used R statistical software (R Core Team 2013) to perform all analyses.

We had three birds with transmitters that attempted to breed within the study area. Two of the three eagles breeding territories, 108502 and 108503, did not overlap with any natural gas infrastructure, which was central to our question. These same two birds' non-breeding season territories also did not overlap any natural gas infrastructure. We assumed these locations were not a result of the birds avoiding natural gas extraction for their territories since other Bald Eagle nests and territories were much closer to producing wells (Appendix B). Instead, we believe the locations of our tracked birds were a result of where we were able to capture eagles within the study area. The territory of the one remaining eagle, 108501, overlapped with a gas field to the west of the PAPA. To test the influence of proximity to well site accounting for major differences in number of wells within territories, we combined all breeding eagles together and used a GLMM, and we also separated eagle 108501 from the other two eagles and conducted a separate analysis. In addition, 108501 did not breed the second year we tracked that individual. In the second year, since that eagle did not have to feed young, we assumed he was likely to use the territory in a different way than if he had young. We also assumed, since it was breeding season, he was likely going to use the landscape differently than during the non-breeding season. We separated the locations for 108501 during the 2013 breeding season and conducted a separate analysis for that bird during that season. We did not include 108501 in the PAPA-only analysis either, since this bird was in a different natural gas extraction field.

To assess potential avoidance within the PAPA during the non-breeding season, we did not have enough locations for each individual to estimate variance, which prevented us from using a random effect, so we used GLMs.

We used GLMs to test the probability of Bald Eagles using a nest site with backwards, stepwise model selection to pick the top model. We used Akaike Information Criteria adjusted for small sample size (AIC*c*) to test the influence of each covariate on the probability of nest-site use by Bald Eagles. We used more covariates in the nest-site selection analysis, since there is ample information on nest-site selection by Bald Eagles. We determined the importance of distance to producing well pad on nest-site selection based on whether it was in the top model.

RESULTS

We captured and tracked a total of six Bald Eagles during the study period. One of the six eagles was a juvenile hatched within the study area. This individual was not included in the analysis, because it left the study area shortly after fledging, and its transmitter stopped working shortly thereafter. It is unknown if this individual died or it transmitter failed. Two of the five adult eagles captured during this study left the study area after wintering within and around the PAPA and bred in Northern Canada (Appendix B). During the non-breeding season, we had an average of 1,676 (SD = 1262) relocation points per bird per year. Only one bird was tracked for two consecutive non-breeding seasons within the PAPA. We tracked two of the three breeding adults for two years (2012-2013). The third breeder died of renal gout within his territory early during the second breeding season. Average KDEs during the non-breeding season were 46,280 ha (SD = 32,643) and average KDEs during the breeding season were 7,830 ha (SD = 5,195).

For the entire extended study area, we used 7,280 locations from 5 individuals to test for avoidance of producing well pads. The distance to well pad covariate significantly improved model fit ($\chi^2 = 14.54$, $P < 0.001$), but the relationship between distance to well pad and probability of use was negative ($\beta = -0.12$, $Z = -3.88$, $P < 0.001$), suggesting selection for proximity to producing well pads. Bald Eagles also selected locations closer to water ($\beta = -1.00$, $Z = -38.18$, $P < 0.001$). We used 442 roost locations from 5 individuals during the non-breeding season to test for avoidance of producing well pads for roost sites. Roost selection followed an identical pattern with distance to well pad significantly improving model fit ($\chi^2 = 50.59$, $P <$

0.001) and eagles selecting areas closer to well pads (β = -1.01, Z = -7.51, P < 0.001) and closer to water (β = -0.83, Z = -7.45, P < 0.001).

Within the PAPA only, we gathered a total of 387 locations from 4 individuals. Two individuals only had one location each within the PAPA. For Bald Eagle habitat use within the PAPA, the distance to well pad covariate significantly improved model fit (χ^2 = 25.42, P < 0.001). Bald Eagles selected areas closer to water (β = -1.19, Z = -10.36, P < 0.001) and avoided producing well pads (β = 0.44, Z = 4.97, P < 0.001).

We used 2,766 locations from individual 108501 during the non-breeding season to test whether this individual appeared to be avoiding producing well sites. This was the only individual of the local breeding population that had a territory overlapping producing well pads. The distance to producing well pad covariate significantly improved model fit (χ^2 = 68.70, P < 0.001). Results suggested this individual selected locations closer to producing well pads (β = -0.27, Z = -8.159, P < 0.001) and closer to water (β = -1.08, Z = -22.85, P < 0.001). We used 3,694 locations from the other two individuals, 108502 and 108503, to test whether they were avoiding producing well pads despite no active pads being located within their territory. We found the distance to producing well pad did not significantly improve model fit (χ^2 = 3.13, P = 0.077). We used 174 roost sites from individual 108501 to test for avoidance of producing well pads and found the distance to producing pad significantly improved model fit (χ^2 = 50.53, P < 0.001). The bird appeared to select roost sites closer to producing well pads (β = -1.00, Z = -5.90, P < 0.001) and closer to water (β = -0.25, Z = -1.64, P = 0.10). The distance to well pad covariate also significantly improved model fit for the other two individuals (χ^2 = 5.57, P = 0.018). They also chose roost sites closer to producing well pads (β = -0.28, Z = -2.34, P = 0.019) and closer to water (β = -1.02, Z = -4.81, P < 0.001).

During the 2013 breeding season, when eagle 108501 did not breed, we used 2,778 locations to test whether this individual avoided producing well pads. The distance to well pad covariate greatly improved model fit (χ^2 = 82.92, P < 0.001) and this individual selected areas closer to producing well pads (β = -0.21, Z = -9.005, P < 0.001) and closer to water (β = -1.04, Z = -29.52, P < 0.001). We used 182 locations to test for avoidance of producing well pads relative to selected roost sites for 108501 as well. The distance to well pad covariate again significantly improved model fit (χ^2 = 57.18, P < 0.001) and this individual selected areas closer to producing well pads (β = -1.50, Z = -6.03, P < 0.001) and closer to water (β = -1.36, Z = -5.66, P < 0.001).

During the breeding season, we used 8,103 locations from 3 individuals to test for avoidance of producing well pads. The distance to well pad covariate greatly improved model fit (χ^2 = 45.02, P < 0.001), and there appeared to be avoidance of producing well pads (β = 0.29, Z = 6.77, P < 0.001). Bald Eagles also selected areas closer to water (β = -0.76, Z = -22.56, P < 0.001) and closer to their nests (β = -0.78, Z = -27.65, P < 0.001).

For eagle 108501, we used 3,172 locations to test for avoidance of producing well pads during the 2012 breeding season. The distance to well pad covariate significantly improved model fit (χ^2 = 75.11, P < 0.001) and this individual appeared to be avoiding natural gas infrastructure (β = 0.34, Z = 8.57, P < 0.001). The distance to well pad covariate did not significantly improve model fit when considering the other two birds with territories that did not overlap producing well pads ($\chi^2 = 2.78$, $P = 0.10$).

Breeding season roost-site selection showed the same pattern as the non-breeding season selection, where distance to well pad significantly improved model fit ($\chi^2 = 17.88$, $P < 0.001$). Bald Eagles appeared to select areas closer to producing well pads ($\beta = -0.89$, $Z = -4.48$, $P < 0.001$). Bald Eagles also selected roosts closer to their nests ($\beta = -2.82$, $Z = -12.17$, $P < 0.001$), and they selected areas close to water ($\beta = -2.11$, $Z = -5.36$, $P < 0.001$).

For roost locations chosen by eagle 108501 only, the distance to well pad covariate significantly improved model fit ($\chi^2 = 8.44$, $P = 0.004$). This individual selected locations closer to producing well pads ($\beta = -1.36$, $Z = -2.77$, $P = 0.007$) and closer to its nest ($\beta = -2.11$, $Z = -5.78$, $P < 0.001$). There was also support for the distance to water covariate ($\beta = -0.27$, $Z = -0.34$, $P = 0.73$).

Results of the LRT describing roost site selection for Eagles 108502 and 108503 suggested the distance to producing well pad covariate significantly improved model fit ($\chi^2 = 14.90$, $P < 0.001$). These two eagles selected roost sites closer to producing well pads ($\beta = -0.52$, $Z = -3.94$, $P < 0.001$), closer to water ($\beta = -2.40$, $Z = -4.99$, $P < 0.001$), and closer to their nest ($\beta = -1.47$, $Z = -9.22$, $P < 0.001$). These results are summarized in Appendices C and D.

We used 10 nest sites in and around the PAPA to test the influence of natural gas extraction on nest site-selection. The top model was the intercept only model, suggesting none of the covariates that we chose had any ability to predict nest-site use by Bald Eagles in our study area.

DISCUSSION

Several of our analyses found evidence to suggest that Bald Eagles were avoiding disturbance associated with natural gas extraction, including non-breeding use within the PAPA, use by all eagles combined during the breeding season, and eagle 108501 during the 2012 breeding season. The remainder of our results suggested that Bald Eagles were choosing areas closer to producing wells. The territories of tracked adults are an important confounding issue that must be addressed before interpreting these results. Our primary objective was to determine if Bald Eagles were avoiding natural gas infrastructure, specifically while within the PAPA. Unfortunately, all of the Bald Eagles captured for this study had nesting territories outside the boundaries of the PAPA. All pre-breeding season captures were within the PAPA, but we also captured two breeders adjacent to the PAPA on the Green River, because territory sizes and wintering movements were unknown at the time. Through the course of the study, we learned that movements of the local, breeding birds were centered near the river, with a little expansion of the territory during the non-breeding season, allowing little to no territory overlap from two of our study animals with the PAPA. One breeder (108501) did have a territory that overlapped with natural gas wells, and we were able model his territorial movements in relation to wells, although our effective sample size regarding this question is one. The subsequent question we investigated relative to breeding eagles was then larger in scale. Instead of focusing on if eagles were avoiding infrastructure while in the PAPA, we investigated whether they were simply avoiding the entire PAPA in where they chose to put their nest sites. This seemed unlikely since Bald Eagle nests distributed evenly throughout the riparian areas within the PAPA and our analysis of nest site selection by Bald Eagles in this study area further support the apparent lack of avoidance of the PAPA for nesting.

We included multiple analyses within this report since the data were available, but the most interesting results are from eagle 108501. Individual 108501 was the only eagle that we tracked for this study that had its territory include producing well pads, although this individual was outside of the PAPA. Although our results including all three breeders indicated avoidance of producing gas wells during the breeding season, the territories of eagles 108502 and 108503 did not overlap any active gas wells, making this result misleading. When we excluded 108501 from the combined analysis, it was clear that neither 108502 nor 108503 exhibited avoidance behavior of gas wells. This result is expected since neither eagle had producing wells within their territories. Further, data from 108501 are not clear even when analyzed separately. This eagle did show avoidance of wells during the 2012 breeding season, when he had chicks. However, in 2013 and other analyses including roosting locations, he showed no signs of avoidance of wells. We interpret these results as either seasonal avoidance of producing well pads by this individual or, despite the model support for the distance to producing well pad covariate, this individual was not avoiding or selecting for proximity to producing well pads and other covariates not explored better define space use by breeding eagles. If the latter was true, our results may be a function of defining availability in the RSF framework and support the need for a larger sample size. We do not believe the producing well pads were providing any incentive for the eagle that is driving selection for proximity. It is possible food sources such as road-kill could be a potential benefit for the birds caused by the activity associated with natural gas extraction, but it seems doubtful there is enough road kill to be driving selection for producing well pads. Further, Bald Eagles typically do not rely on road-kill for prey during the breeding months. With conflicting selection and avoidance results, we are unable to derive any strong conclusions from this individual but certainly do not discount the possibility he may have been avoiding producing well pads during the 2012 breeding season when he was tending an active nest.

At the within-PAPA analysis, we did find evidence to suggest the eagles were avoiding natural gas infrastructure during the non-breeding season. These results are likely the most important and clear-cut of our analysis. These results are primarily based on locations from 2 individuals and only include 387 of 18,161 total locations used for our analyses. Therefore, we cannot expand inference to the population level due to low sample size. While sample size limits population-based conclusions, our results do indicate that the individuals we studied are avoiding producing well pads within the PAPA during the winter. Most producing well pads within the PAPA are located in a strip near the center of project area, and most eagle locations are near riparian areas. Our results from the local breeders indicate that nesting birds remain on territory year-round and include the majority of riparian areas. Eagles are highly territorial, and it is likely that residents defend their territories from wintering eagles, essentially excluding them from riparian areas. Migratory birds are more likely to wander larger areas in search of resources and are more likely to encounter producing well pads. This behavior is supported by the wintering locations of migrants versus adults (Appendix B). These eagles are likely more affected by potential disturbance related to extraction practices, which is supported by our models.

Despite the conflicting results of our analysis, we showed Bald Eagles may be avoiding producing gas wells in the PAPA, particularly during the winter months. Before prioritizing management actions for Bald Eagles, we suggest it is necessary to have a better understanding habitat-use by migratory eagles utilizing the PAPA, the non-migratory breeding population within the PAPA, and their potential interaction. Based on the home ranges and territory sizes we measured for breeding eagles on the Green River and South Piney Creek, it is likely that only three of the nests within and surrounding the PAPA are host to eagles whose territory includes active natural gas wells. Breeding eagles limit their movements typically to riparian corridors and other wetlands, limiting their potential interaction with disturbance from wells, which are typically in sagebrush communities. However, overwintering eagles have a more widespread distribution and habitat use, likely due to competition with breeding adults and a greater reliance on carrion, which places them more often in sagebrush steppe. This habitat partitioning may lead to a higher likelihood that wintering eagles utilize the PAPA, which is evidenced by the greater avoidance of producing wells by wintering eagles compared to breeders. There may be slight wintering habitat loss within the PAPA but use of non-riparian areas is typically limited by eagles where the majority of development occurs. However, eagles winter ranges are so extensive that limits to winter range within the PAPA likely have little influence on the over-winter survival of Bald Eagles.

One eagle we tracked whose home range overlaps significant development in the Big Piney oil field did show avoidance of well sites while raising young, indicating that there may be a negative interaction between well sites and eagle productivity. Integrating movements of eagles with territories overlapping producing wells with productivity data from these and other surrounding nests would provide a more comprehensive approach to assessing the influence of natural gas extraction on Bald Eagles. Regardless, we suggest limiting the construction of new wells close to riparian areas would reduce the possibility of negatively influencing Bald Eagles due to the heavy use of these habitats by eagles tracked for this study.

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Appendix A. Study area maps from Bald Eagle (*Haliaeetus leucocephalus*) surveys in western Wyoming, 2011-2013, including the study area and all locations for captures and nests.

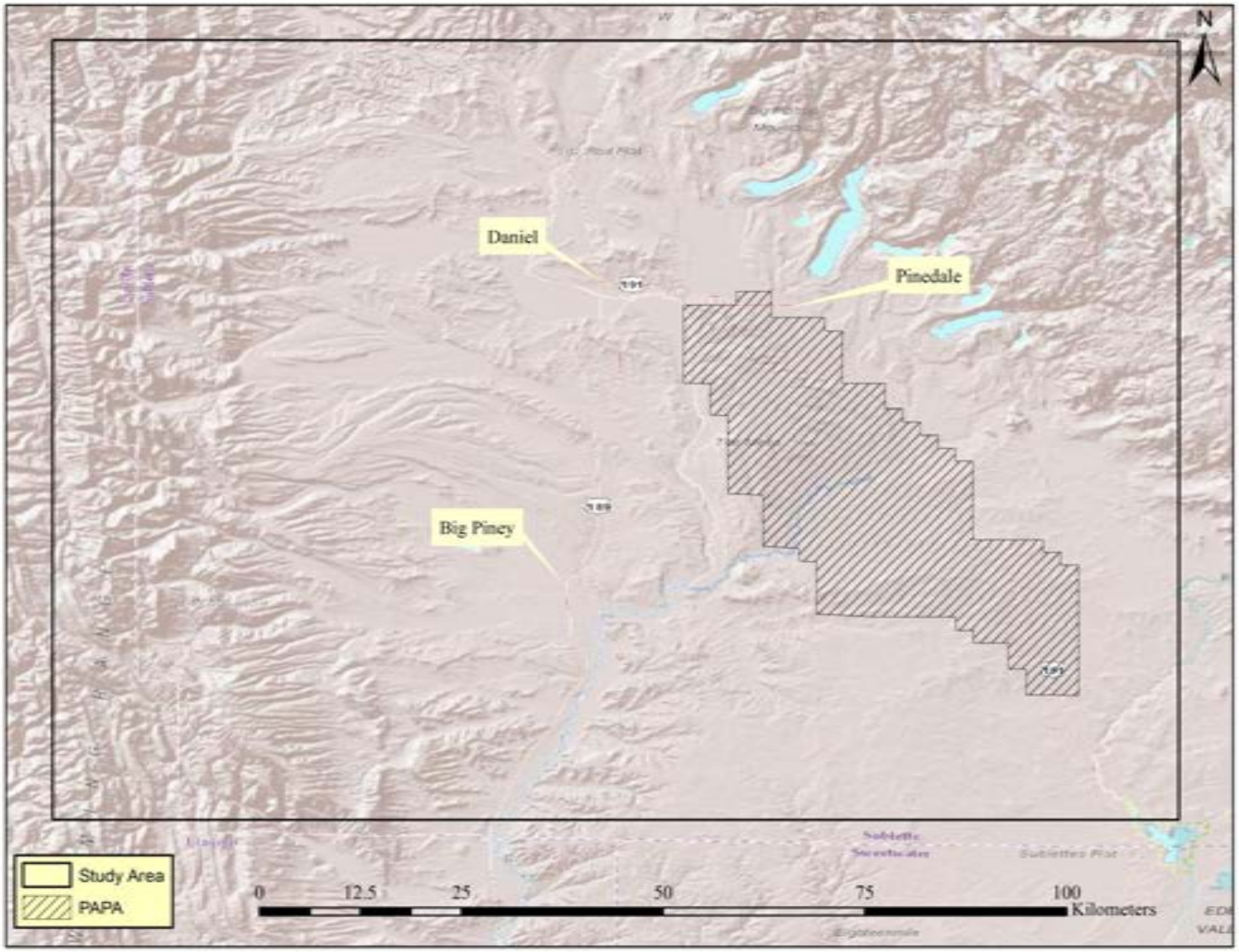

Figure A.1. Study area including the Pinedale Anticline Project Area (PAPA).

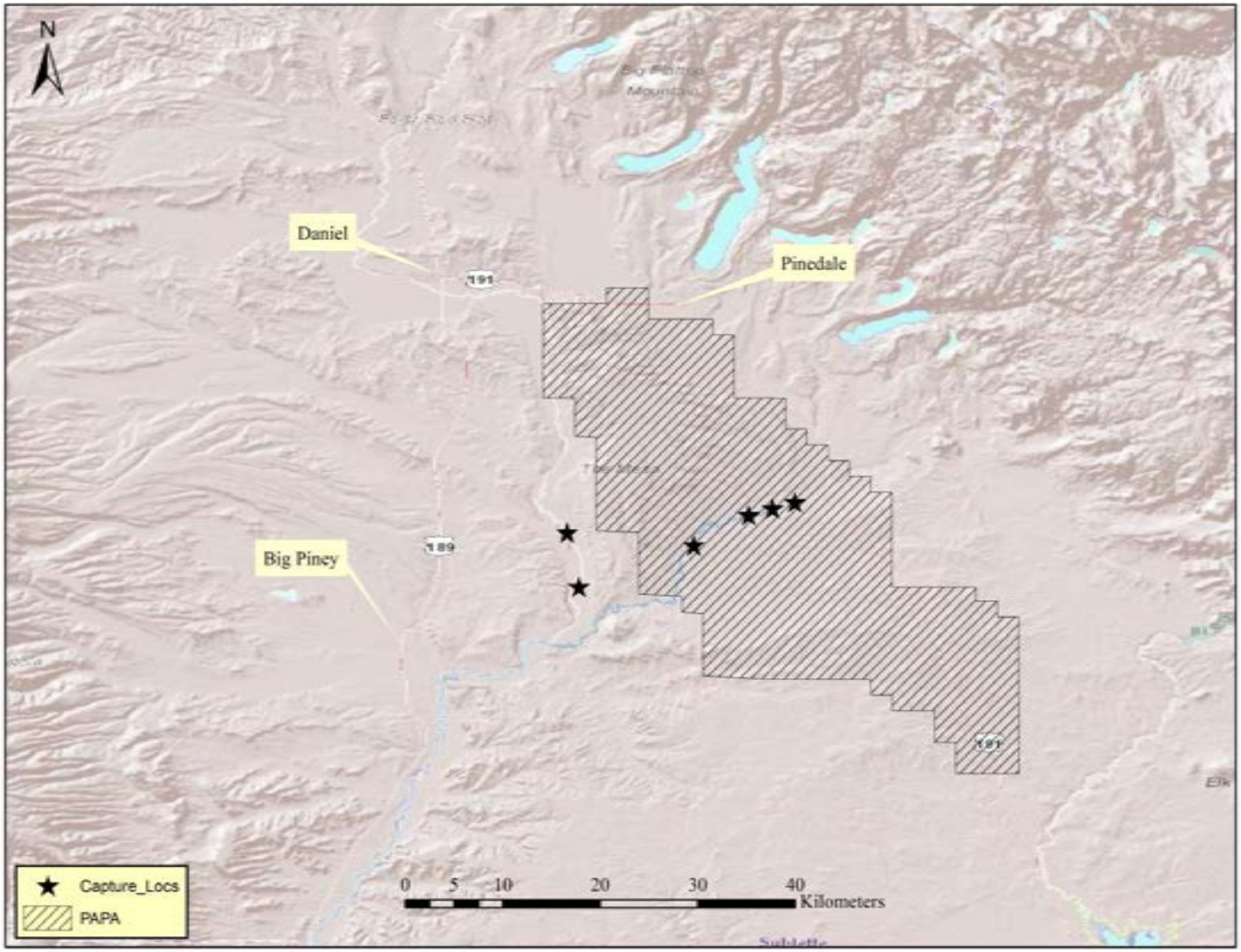

Figure A.2. Locations of captures of Bald Eagles (*Haliaeetus leucocephalus*).

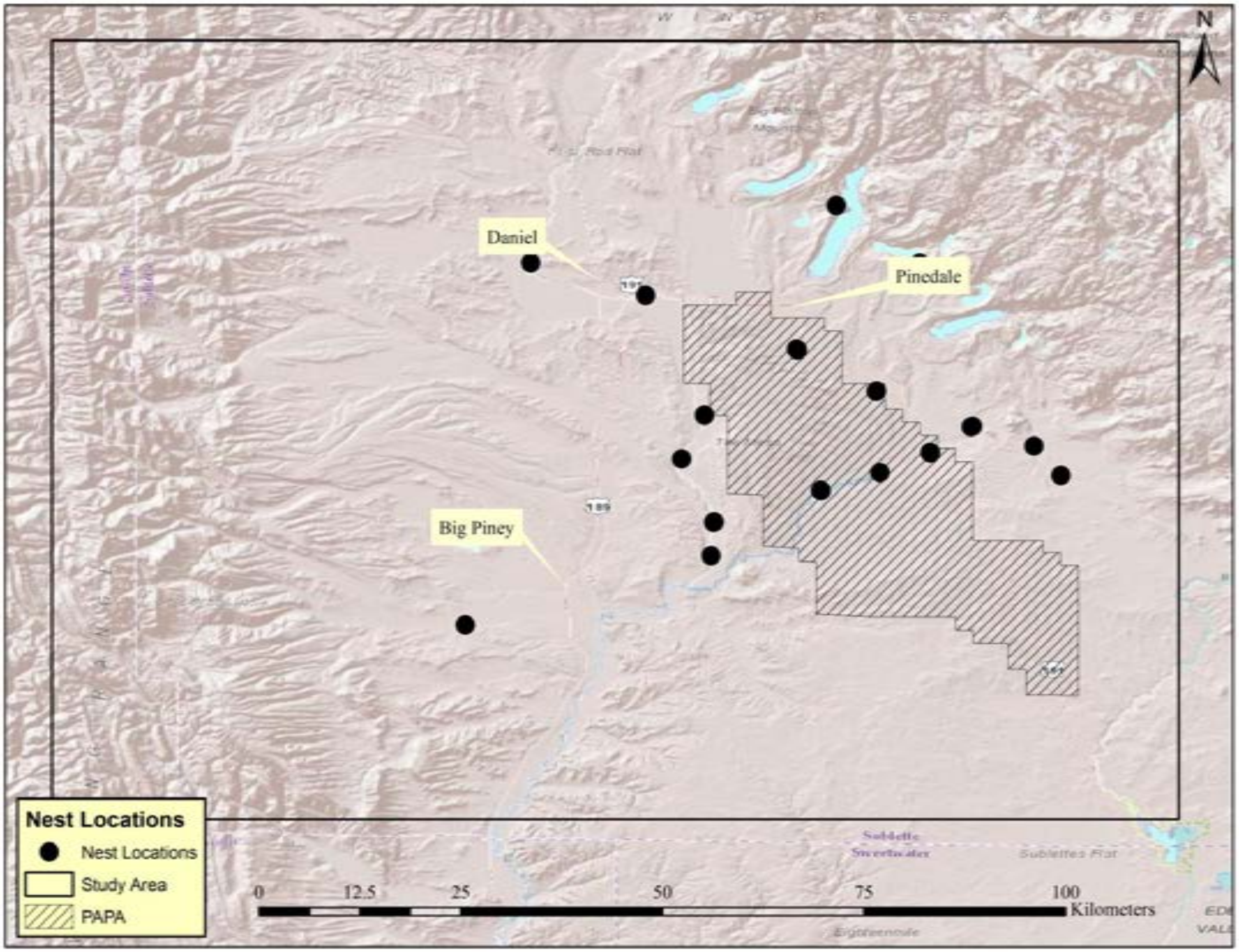

Figure A.3. All known Bald Eagle (*Haliaeetus leucocephalus*) nest locations.

Appendix B. Capture information and locations and movements of Bald Eagle (*Haliaeetus leucocephalus*) in western Wyoming, 2011-2013.

Table B.1. Information on each captured Bald Eagle (*Haliaeetus leucocephalus*).

ID	Sex	Capture Date	Date Start	Date End	Season	Number of Non-Roost Locations	Number of Roost Locations	Number of Locations PAPA	95% KDE (ha) Breeding	95% KDE (ha) Non-Breeding
108499	Male	1/12/2012	12/8/2012	1/9/2013	Non-Breeding	155	8	45	-	58603
108500	Male	1/20/2012	12/1/2012	2/26/2013[a]	Non-Breeding	665	39	340	-	89065
108501	Male	1/22/2012	2/15/2012[b]	8/15/2012	Breeding	3172	196	-	14174	-
108501			8/16/2012	2/14/2013	Non-Breeding	2766	164	-	-	16646
180501			2/15/2013[c]	8/14/2013	Breeding	2778	182	-	-	14503
108502	Male	6/6/2012	7/12/2012	8/14/2012	Breeding	544	12	-	5880	-
108502			8/15/2012	2/14/2013	Non-Breeding	806	52	1	-	56737
108502			2/15/2013	4/29/2013[d]	Breeding	1057	86	-	5674	-
108503	Male	7/11/2012	7/12/2012	8/14/2012	Breeding	532	40	-	2366	-
108503			8/15/2012	2/14/2013	Non-Breeding	2888	179	1	-	10360
108503			2/15/2013	8/14/2013	Breeding	2798	170	-	4385	-
					Total	**18161**	**1128**	**387**	-	-
					Average	**1651.0**	**102.5**	**96.8**	**6495.8**	**37462.2**
					S.D.	**1201.1**	**75.6**	**163.5**	**4514.4**	**31943.0**

[a] = Not enough locations within the study area during 2011 to use for this analysis.
[b] = Did not use non-breeding season locations from 2012 due to short duration to breeding season.
[c] = Did not breed in 2013, therefore we considered it non-breeding during the breeding season.
[d] = Bird died during breeding season.

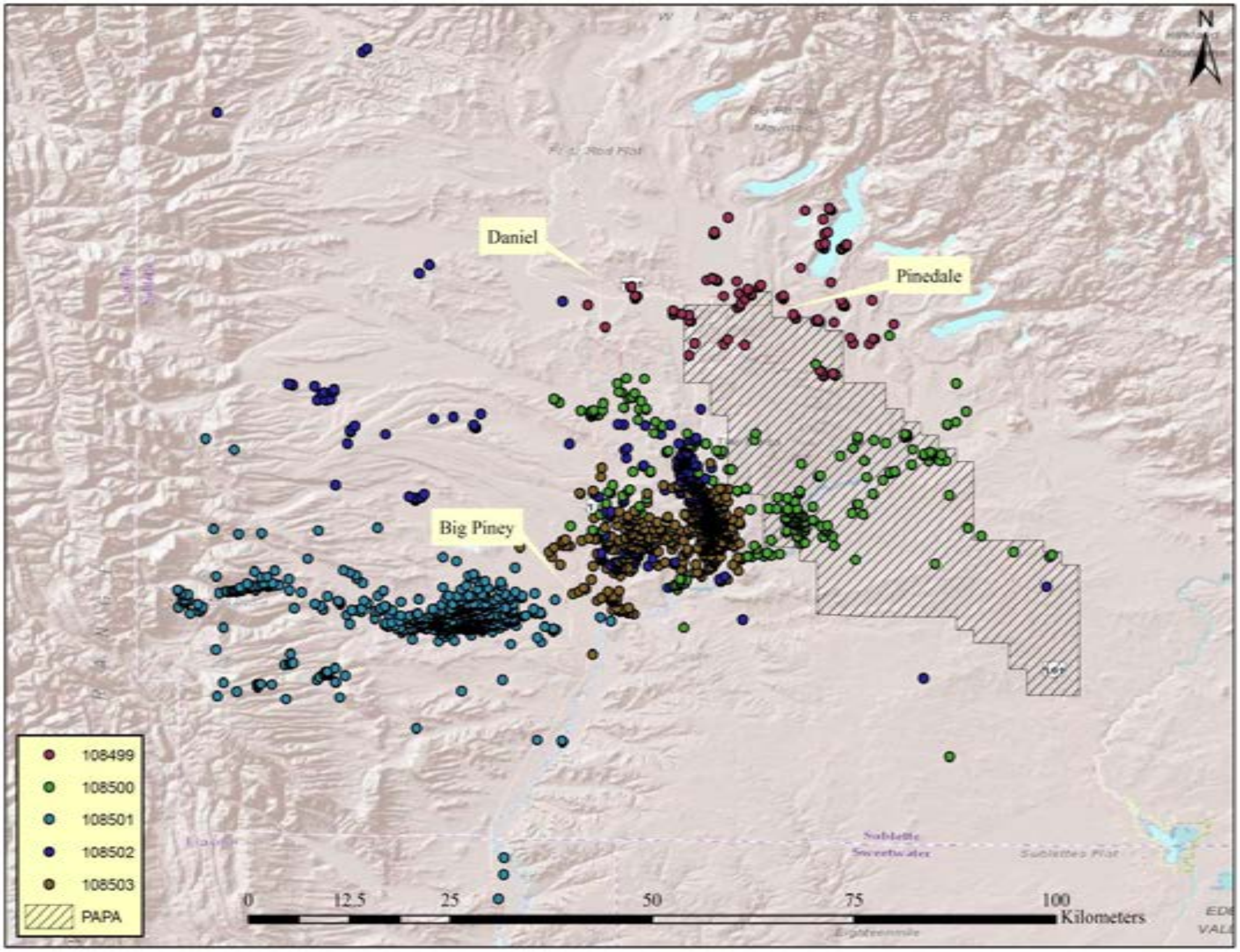

Figure B.1. Non-breeding season movements from all marked Bald Eagles (*Haliaeetus leucocephalus*).

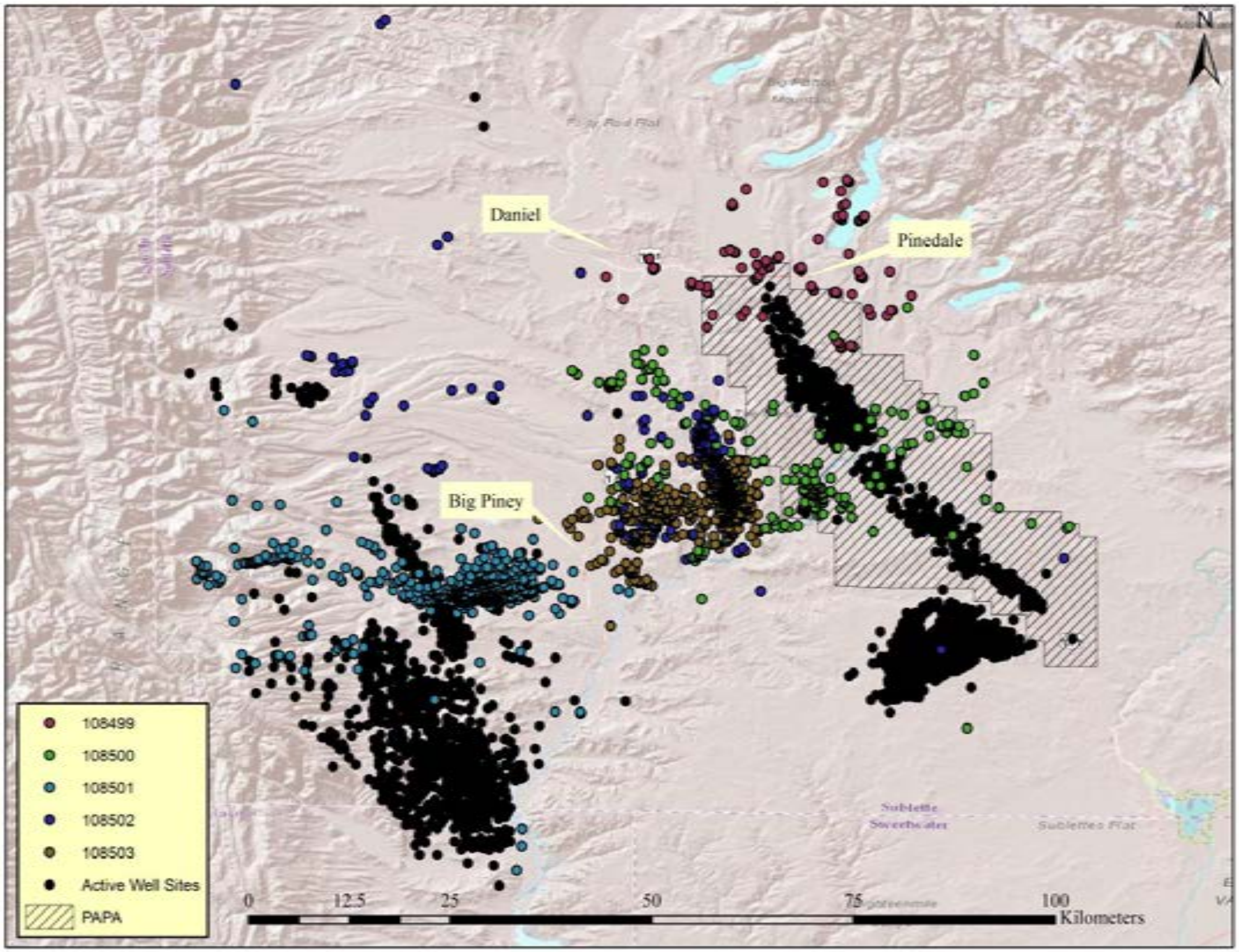

Figure B.2. Non-breeding season movements of Bald Eagles (*Haliaeetus leucocephalus*) overlaid with active well sites.

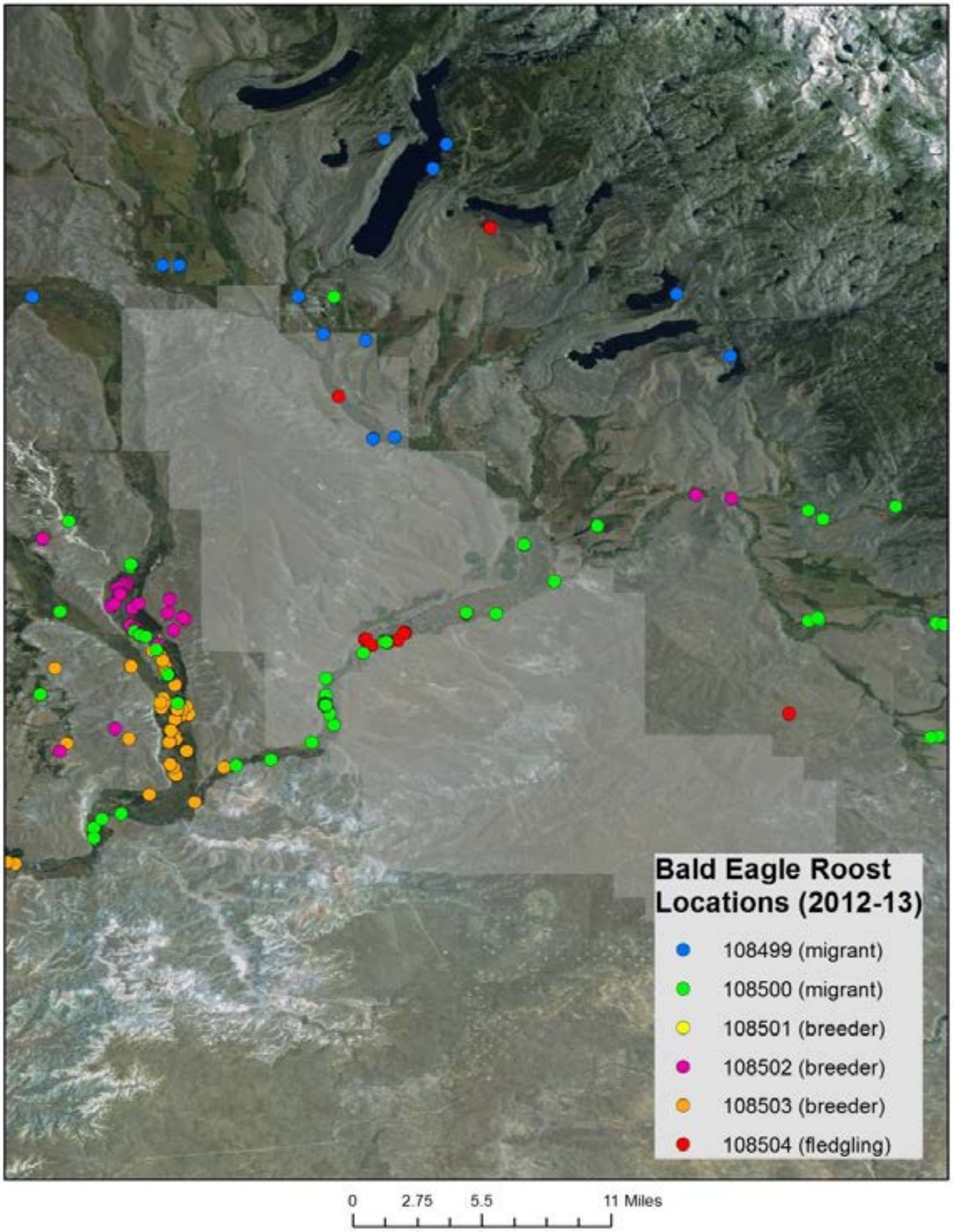

Figure B.3. Roosting locations from all Bald Eagles (*Haliaeetus leucocephalus*) within and around the Pinedale Anticline Project Area, 2012-2013.

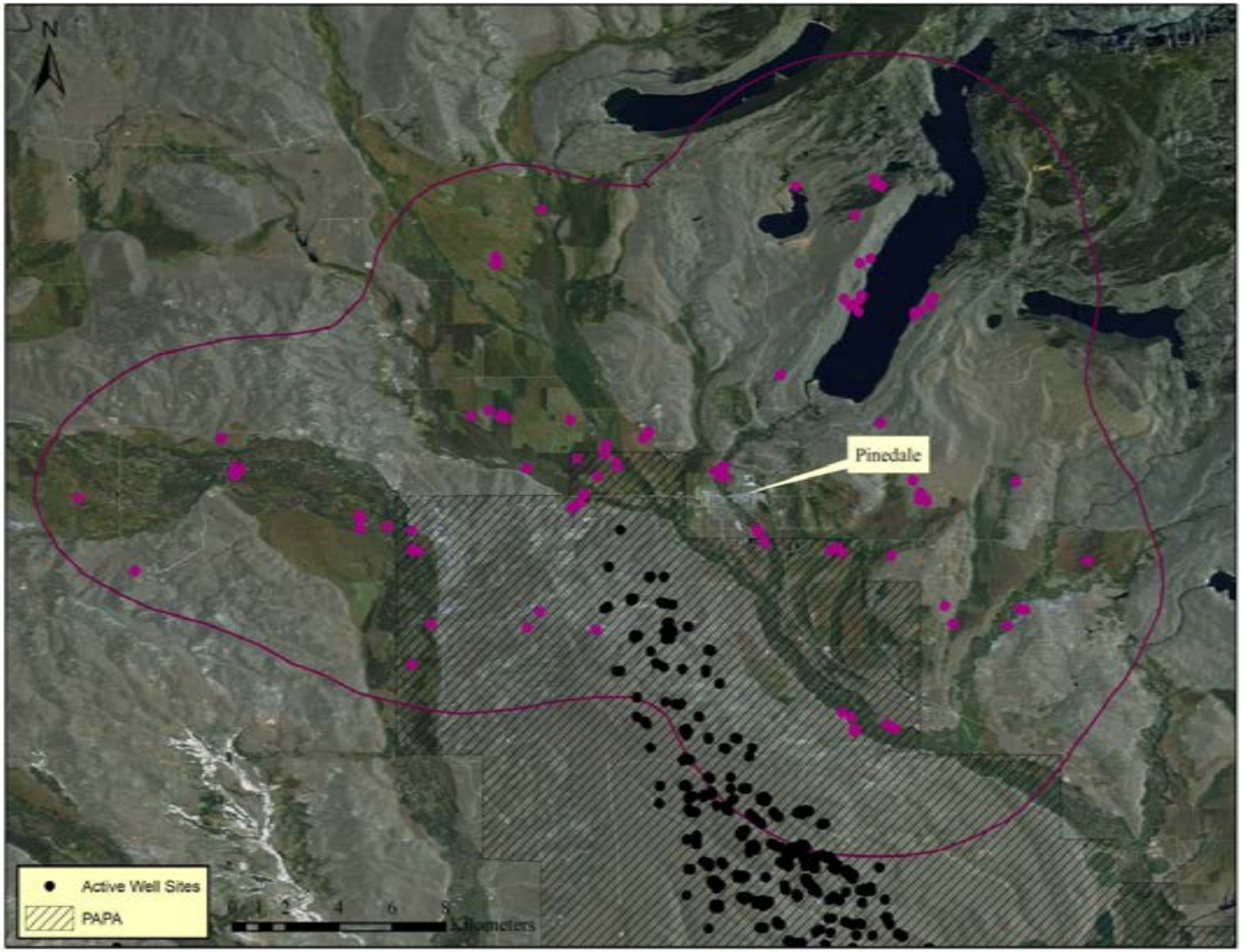

Figure B.4. Non-breeding season movements and 95% Kernel Density Estimate for Bald Eagle (*Haliaeetus leucocephalus*) 108499.

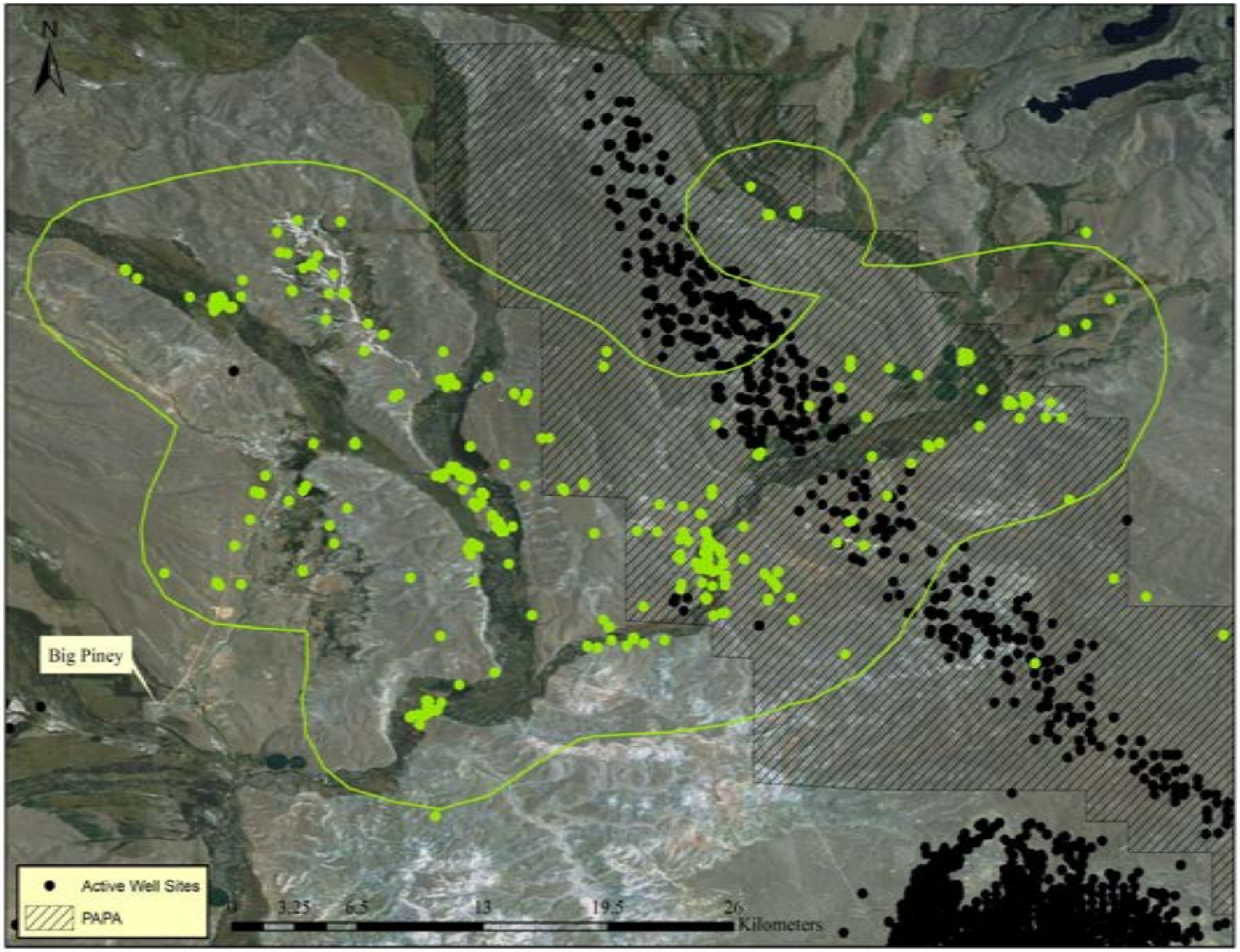

Figure B.5. Non-breeding season movements and 95% Kernel Density Estimate for Bald Eagle (*Haliaeetus leucocephalus*) 108500.

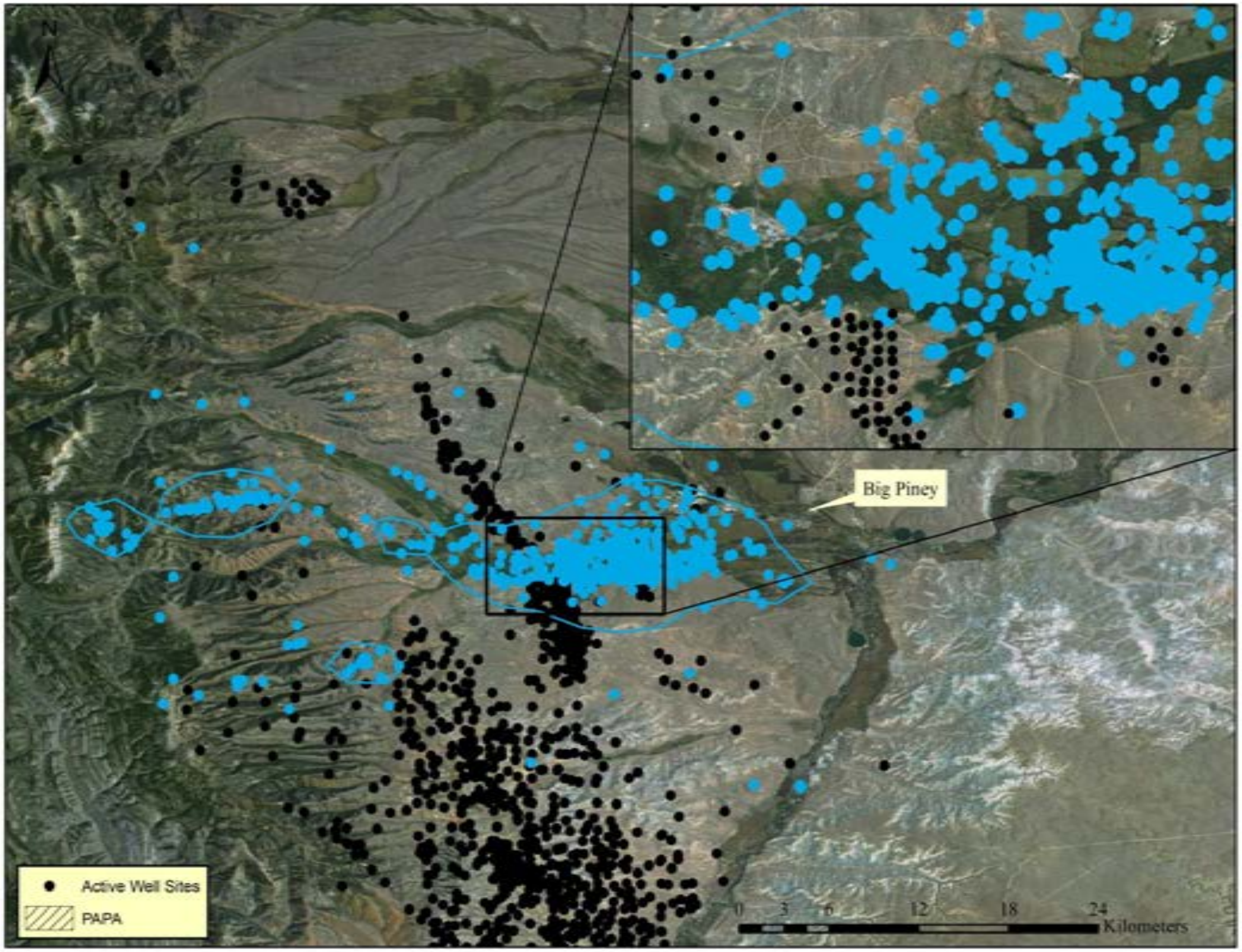

Figure B.6. Non-breeding season movements and 95% Kernel Density Estimate for Bald Eagle (*Haliaeetus leucocephalus*) 108501. Only includes 2012-2013 non-breeding season (15 August 2012-14 February 2013).

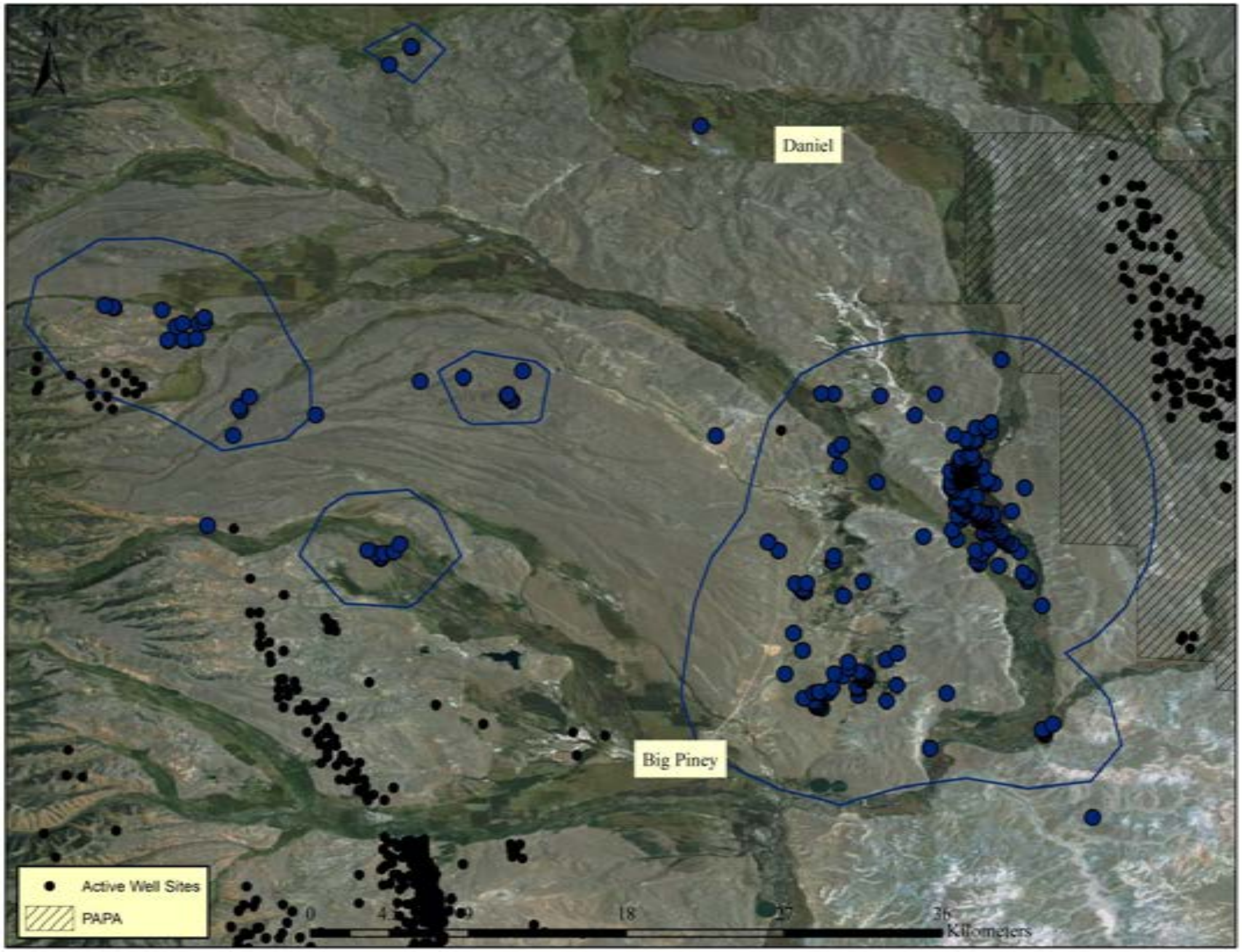

Figure B.7. Non-breeding season movements and 95% Kernel Density Estimate for Bald Eagle (*Haliaeetus leucocephalus*) 108502.

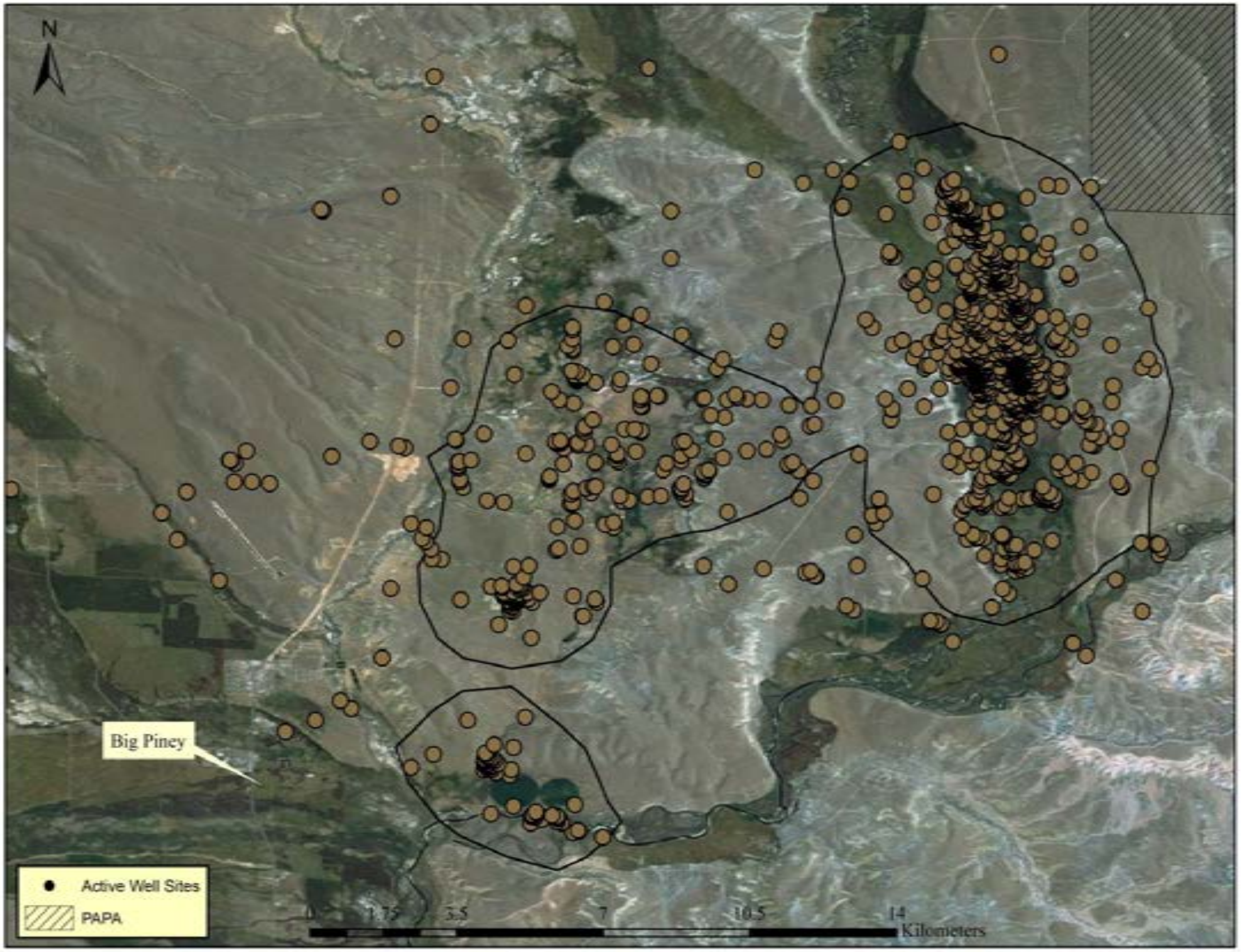

Figure B.8. Non-breeding season movements and 95% Kernel Density Estimate for Bald Eagle (*Haliaeetus leucocephalus*) 108503.

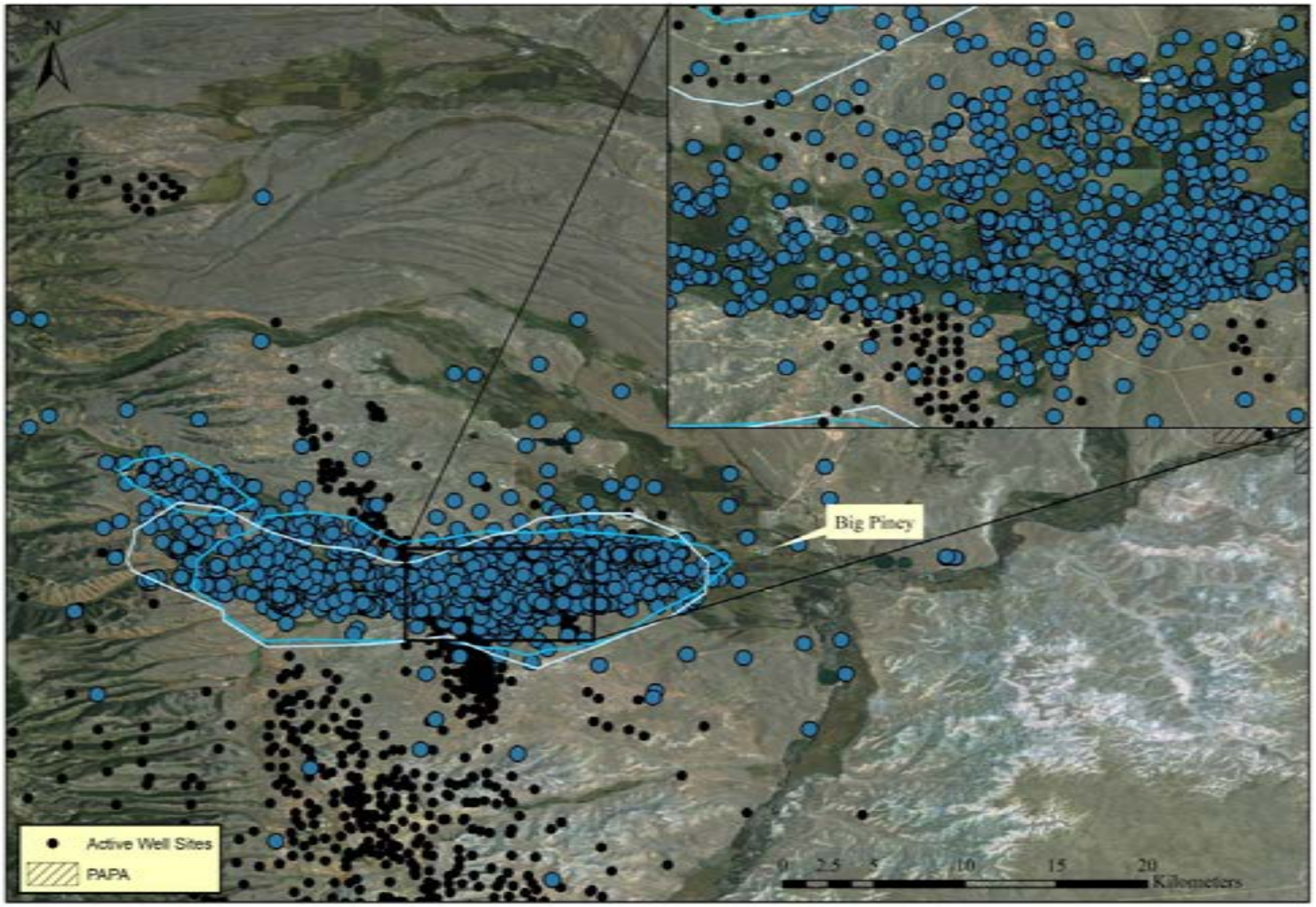

Figure B.9. Breeding season locations and 95% Kernel Density Estimate (KDE) for Bald Eagle (*Haliaeetus leucocephalus*) 108501. Lighter blue represents KDE from 2013 breeding season, and darker blue represents 2012 breeding season. Points from both years are combined. Lighter blue KDE represents home-range used during breeding season, yet the bird did not breed in 2013. Shown here for comparison only, since locations from 2013 were not included in the selection analysis.

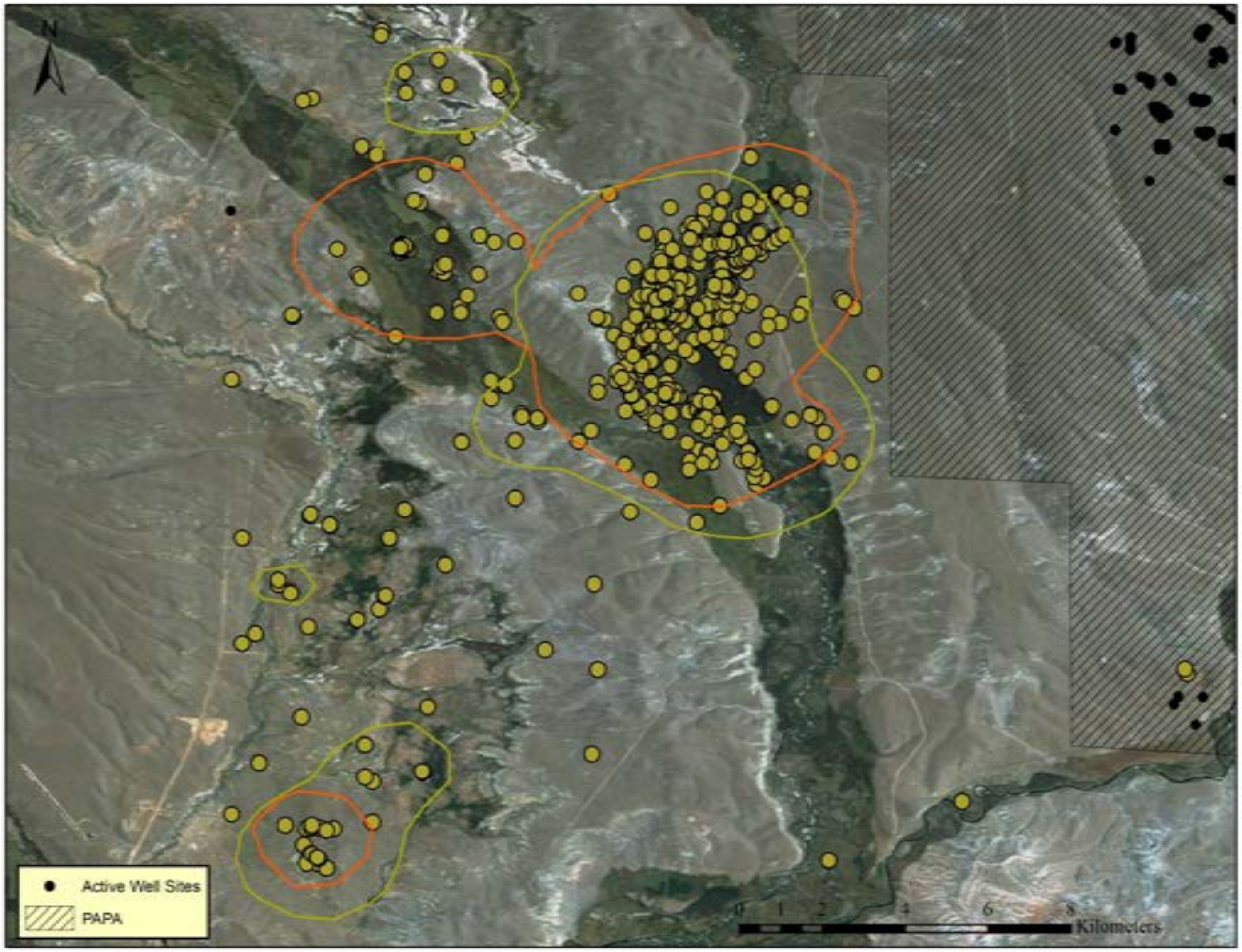

Figure B.10. Breeding season locations and 95% Kernel Density Estimates (KDE) for Bald Eagle (*Haliaeetus leucocephalus*) 108502. Orange KDE represents home-range estimate from 2013 breeding season, and olive KDE represents 2012 breeding season. Points from both years are combined.

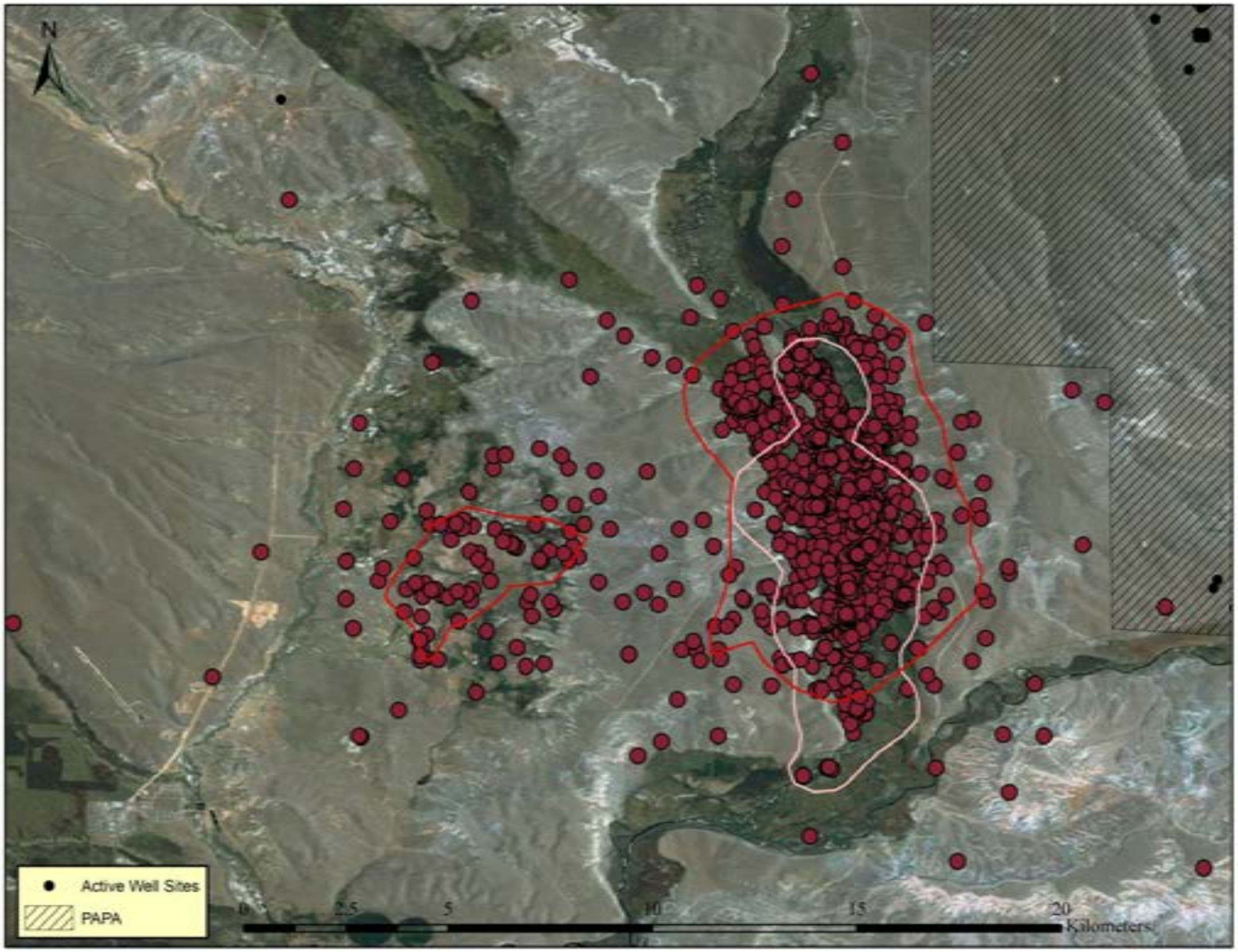

Figure B.11. Breeding season locations and 95% Kernel Density Estimates (KDE) for Bald Eagle (*Haliaeetus leucocephalus*) 108503. Red KDE represents home-range estimate from the 2013 breeding season, and pink KDE represents 2012 breeding season. Points from both years are combined.

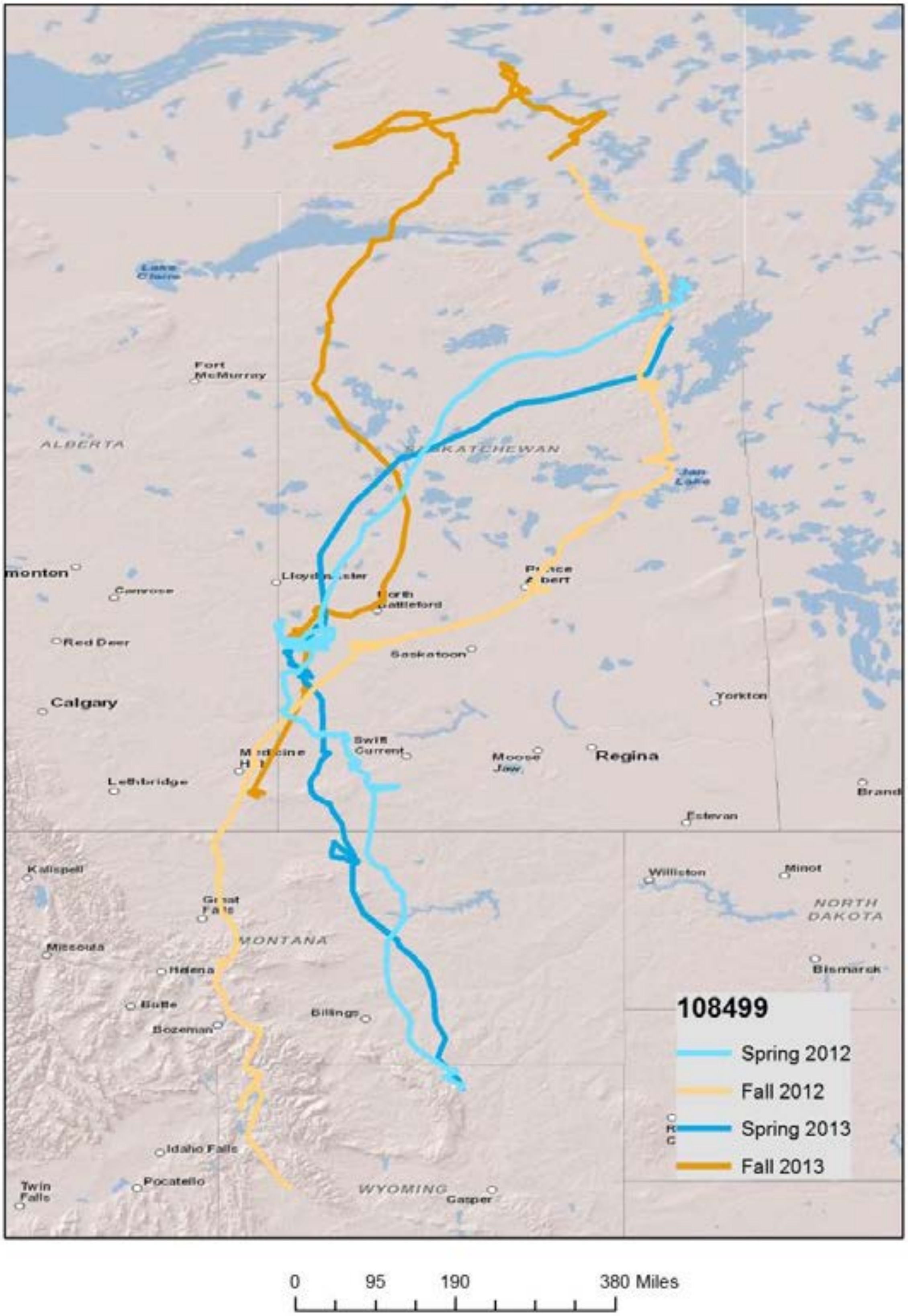

Figure B.12. Migration routes of adult Bald Eagle (*Haliaeetus leucocephalus*) 108499.

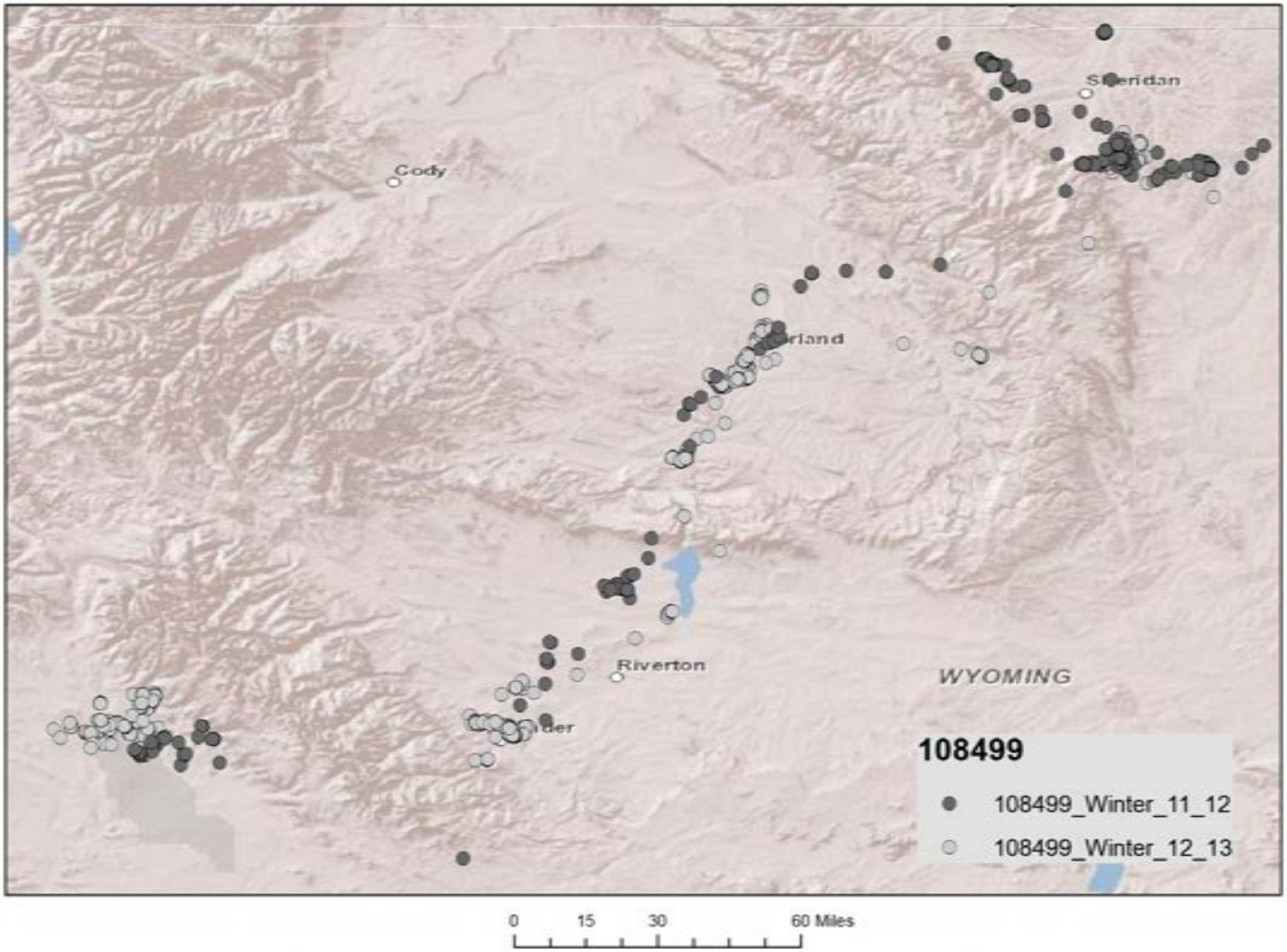

Figure B.13. Wintering locations of adult Bald Eagle (*Haliaeetus leucocephalus*) 108499.

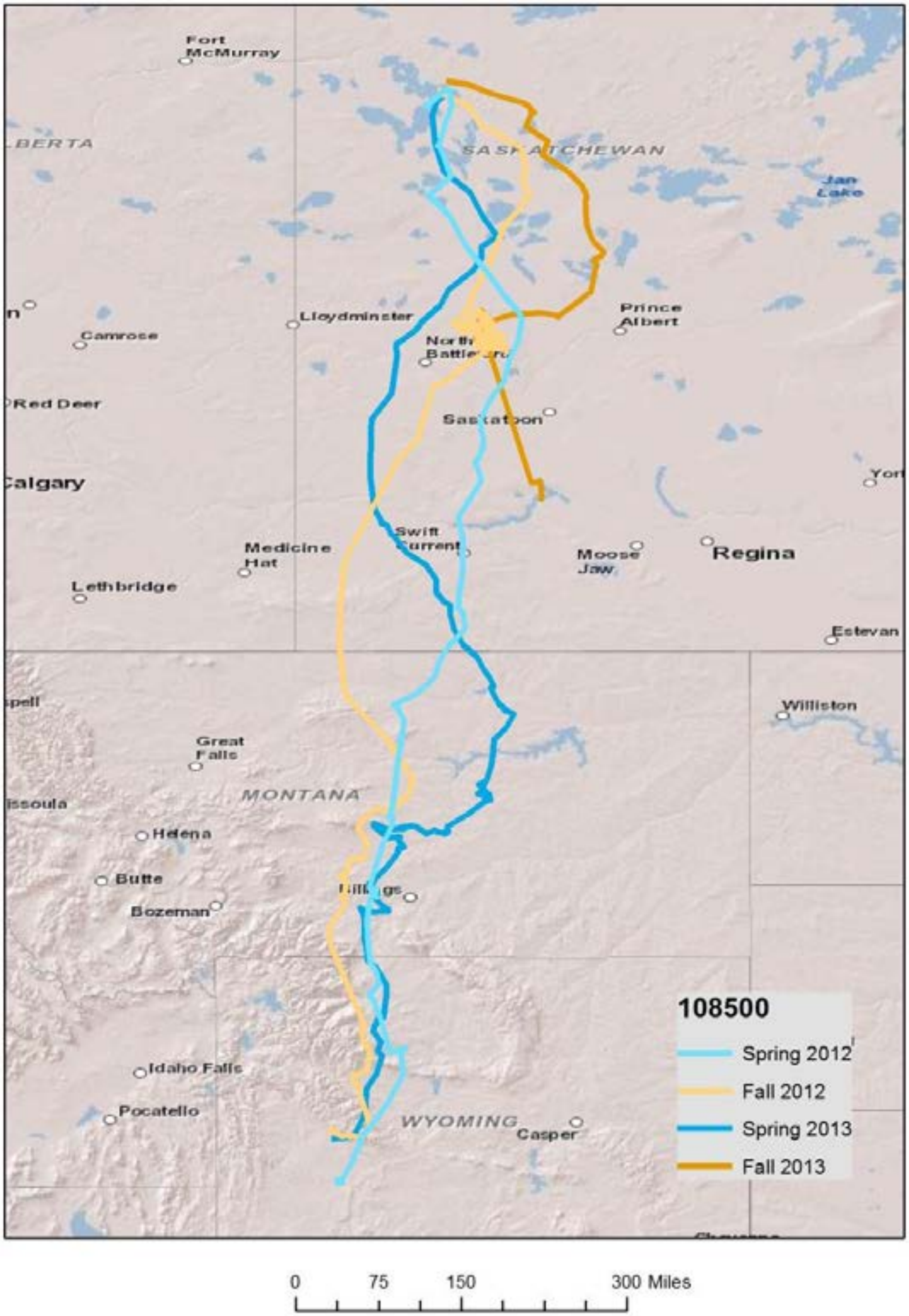

Figure B.14. Migration routes of adult Bald Eagle (*Haliaeetus leucocephalus*) 108500.

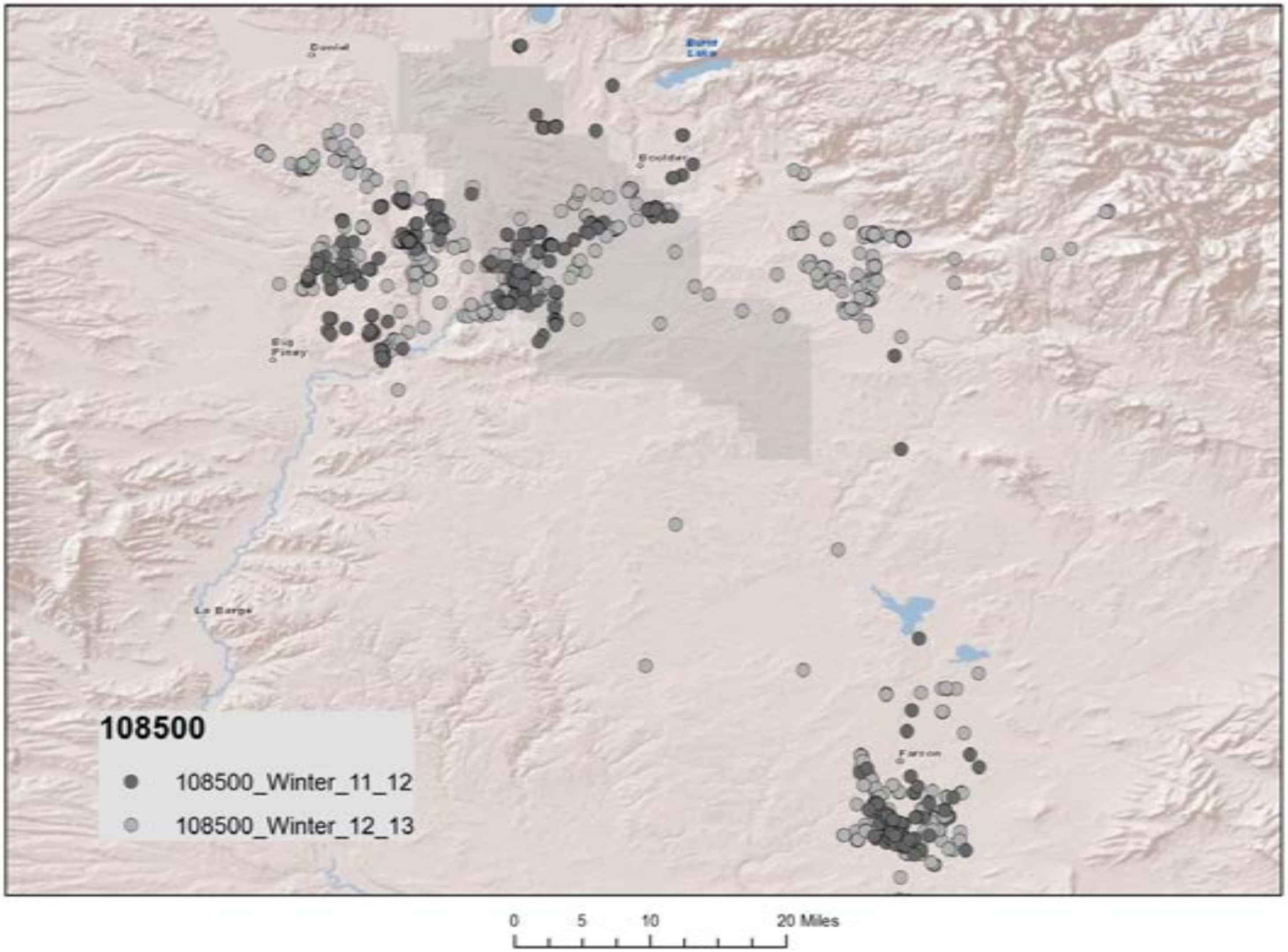

Figure B.15. Wintering locations of adult Bald Eagle (*Haliaeetus leucocephalus*) 108500.

Appendix C. Proportion and number of locations of Bald Eagles (*Haliaeetus leucocephalus*) to producing well pads and available water in western Wyoming, 2011-2013.

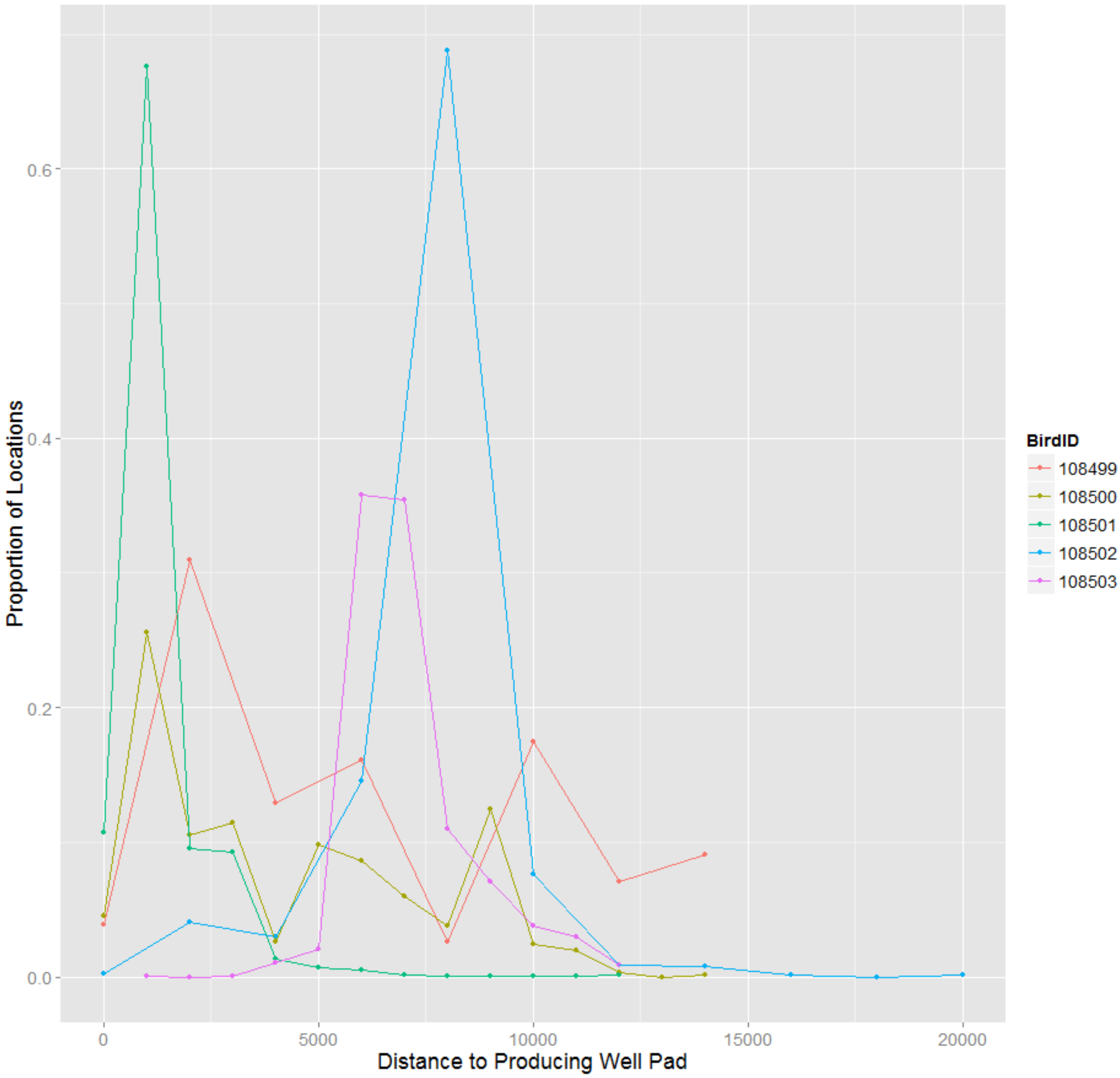

Figure C.1. Proportion of locations during non-breeding season for each Bald Eagle (*Haliaeetus leucocephalus*) relative to distance (m) to producing well pad.

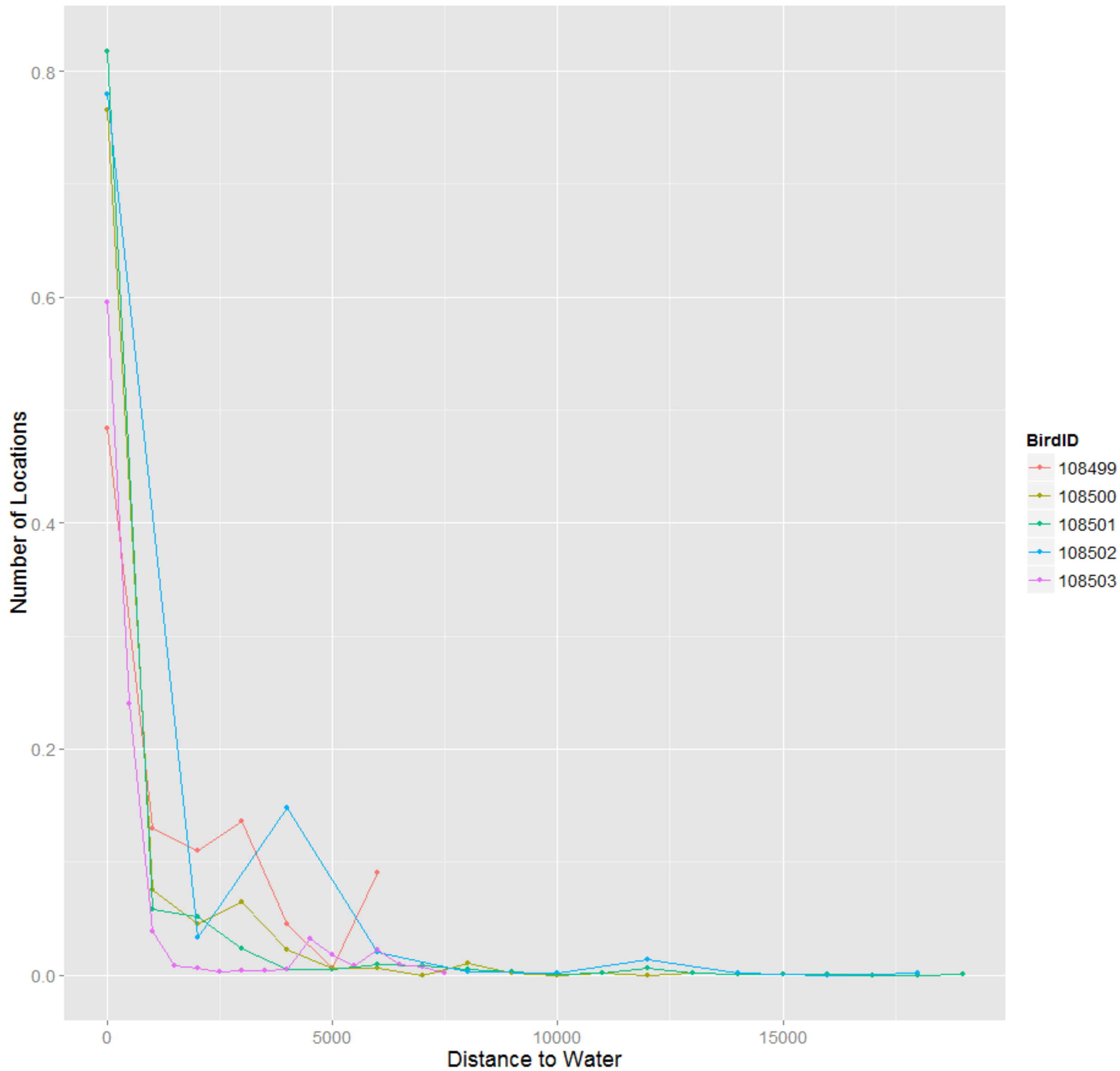

Figure C.2. Number of locations for each Bald Eagle (*Haliaeetus leucocephalus*) during non-breeding season relative to distance (m) to water.

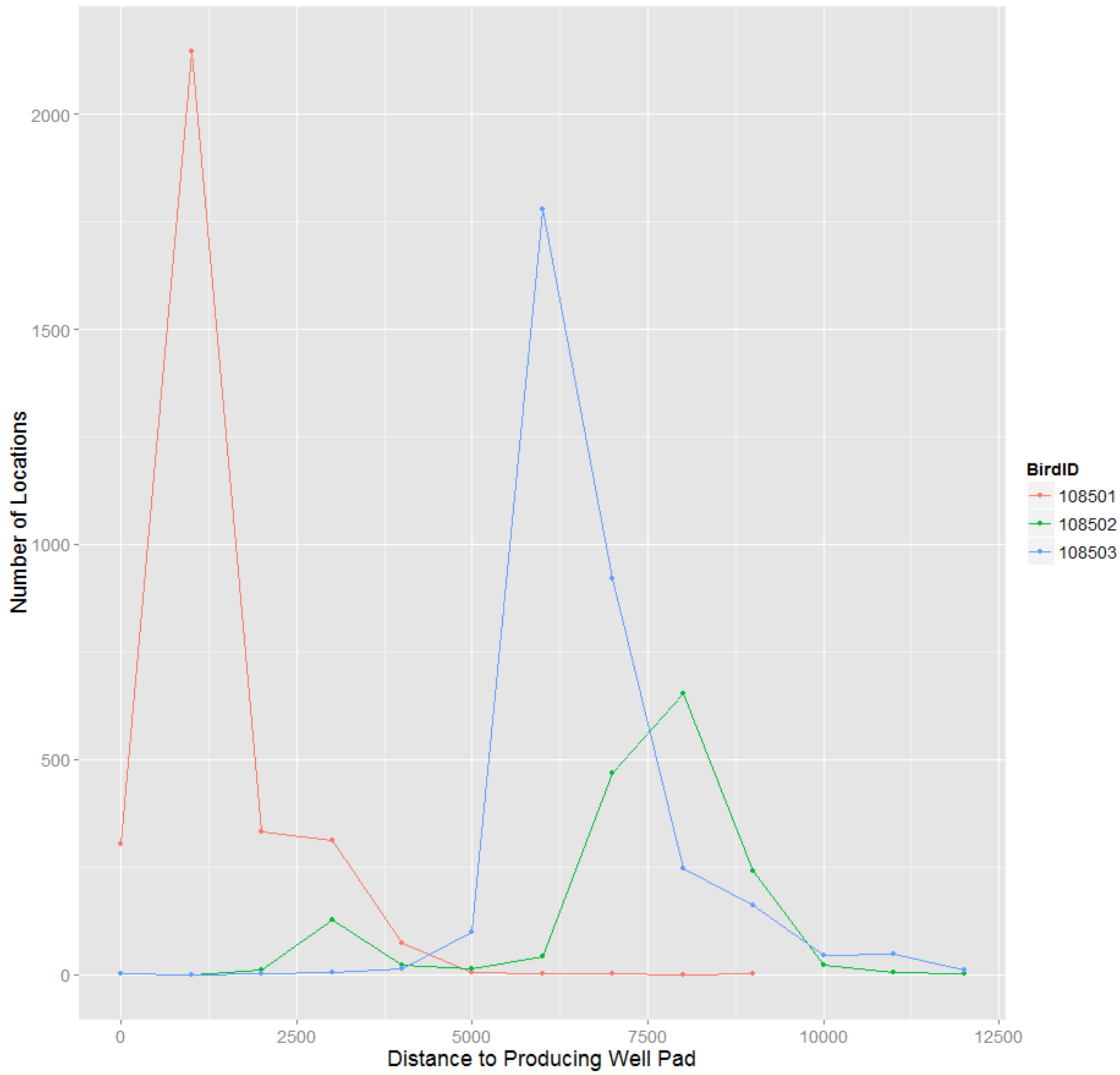

Figure C.3. Number of locations per Bald Eagle (*Haliaeetus leucocephalus*) during breeding season relative to distance (m) to producing well pad.

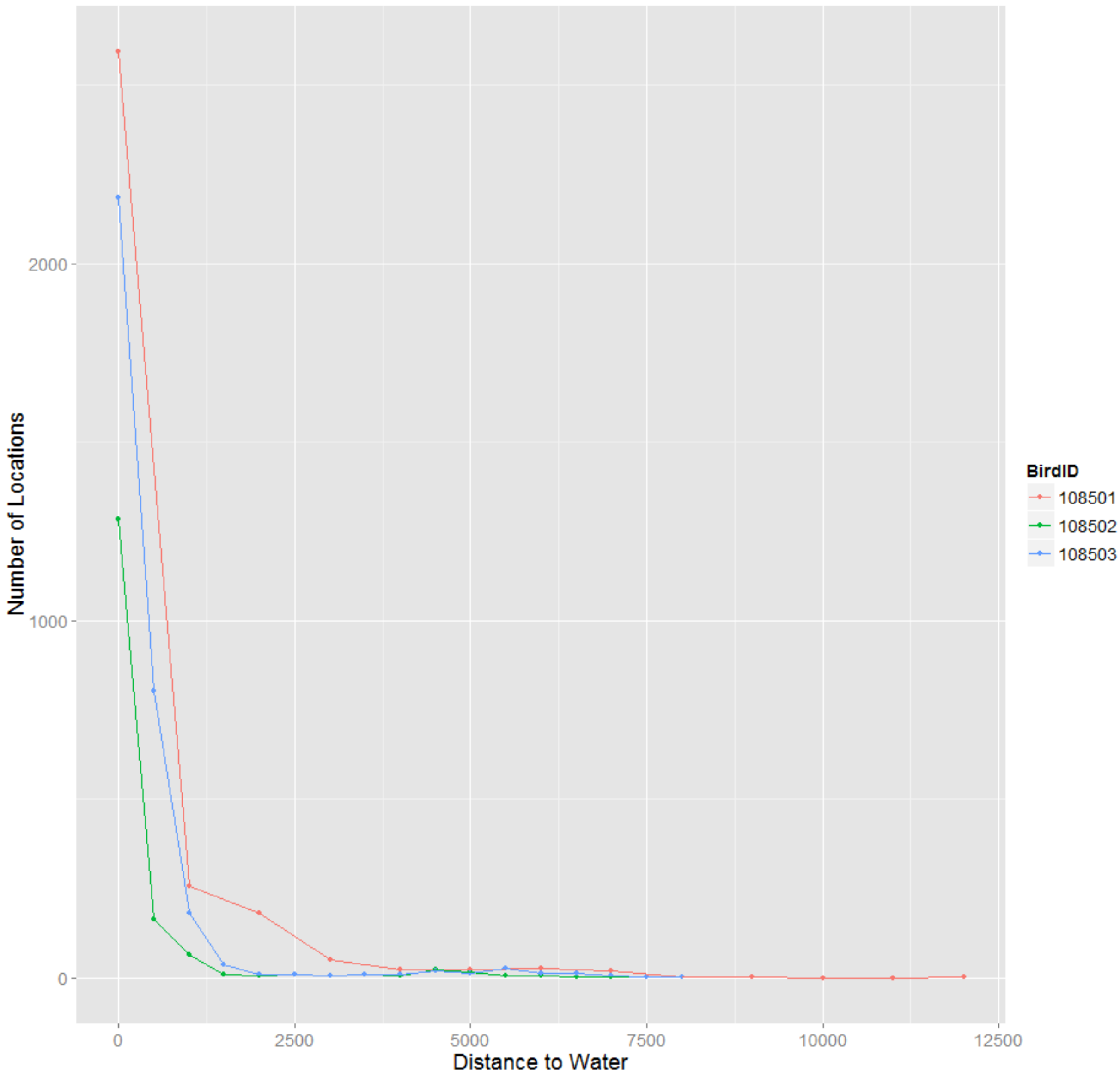

Figure C.4. Number of locations per Bald Eagle (*Haliaeetus leucocephalus*) during breeding season relative to distance (m) to water.

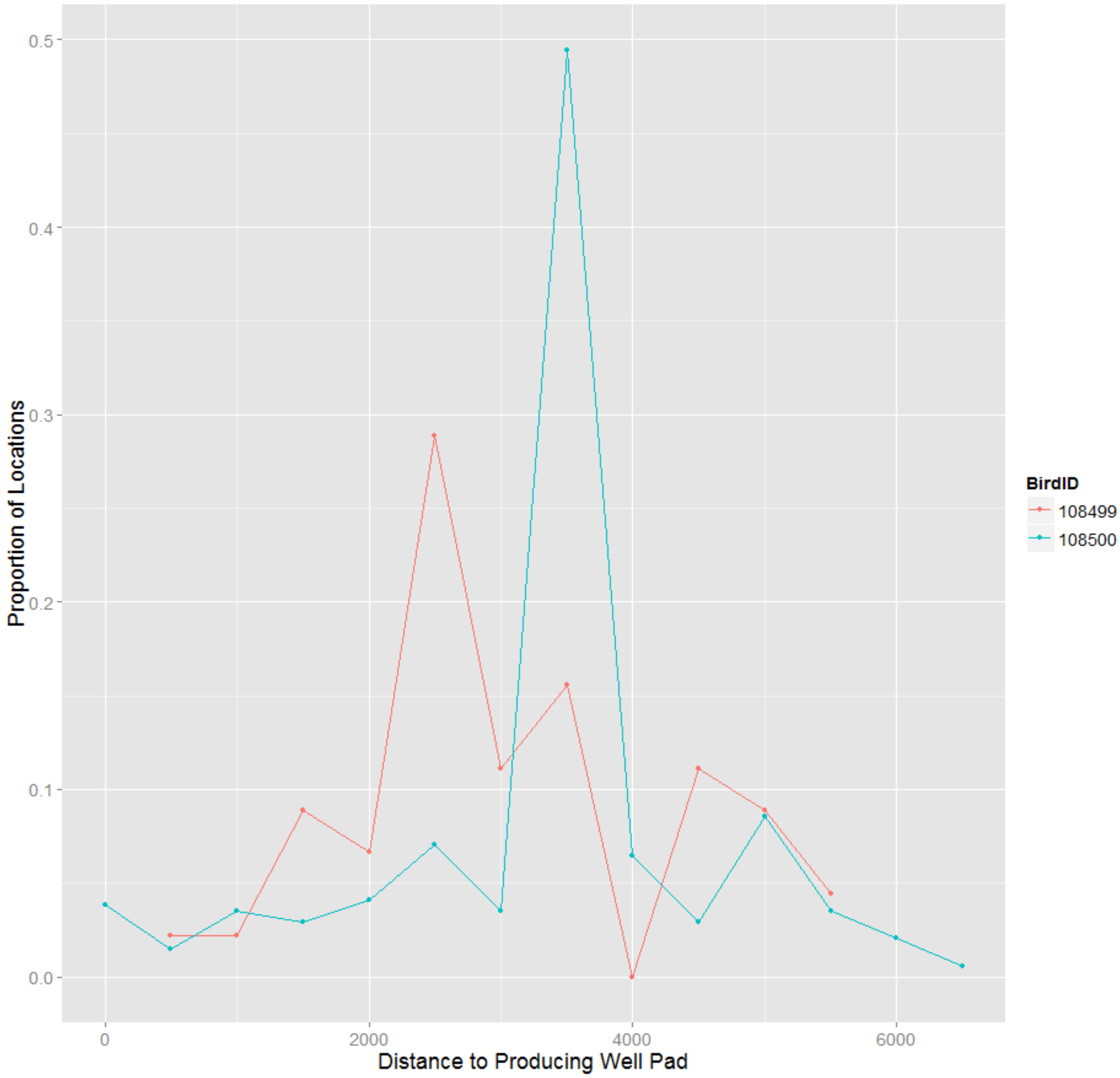

Figure C.5. Proportion of locations per Bald Eagle (*Haliaeetus leucocephalus*) during non-breeding season relative to distance (m) to producing well pad within the Pinedale Anticline Project Area (PAPA). Two additional birds had points within the PAPA but only had one point each so were not included.

Appendix D. Models evaluating the influence of *Distance to Producing Well Pad* on point locations of Bald Eagles (*Haliaeetus leucocephalus*) in western Wyoming, 2011-2013.

Table D.1. Coefficient estimates for models including *Distance to Producing Well Pad* covariate for the non-breeding season for Bald Eagles (*Haliaeetus leucocephalus*). Note for all analyses, the *Distance to Producing Well Pad* covariate significantly improved model fit. A "+" in the relationship column represents selection and "-" represents avoidance.

Non-Breeding Season (August 16 - February 14)

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	-0.05984	0.0599	-1	0.31722	
dist to water	-1.00151	0.02623	-38.18	< 0.0001	+
dist to well	-0.12014	0.03093	-3.88	0.0001	+

Roost Non-Breeding Season (August 16 - February 14)

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	0.3874	0.3371	1.149	0.251	
dist to water	-0.8302	0.1114	-7.454	< 0.0001	+
dist to well	-1.0087	0.1343	-7.513	< 0.0001	+

PAPA Only Non-Breeding Season (August 16 - February 14)

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	-0.13031	0.08744	-1.49	0.136	
dist to water	-1.19138	0.11501	-10.359	< 0.0001	+
dist to well	0.43903	0.08837	4.968	< 0.0001	-

Non-Breeding Season - 108501

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	-0.13975	0.03166	-4.414	< 0.0001	
dist to water	-1.08134	0.04733	-22.846	< 0.0001	+
dist to well	-0.27282	0.03344	-8.159	0.0001	+

Roost Non-Breeding Season - 108501

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	-0.1055	0.1225	-0.861	0.389	
dist to water	-0.2451	0.1494	-1.64	0.101	+
dist to well	-1.0021	0.1698	-5.903	< 0.0001	+

Roost Non-Breeding Season - 108502 & 108503

	Estimate	Std. Error	Z value	*p* -value	Relationship
Intercept	-0.146	0.114	-1.281	0.2003	
dist to water	-1.0199	0.2121	-4.807	< 0.0001	+
dist to well	-0.2819	0.1203	-2.343	0.0191	+

Table D.2. Coefficient estimates for models including *Distance to Producing Well Pad* covariate for the breeding season for Bald Eagles (*Haliaeetus leucocephalus*). Note for all analyses, the *Distance to Producing Well Pad* covariate significantly improved model fit. A "+" in the relationship column represents selection and "-" represents avoidance.

Breeding Season (February 15 - August 15)

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-0.18162	0.30496	-0.596	0.551	
dist to water	-0.76124	0.03375	-22.556	< 0.0001	+
dist to nest	-0.78475	0.02838	-27.653	< 0.0001	+
dist to well	0.28974	0.04277	6.744	< 0.0001	-

Roost Breeding Season (February 15 - August 15)

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-0.9965	0.3906	-2.551	0.0107	
dist to water	-2.1104	0.3936	-12.168	< 0.0001	+
dist to nest	-2.8162	0.2315	-5.361	< 0.0001	+
dist to well	-0.886	0.1976	-4.483	< 0.0001	+

2013 Breeding Season 108501[a]

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-0.11967	0.02169	-5.518	< 0.0001	
dist to water	-1.03896	0.03519	-29.521	< 0.0001	+
dist to well	-0.2067	0.2296	-9.004	< 0.0001	+

2013 Roost Breeding Season 108501[a]

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	0.57004	0.192412	2.963	0.00305	
dist to water	-0.00098	0.000174	-5.662	< 0.0001	+
dist to well	-1.50288	0.249112	-6.033	< 0.0001	+

2012 Breeding Season 108501

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-0.18236	0.03118	-5.85	< 0.0001	
dist to water	-0.8673	0.0503	-17.244	< 0.0001	+
dist to nest	-1.07509	0.04959	-21.681	< 0.0001	+
dist to well	0.34482	0.04025	8.566	< 0.0001	-

2012 Roost Breeding Season 108501

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-2.6702	0.5266	-5.071	< 0.0001	
dist to water	-0.271	0.7982	-0.339	0.73427	na
dist to nest	-5.6202	0.9723	-5.781	< 0.0001	+
dist to well	-1.3565	0.4893	-2.773	0.00556	+

Roost Breeding Season - 108502 & 108503

	Estimate	Std. Error	Z value	*p*-value	Relationship
Intercept	-0.6239	0.2903	-2.149	0.0316	
dist to water	-1.4699	0.1595	-9.215	< 0.0001	+
dist to nest	-2.4029	0.4818	-4.988	< 0.0001	+
dist to well	-0.5202	0.132	-3.94	< 0.0001	+

[a] = 108501 did not breed in 2013.

WYOMING RANGE NORTHERN GOSHAWK (*ACCIPITER GENTILIS*) NEST SEARCH AND MONITORING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Northern Goshawk

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 24 February 2012 – 31 December 2013

PERIOD COVERED: 24 February 2012 – 31 December 2013

PREPARED BY: Jenny Berven, Rocky Mountain Bird Observatory

ABSTRACT

The Wyoming Game and Fish Department (Department) contracted Rocky Mountain Bird Observatory (RMBO) to design and conduct surveys for nesting Northern Goshawks (*Accipiter gentilis*) during the 2012 and 2013 nestling and fledgling seasons in the Wyoming Range in southwestern Wyoming. Data are needed on this state Species of Greatest Conservation Need associated with mature and older aged conifer forests, as a number of landscape-scale habitat projects have been proposed for this area of the Bridger-Teton National Forest. This work, funded through the US Fish and Wildlife Service State Wildlife Grants program, continues survey efforts initiated in 2009 by the Department to locate nest sites and collect habitat data to identify and map suitable nesting habitat in the Wyoming Range. The Department also funded occupancy surveys by RMBO in 2009 in the Wyoming Range and the adjacent Salt River Range as part of a US Forest Service region-wide Northern Goshawk survey effort. In addition to locating new active nests, RMBO was responsible for collecting nest-site habitat data at all new nests found and for checking the status of seven historic nest sites. RMBO designed an unbiased survey based on Northern Goshawk Monitoring and Technician Guide protocols. We split the approximately 73,000 ha study area into 160 Primary Sampling Units by laying 600.25 ha grids across the study area. Primary Sampling Units along the study area boundary varied in size, as they were clipped to the study area boundary. We used a spatially balanced design with generalized random tessellation stratification to rank Primary Study Units and then re-ranked the grids in 2012 according to the amount of primary habitat within each Primary Study Unit. In 2013, we used a GIS layer created by the US Forest Service to adjust the ranking technique according to the amount of primary nesting habitat within each Primary Sampling Unit. Technicians conducted broadcast acoustical surveys at all safe, accessible call stations within the Primary Sampling Unit located in suitable habitat. Technicians

did not survey at locations with a slope >36% or ≤1.6 km of previously identified nest sites. We defined suitable habitat as any location within 150 m of any tree cover.

During the 2012 field season, technicians surveyed 2,196 call stations in 38 Primary Sampling Units between 10 June and 21 August. Technicians surveyed a Primary Sampling Unit in an average of 4.2 survey days (33.9 hrs). Technicians detected goshawks in six Primary Sampling Unit and found four new active nests. The naïve detection rate for Primary Sampling Units was 15.8% and 0.73 detections per 100 call stations. Of the seven historic nest sites, two nests were active.

During the 2013 field season, technicians surveyed 1,759 call stations in 43 Primary Sampling Units between 10 June and 28 August. Technicians completed a Primary Sampling Unit in an average of 3.7 survey days (29.6 hrs). Technicians detected goshawks in three Primary Sampling Units. One detection resulted in finding one new active nest in the adjacent Primary Sampling Unit. The naïve detection rate for Primary Sampling Units was 7.0% and 0.17 detections per 100 call stations. Of the seven historic nest sites, RMBO technicians checked three of the sites and a US Forest Service crew checked the other four sites. None of the historic nests showed evidence of activity for the 2013 breeding season. Technicians revisited the four 2012 active nests between 4 June and 10 June 2013; all four nests were inactive at the time.

Overall, a total of 3,933 different call stations were visited within 78 Primary Sampling Units. Technicians surveyed a Primary Sampling Unit in an average of 3.9 survey days (30.6 hrs). Technicians detected goshawks in eight different Primary Sampling Units. The naïve detection rate for Primary Sampling Units was 11.1% and 0.48 detections per 100 call stations.

For all new nests, technicians recorded nest-tree elevation, slope aspect, and slope percent. Technicians also recorded canopy cover, number of seedlings, downfall, live and dead trees per hectare, average ground cover height, dominant ground cover species, and average diameter of all live and dead species of trees within a 0.217-ha radius plot. Overall, new nests were found in lodgepole pine (*Pinus contorta*; *n* = 3), Douglas-fir (*Pseudotsuga menziesii*; *n* = 1) and limber pine (*Pinus flexilis*; *n* = 1) trees within mature mixed coniferous stands with varying understory and composition. All new nest trees were found at elevations between 2,510 and 2,644 m on gentle to moderate slopes and with northerly to northeasterly facing aspects.

INTRODUCTION

The Wyoming Game and Fish Department (Department) solicited proposals for Northern Goshawk (*Accipiter gentilis*; goshawk) nest site survey and habitat work through Request for Proposal (RFP) No. 0185-V in December 2011. As stated in the RFP, requirements included using a broadcast acoustical survey method to locate new, previously unidentified Northern Goshawk nests in the Wyoming Range (Fig. 1). The RFP called for using an unbiased approach to select survey units, while striving to survey the greatest amount of potential habitat during the nestling and fledgling seasons (June-August) of 2012 and 2013.

The Northern Goshawk is the largest of three accipiter hawks found in North America (Squires and Reynolds 1997). Goshawks inhabit and nest in several classes of woodlands and forests including coniferous, deciduous, and mixed forests ranging from Alaska to Mexico. Preferred forest and woodland types vary throughout the bird's range and depend on the forest types available locally. For example, goshawks primarily nest in ponderosa pine (*Pinus ponderosa*), mixed coniferous, and spruce-fir forests in the southwest, and pine (*Pinus* spp.) forests interspersed with quaking aspen (*Populus tremuloides*) groves in the forests of Colorado, Wyoming, and South Dakota (Shuster 1980, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Squires and Ruggiero 1996, Reynolds and Joy 1998, Greenwald et al. 2005, Reynolds et al. 2008). In the Great Basin, goshawks inhabit small patches of aspen within the shrub-steppe communities (Squires and Ruggiero 1996). Goshawks are known to use Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and aspen trees for nesting in the Caribou-Targhee National Forest within the Greater Yellowstone Ecosystem (Patla 2005). Studies show a general consistency in the goshawk's need for large, mature stands of trees with a high percent of canopy cover for nesting (Reynolds et al. 1992, Anderson et al. 2005).

The goshawk has been a species of conservation concern within the US Forest Service (USFS) due to the potential for forest management practices to affect goshawk nesting habitat and populations (Woodbridge and Hargis 2006). Out of this concern, the goshawk has been designated a Management Indicator Species or a Sensitive Species on many national forests in the west. In 2006, the US Department of Agriculture published the "Northern Goshawk Inventory and Monitoring Technical Guide" to assist USFS biologists in the development and implementation of monitoring programs that use occupancy estimates to determine population trends within large administrative and biological regions (Woodbridge and Hargis 2006). Occupancy surveys determine the proportion of a landscape occupied by a species, whereas abundance surveys determine how many individuals of a species are found within a landscape. Although occupancy does not provide as much detail on a population as abundance and does not result in locating specific nest sites, it has been proposed as a surrogate for abundance because the two are positively correlated (MacKenzie and Nichols 2004), and occupancy estimates are much cheaper to obtain. Occupancy is the preferred method to assess status and changes in goshawk populations on a regional basis from year to year without the need for extensive abundance surveys (MacKenzie and Nichols 2004, Woodbridge and Hargis 2006). However, on the Bridger-Teton National Forest (BTNF) and many other national forests, management prescriptions for this species are based on identification and protection of nesting territories and habitat.

RMBO and the Department conducted surveys in 2009 to determine baseline data on occupancy and nest sites in suitable habitat. RMBO conducted occupancy surveys based on the technical guide (Woodbridge and Hargis 2006) with a naïve occupancy of 0.412 (95% CI: 0.151-0.673) in the Salt River and Wyoming Ranges in the BTNF (Berven and Pavlacky 2010). The Department independently conducted nest-site searches within the Wyoming Range. RMBO found no new nest sites during the occupancy surveys in 2009, but the Department located six active nest sites in the Wyoming Range, including three new territories (Patla and Derusseau 2010).

METHODS

In 2012, RMBO used the same Primary Sampling Units (PSU) grid developed for the 2009 regional monitoring effort for survey work (Berven and Pavlacky 2010). Using ArcGIS (ESRI 2006), a grid of 600.25 ha cells was overlaid on the study area following the methods of the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006). Each grid cell defined a PSU. If any part of the PSU fell within the study area boundary, that PSU was included in the sampling frame and the PSU boundary was clipped to the study area boundary.

A spatially balanced study design was implemented to order all PSUs within the Wyoming Range study area by using the generalized random-tessellation stratification (GRTS) function (Spsurvey package) in R (Stevens and Olsen 2004).

Stratification and sample weighting are common methods used to increase the effectiveness of surveying a study area by allocating more survey effort to areas more likely to contain the target species. Goshawks are known to nest in Douglas-fir and lodgepole pine trees in the Wyoming Range and in nearby areas of eastern Idaho and western Wyoming (Patla 2005). In 2012, RMBO used a post-hoc sample weighting system to rank preferred habitat (Douglas-fir and lodgepole pine stands) and secondary habitat (aspen, spruce, limber pine) forest types. According to the LANDFIRE (2012) data set, the eastern half of the Wyoming Range is strongly dominated by spruce-fir (*Picea-Abies*) forests with only pockets of either Douglas-fir or lodgepole pine stands. After the PSUs were ranked by the GRTS function, PSUs were re-ranked by multiplying the area of preferred habitat to its GRTS function rank. Therefore, PSUs with a greater area of Douglas-fir and lodgepole pine were weighted more and ranked higher than PSUs with little or no preferred habitat. In 2013, RMBO used a post-hoc weighting system to prioritize PSUs with more primary nesting habitat using a GIS layer provided by the USFS (LANDFIRE 2012).

Using ArcGIS, we added a grid of call station points to PSUs in the study area. For unclipped PSUs, 120 call stations on 10 transect lines (each containing 12 stations spaced 200 m apart) were overlaid on the PSU (Fig. 2). Each transect line was placed 250 m apart and located ≥150 m from the PSU border. Points on adjacent transect lines were vertically offset by 100 m. The call station grid was overlaid onto border PSUs as if the PSU was unclipped, but all points outside of the study area were removed from the survey effort. We used ArcGIS to identify call stations in unsuitable locations (slope >36% or >150 m away from forest cover; Fig. 2). A 30 × 30 m LANDFIRE slope layer (2006) was used to identify call stations located in areas that were too steep to survey. The LANDFIRE vegetation cover layer (2012) was used to identify call stations >150 m from tree cover. Goshawks maintain consistent territory sizes; therefore, we excluded call stations located within historic nest site territories as defined by the RFP (Reynolds and Joy 1998, Reich et al. 2004, Woodbridge and Hargis 2006). We used the buffer tool in ArcGIS to identify call stations <1.6 km and <2.4 km of a historic nest. When technicians found a new nest, all remaining call stations within the PSU or <1.6 km of the new nest were removed from the survey effort. Technicians surveyed call stations in preferred habitat between the 1.6 km and 2.4 km nest buffer. PSUs were further scrutinized to the call station level to eliminate

PSUs from the survey effort that had no call stations with suitable habitat within the study area (e.g., WY-BT-NOGO6).

Using ArcGIS, we created field maps showing PSU and study area boundaries and call stations overlaid onto 1:24,000-scaled topographic maps (ESRI 2011). Maps were scaled to 1:20,000 to help navigate between call stations. All call stations were included on the maps but were labeled according to criteria explained previously.

Broadcast survey protocols were based on methods described in the monitoring technical guide (Woodbridge and Hargis 2006). Field technicians were responsible for conducting broadcast acoustical surveys during the nestling and fledgling stages of the goshawk breeding season.

Field technicians, in crews of at least two, visited PSUs based on rank-order determined by the GRTS function and habitat weighting throughout the nestling and fledgling seasons. Experienced technicians could survey call stations within the PSU alone, but at least two technicians surveyed the same PSU at the same time. If the crew separated, technicians maintained a two-transect line distance (≥500 m) to prevent false detections caused by the other technician's call. To maximize goshawk detectability for the region, input was requested from wildlife managers (Department and USFS biologists) monitoring goshawk nests throughout the region to identify when eggs were expected to hatch, typically the first week of June (Patla 2005). Technicians could conduct broadcast acoustical surveys between 30 min before sunrise to 30 min before sunset, coinciding with goshawk activity. Due to the large size of a PSU, technicians could take as many days needed to survey one PSU and began the PSU at any time of day within the timeframe listed. Technicians broadcasted one of three goshawk calls depending on the season (nestling or fledgling). During the nestling season, we used an adult alarm call and, during the fledgling survey, a juvenile food-begging call or a wail call. Technicians used FoxPro NX3 digital callers preloaded with the calls at a volume producing 80-110 dB output 1 m from the speaker.

At each call station, technicians played 1 call for 10 sec, then watched and listened for goshawk activity for 30 sec, then repeated the procedure after rotating 120°. Once this procedure was done 3× (one complete rotation), the technician waited, watched, and listened for 2 min, then repeated the cycle. Technicians recorded any significant findings and time spent at each call station on a standardized field form. After two full rounds of playing the call, the technician moved on to the next call station, while keeping alert for goshawks or goshawk sign.

Technicians surveyed all call stations within a PSU located in suitable habitat that could be safely reached or surveyed until a goshawk detection was made. Technicians were not required to survey call stations located in suitable habitat that was inaccessible due to safety reasons. Initial goshawk detections consisted of visual sightings, aural observations, finding an active nest, or finding a freshly molted feather. When a bird was seen, sex, age (if known), and the UTM coordinates of the detection location was recorded. Aural and feather detections were followed by an attempt to visually locate a goshawk. Technicians would search for the goshawk(s) up to 150 m from the call station area or until the goshawk was no longer vocalizing.

Nest search protocols were based on intensive nest search methods described in the goshawk monitoring technical guide (Woodbridge and Hargis 2006). Once a visual detection was made, technicians conducted a systematic search for the goshawk nest by walking concentric circles ≤200 m around the point of detection. During the nest search, technicians carefully looked at trees and the surrounding area for goshawk sign (including nest structures, whitewash, freshly molted feathers, etc.). If no nest was found after the detection, the technician continued to survey the PSU until another detection was made and either a nest was found or all call stations were visited. Each time a new detection was made, the technician employed the same systematic search for a nest. PSUs that had a goshawk detection during the broadcast acoustical surveys but did not result in a found nest were re-surveyed at a later date. If no detection was made on a PSU, the unit was deemed unoccupied and was not visited again.

When technicians found a nest, they recorded nest location, observations of goshawk behavior and nest use, general habitat description, and nest tree description. The nest tree was marked with flagging if there was little or no risk of stressing the birds (i.e., the adult birds were not defensive or incubating). Once the survey season was over, technicians returned to new nests to collect nest-site habitat information and digital photographs of the nest tree and stand (Patla 1997).

Technicians collected nest plot data after the juvenile goshawks fledged and the adults no longer defended the area. Vegetation was measured within a 0.217-ha circular plot and consisted of number and size of overstory trees; percent canopy cover; number of seedlings, snags and downed trees; ground cover height and species; and bare ground. Tree age was determined with the use of an increment borer. Habitat and nest tree data were collected using methods described by Patla (1997). We used a concave spherical densiometer to measure canopy cover. Vegetation results were compared to nest-site data collected in 2009 (Patla and Derusseau 2010).

Weather data for the months of March, Apri,l and May were obtained from the National Oceanic and Atmospheric Administration's National Climate Data Center (NOAA 2013). Monthly temperature and precipitation data were obtained from the Big Piney Station; snowfall data were obtained from the Daniel Hatchery station.

RESULTS

There were 160 PSUs associated with the study area, 96 of which were completely within the study area. The 64 border PSUs totaled 16,738 ha. The average area within the study area of border PSUs was 261.5 ha (SD = 184.3). Because of the large area and standard deviation, we decided to include all PSUs in the sampling frame and only eliminate call stations outside the study area after ranking the PSUs with the GRTS function and habitat weighting.

We used GRTS to select and rank PSUs from 1 to 160 (Fig. 3). Both the habitat and nesting habitat weighting system effectively moved the survey effort priority to lower elevations with large stands of preferred habitat (Figs. 4 and 5). The overall average PSU mean elevation was 2,731 m. The average PSU mean elevation for surveyed PSUs was 2,676 m and the average PSU mean elevation for PSUs not surveyed was 2,784 m. This process also helped decrease the potential of having a highly GRTS-ranked border PSU require surveying if the PSU had little or no suitable habitat.

Technicians conducted broadcast acoustical surveys from 10 June-21 August 2012 and 10 June-28 August 2013. In 2012, technicians surveyed 2,196 call stations in 38 PSUs (Fig. 6) with a majority of stations visited during the nestling season (*n* = 1,375; Tables 1 and 2). In 2013, technicians surveyed 1,759 call stations[1] in 43 PSUs with a majority of stations visited during the nestling season (*n* = 1,070; Table 3). A total of 3,933 call stations in 78 PSUs were surveyed (Fig. 7). Technicians used the adult goshawk alarm call until 25 July 2012 and 21 July 2013 and then juvenile food begging or wail call for the remainder of the season.

Although technicians could survey anytime between 30 min before sunrise to 30 min after sunset, technicians typically surveyed between 0800 and 1600 MST. In 2012, the earliest survey began at 0714 and the latest surveyed ended at 1848. In 2013, the earliest survey began at 0709 and the latest survey ended at 1802.

The two 2012 crews surveyed a total of 91 days. The 2012 survey window allowed 110 possible workdays for the crews; 6 of those days were required office and coordination days where technicians submitted timesheets, copied data, and prepared themselves for the following pay period (purchased food, determined work, etc.). Four days within the survey window were spent conducting targeted nest searches or collecting habitat data. The remaining workdays were not spent surveying because of the following reasons: Fontenelle Fire (5 days), technician injury (2 days), and vehicle repair needs (2 days). Field crews completed PSUs, on average, in 4.2 survey days (range: 0.7-11.8 survey days) or 33.9 hrs. A survey day includes the time spent for a crew of two people getting to the PSU, surveying call stations, hiking between call stations and getting back to field housing. The average time spent on a PSU was 27.7 hrs (includes time spent hiking between call stations), and crews spent, on average, about 47 min driving and hiking to the PSU and back to field housing each day.

The two 2013 crews surveyed a total of 109 days. The 2013 survey window allowed 118 possible workdays for two crews (the 2013 crew was able to work 4 days longer than the 2012 crew); 7 of those days were required office and coordination days where technicians submitted timesheets, copied data, prepared themselves for the following pay period (purchased food, determined work, etc.), and moved out of the field rental house. Two days within the survey window were spent conducting targeted nest searches. Field crews completed PSUs, on average, in 3.7 survey days (range: 0.0308.0 survey days) or 29.6 hrs. The average time spent on a PSU was 23.7 hrs (includes time spent hiking between call stations), and crews spent, on average, about 44 min driving and hiking to the PSU and back to field housing each day.

Overall, PSUs were completed in an average of 3.9 survey days or 30.6 hrs, and the average time spent on a PSU was 25.6 hrs.

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[1] Technicians re-surveyed 22 call stations in WY-BT-NOGO35 during the fledgling season of 2013 in an attempt to follow-up on a detection made late in the 2012 field season.

Of 14,638 potential call stations within the study area, we used to eliminate GIS 6,317 call stations before the 2012 field season began (Table 2). Historic nest buffers eliminated 1,427 call stations; however, technicians could survey call stations between the 1.6 km and 2.4 km historic nest buffer if no active nest had been located in the early season check of that site and the habitat was suitable. PSUs averaged 42 (range: 2-120) call stations in safe, suitable habitat after categorizing call stations with GIS.

Three factors decreased the number of call stations to survey during the field season.

1. Technicians determined the call station was in unsuitable habitat or was unsafe to access.
2. Technicians found a new nest.
3. Changing environmental factors prevented access.

Technicians deemed 504 (2012, *n* = 346; 2013, *n* = 158) call stations inaccessible, unsafe, or in unsuitable habitat while in the field. In addition to call stations misidentified by GIS in steep locations or far from tree cover, technicians found 439 call stations in recently or currently logged or burned locations (2012, *n* = 87; 2013, *n* = 352).

At the beginning of each field season, we expected dynamic environmental factors to prohibit access due to high water, snow, or hazardous wildlife. Technicians never reported issues related to those factors in 2012; instead, the large Fontenelle Fire, which started on 24 June 2012, eliminated a large survey area. A total of 1,003 call stations previously expected to be surveyed were located within the burn perimeter. In 2013, eight call stations were not surveyed due to an adult black bear with a cub in the area, and one point was not surveyed due to high wind. As the project progressed and lower-ranking PSUs were evaluated, several high elevation PSUs, as a whole, were deemed inaccessible due to terrain or lacked suitable habitat (Table 2). This resulted in eliminating an additional 342 call stations.

Technicians conducted surveys at any location with suitable habitat that could be safely accessed and used the GIS designations of too steep or lack of tree cover only as a guide. During the 2 years, technicians surveyed 47 (2012, *n* = 30; 2013, *n* = 17) call stations designated as too steep by GIS and 11 (2012, *n* = 1; 2013, *n* = 10) call station designated as >150 m from tree cover. Thirty of the surveyed GIS-designated too steep call stations were at 36% slope as defined by GIS.

In all, 3,933 different call stations were surveyed, 6,402 call stations were evaluated and eliminated due to habitat suitability and safety, 1,683 call stations were within nest buffers, 1,400 call stations were located in burned areas, and 94 call stations were removed from the survey effort due to changing environmental conditions (Fig. 8). Of the remaining 1,126 call stations, 90 were located in Primary Nesting Habitat and 71 were located in Marginal Nesting Habitat.

Goshawks were detected in 7 of the 38 surveyed PSUs throughout the 2012 field season (Table 3). One detection was determined to be invalid because it was only an aural detection and later determined to be Gray Jay (*Perisoreus canadensis*) calls. Of the six PSUs with true detections in 2012, technicians found four new active nests (Table 4). Of the two detections that did not result in finding a nest, one detection was of a sub-adult that did not display any defensive behavior and the other was a fledgling detected late in the survey season (WY-BT-NOGO35; 21 August 2012). The naïve detection rate for PSUs surveyed in 2012 was 15.8% and 0.73 detections per 100 call stations. The first fledglings (n = 3) were observed on 19 July and were approximately 40 days post-hatch (no down was seen), and two of the three fledglings were capable of extended flight.

Technicians found one nest during the 2012 nestling season and three nests during the fledgling season (Table 4). Technicians found 2 nests ≤45 min of the initial detection, 1 of which was during the nestling season and the other during the fledgling season. The nest at WY-BT-NOGO49 was found during the 2nd nest search 10 days after the initial detection. Technicians found the nest at WY-BT-NOGO88 during the third nest search more than a month after the initial detection. S. Patla located the only nest in 2013 while conducting a nest search 42 days after the initial detection and first 2 nest searches. Both the initial detection and the successful nest search occurred during the fledgling season.

Of the four new nests found in 2012, three had confirmed young present (Table 4). During the initial detections, technicians reported three fledglings at PSUs WY-BT-NOGO33 and WY-BT-NOGO88 and one fledgling at WY-BT-NOGO49. Technicians were unable to count the number of young in the nest at WY-BT-NOGO5 at the time of discovery; however, they did see movement in the nest. When the technicians went back on the 24th of August to collect habitat data, no birds were seen in the area.

Goshawks were detected in 3 of the 43 surveyed PSUs throughout the 2013 field season (Table 5). One detection resulted in finding one new active nest in the adjacent PSU. The naïve detection rate for PSUs surveyed in 2013 was 7.0% and 0.17 detections per 100 call stations. The only fledglings (n = 2) were observed on 28 August and were well beyond 42 days post-hatch (fully fledged and no down was seen, even along the underside coverts).

One of the 2013 detections was made in a PSU that was burned in the Horseshoe Fire of 2007. The adult goshawk flew over the crew in a location that had no suitable nesting habitat due to the burn. Another detection was of an adult goshawk soaring above PSU WY-BT-NOGO35. This PSUs was resurveyed in 2013 because there was evidence of a nest in or near the PSU in 2012, but technicians were unable to devote significant time to nest searches before the end of the season. The 2013 crew spent approximately 7 hrs between 2 days searching for the nest without success. The final 2013 detection occurred in WY-BT-NOGO80. Technicians witnessed an adult female defending the area against a Red-tailed Hawk (*Buteo jamaicensis*) in the northeast part of the PSU. The technicians followed the bird and saw her defending the area from a Golden Eagle (*Aquila chrysaetos*). She eventually flew into the canopy near the center of the PSU. Technicians spent approximately 4.5 hrs searching that area for a nest without success. S. Patla returned to the area to conduct a nest search later in the season. On her way into the PSU, she detected two fledglings approximately 700 m north of the original detection point. Upon further exploration, she located a nest (approximately 650 m north of the original detection point) within the adjacent PSU, WY-BT-NOGO56. After finding the nest in WY-BT-NOGO56, she spent >1 hr trying to locate a nest around the center of WY-BT-NOGO80 (where the goshawk flew into the canopy) without success.

The Department provided coordinates for seven historical nest sites. Technicians visited all the historic nest sites one time each between 7 June and 18 June 2012. Two historic nests were active, with aggressive or incubating adults. There was evidence of hatching at one nest, but technicians were unable to count nestlings because the female was brooding. Technicians were unable to observe another nest because the adult female was very defensive. The Fontenelle Fire likely burned both of these active historic nest sites based on the burn perimeter and personal observation of the area surrounding the nest. Of the inactive historic nest sites, technicians found all but one nest tree. The technicians suspect the tree had fallen as there was significant blow-down in the area. Technicians played calls between 0 m and 500 m of the inactive nest sites and did not receive any response; no alternative nest sites were located in 2012.

Technicians revisited two of the historic nest sites and all four of the nests found in 2012 one time between 5 June and 9 June 2013. A USFS wildlife crew surveyed within the Fontenelle burn perimeter and near the McDougal Gap and Pass nest sites for future timber project work. Because they would be in the area, they took responsibility in checking the remaining historic nest sites. All nests were inactive when visited. There was a detection near the McDougal Gap nest site, but no new nests were found.

Three of the five newly discovered nests were in lodgepole pine trees, one was in a Douglas-fir and one was in a limber pine (Table 6). All new nest trees were found at elevations between 2,510 and 2,644 m on gentle to moderate slopes and with northerly to northeasterly facing aspects.

Nest plot (0.217 ha) habitat data are summarized in Table 7. The plot area around each nest tree consisted primarily of lodgepole pine and Douglas-fir forests. Some plots also contained subalpine fir (*Abies lasiocarpa*), limber pine, and Engelmann spruce (*Picea engelmanii*). The understory consisted of coniferous seedlings and low-growing (≤12.7 cm) forbs at most sites. The WY-BT-NOGO49 and WY-BT-NOGO88 nest sites had denser understory (4,207 seedlings per ha and 4,622 seedlings per ha, respectively) than WY-BT-NOGO5 and WY-BT-NOGO33 (3,613 seedlings per ha and 2,041 seedlings per ha, respectively). The understory in WY-BT-NOGO56 nest site (14,332 seedlings per ha) was more than 3.1× more dense than the understory of WY-BT-NOGO88. Nest plot canopy cover averaged 62%. The WY-BT-NOGO56 canopy cover was significantly less than the other sites. This nest was located in a lodgepole pine stand where a majority of the large diameter trees were dead. However, there was significant regeneration within the plot causing that location to have the highest number of live trees per ha. The average number of live mature trees per hectare for the nest stand plots was 286. The average downfall per hectare for the nest stand plots was 334 trees. WY-BT-NOGO33, WY-BT-NOGO56, and WY-BT-NOGO88 plots all consisted of about 39% of dead trees; WY-BT-NOGO33 consisted of 24% dead trees. WY-BT-NOGO5 was the only location where there were more dead trees than live trees (62%). Stand Basal Area of live trees averaged 20 m^2 per ha (range: 15-28. Stand Basal Area of mature live trees averaged 17 m^2 per ha.

We combined new and historical nest data to provide descriptive statistics for the elevation, aspect, and slope variables (Table 8). All nests were found at elevations between

2,453 m and 2,644 m with an average of 2,554 m (SE = 15.0). Slope averaged 23% (SE = 2.9) and nest aspect was between 340° to 67° (NNW to ENE).

In between the 2012 and 2013 field seasons, the ranking system and accuracy of the GIS layers were evaluated to determine if a better method could be used to rank PSUs. According to the LANDFIRE layer (2012), only one of the historic nest sites was located in a Douglas-fir stand; all other nest sites were located in Engelmann spruce stands (Table 9). However, all the historic nest trees were all lodgepole pine, Douglas-fir trees, or subalpine fir (one nest only). Furthermore, according to the LANDFIRE layer, all of the new nest sites were located in Engelmann spruce stands, but habitat data show none of the nest trees were Engelmann spruce nor were most of the nests located in Engelmann spruce-dominated stands. Only one new nest site, WY-BT-NOGO33, had a spruce component. We sought better GIS layers to use to rank the remaining PSUs because of these inconsistencies. The USFS recently completed a nesting habitat layer that used historical nest site data throughout the BTNF to select habitat that contained features commonly used by nesting goshawks (LANDFIRE 2012). These polygons contained elevation <2,896 m, slope ≤50%, aspect between 270° and 90°, aspen, lodgepole pine, Douglas fir, and subalpine fir forest types with a canopy closure of ≥45% and dbh ≥5 in patches ≥16 ha. All historic and new nests (within USFS boundaries) were located within the primary nesting habitat as defined by the USFS. The study area was 4% primary habitat as defined by the LANDFIRE layer (Fig. 4); whereas, 26% of the study area fell within primary nesting habitat as defined by the BTNF layer (Fig. 5).

The 30-year (1981-2010) monthly mean temperature for March, April, and May was -3.2° C, 2.6° C, and 7.3° C, respectively (Fig. 9). Average monthly temperatures during the 2012 spring were higher for each month than the 30-year average (March: 0.7° C, April 4.6° C, May: 8.4° C). Temperatures in March and May of 2013 were warmer than the 30-year average (-1.7° C and 9.1° C, respectively) but averaged colder in April (1.1° C). The 2012 springtime was drier and had less snowfall than average (Fig. 10). The 2013 spring started out drier than average, but a large storm from 30 April through 1 May dropped 1.3 cm of precipitation (61% of the average precipitation for May), and another large storm in late-May dropped another 1.2 cm of rain. The total precipitation for May was 3.22 cm; which is 1.5× the average.

DISCUSSION

The number of PSUs surveyed for both the 2012 (n = 38) and 2013 (n = 43) season was less than expected (55 PSUs per year) but still greater than the minimum estimate of 22 surveys per year. The largest factor increasing the PSU survey time (avgerage of 4.2 survey days) and decreasing the number of surveyed PSUs in 2012 was the impact of the Fontenelle Fire, which prevented each crew from working for about 5 days (10 survey days). Technicians were able to work while the fire was actively burning, but had to leave the study area at times because of evacuations, smoke, and logistical planning needs. Not only did technicians spend more time hiking in and out of PSUs because of the fire, they also surveyed together more often for safety reasons. PSUs were completed in less time (3.7 survey days per PSU) during the 2013 season. A majority of PSUs located in the lower elevations and with better habitat were surveyed, whereas a majority of PSUs left un-surveyed had little suitable habitat and were generally inaccessible due to terrain (Fig. 7).

While the technical guide establishes methods that use broadcast acoustical surveys to determine occupancy, it also provides two methods for nest searches, one of which is conducting areal nest searches. This method is used in deciduous forests early in the nesting season. Areal searching was not considered for this project because the Wyoming Range is primarily covered in coniferous forests (LANDFIRE 2012). The other method is conducting intensive search surveys. This method requires the identification of primary forest stands most likely to contain nesting goshawks. Once the forest stands are identified, teams of technicians walk along pre-determine transects broadcasting goshawk calls at 250-m intervals. Although research suggests goshawks in the Greater Yellowstone Area prefer Douglas-fir and lodgepole pine stands, there is no current definitive research on nest-habitat preference in the Wyoming Range. About 4% of the study area is classified as Douglas-fir and lodgepole pine (LANDFIRE 2012). Additionally, the cover type in the Wyoming Range study area is predominantly Engelmann spruce-subalpine fir (36.7%) and some of these stands are >1,000 ha in size (LANDFIRE 2012). If survey effort concentrated only in the Douglas-fir and lodgepole pine stands, a significant portion of potentially suitable habitat within the study area would be ignored. There would also a be significant loss of cost effectiveness if technicians were to survey only the smaller, widely-spaced Douglas-fir and lodgepole pine stands randomly across the study area.

Stratification based on proximity to roads can be used to maximize cost effectiveness among high- and low-cost survey units. Because of the scale of the 600.25-ha PSUs, the size and location of the study area and road coverage, almost all PSUs were within 1.6 km of a road. Therefore, cost-stratification based on roads was not applicable.

The nest search protocol was effective in 2012 once a goshawk was detected. Four of six detections resulted in a found nest in, on average, less than two site visits. We did not expect a nest in the PSU where technicians detected the sub-adult goshawk. Although sub-adult goshawks are capable of breeding, successful nest attempts are unlikely (Squires and Reynolds 1997). Because of the bird's lack of defensive behavior, we believe there was no nest in that PSU. Adjusting for the sub-adult detection, four of five detections resulted in a found nest. Technicians did conduct a nest search after a fledgling was detected at WY-BT-NOGO35, but the nest search was conducted at the end of the day and technicians were unable to spend an appropriate amount of time conducting a thorough search. Technicians were unable to return to the PSU before the end of the field season.

Because nest searches were successful after a goshawk was detected in 2012, we believed we could find more nests in 2013 by increasing the detection rate rather than changing nest-search protocol. We aimed to increase the detection rate by prioritizing survey effort within preferred nesting habitat. Because finding new goshawk nests was the primary objective of this project and statistical analyses were not, we had the ability to adjust our sampling design to improve our chances of finding additional sites while still surveying all types of suitable nesting habitat. Changing some of the protocols was considered a favorable approach especially since the Fontenelle Fire decreased the amount of suitable habitat to survey within the study area. We initially used the LANDFIRE cover type layer (2012) because we thought it better differentiated between vegetation coverage and non-coverage and specific tree species. However, during the 2012 field season, very few of the LANDFIRE attributes matched what was seen at the nest sites; the NWGAP (2008) and BTNF Cover (USDA 2007) layers appeared to match actual habitat more accurately than the LANDFIRE layer. We believed we could improve detection rates by prioritizing specific locations within the study area where we were more likely to find goshawks, and re-ranking the PSUs according to more accurate cover layers. Based on summary statistics from new and historic nests, there is evidence we were more likely to find goshawk nests between about 2,454 and 2,636 m on NNW to ENE facing slopes with mild to moderate slopes (Table 8). The newly created primary nesting habitat layer provided by the USFS (LANDFIRE 2012) not only uses these elevation and aspect criteria, but also uses cover type based on the BTNF Cover layer.

2013 was a poor year for goshawk detections within the Wyoming Range. There were no significant changes in the survey protocol, crew experience, or survey effort between 2012 and 2013. Although PSUs were ranked differently between years, technicians still surveyed all suitable habitat within a PSU and surveyed several PSUs with significant amounts of suitable habitat, whether it was defined by primary habitat or primary nesting habitat. Detection probabilities and rates vary within populations season-to-season with many factors (e.g., fire, weather, and species productivity; MacKenzie et al. 2002, Reich et al. 2004, Patla 2005). There were significant differences in springtime weather between 2012 and 2013 and the area's 30-year average. According to the nearest weather stations to the Wyoming Range (with comprehensive historical data), March, April, and May 2012 were drier and warmer than the 30-year average, and the area suffered no significant weather events in that timeframe, whereas in 2013, there was a wet and cold storm that occurred 30 April through 1 May. Weather could explain the low detection rate in 2013 as it has been shown that goshawk productivity deceases with cold, wet springs (Younk and Bechard 1994, Patla 1997).

Despite the overall low detection rate, we still recommend using methods to prioritize survey effort at the point and regional scale while still sampling locations with suitable habitat where no empirical data exist about nesting preferences for that specific region. We recommend keeping slope and tree-cover elimination procedures. We believe using GIS to determine which call stations to eliminate was effective for increasing the cost effectiveness and safety of the fieldwork without significantly decreasing the likelihood of a technician surveying at suitable locations. While in the field, technicians agreed with GIS designations more often than not and, when inconsistencies arose, GIS was conservative with the elimination. For example, there were only 11 call station eliminated by GIS because of tree cover that were actually ≤150 m from tree cover, whereas there were 246 call stations labeled by GIS as safe and ≤150 m from suitable habitat that were actually >150 m from tree cover. In addition, only 1 of the 12 nests (historical and new) were located on a hill with a slope >36%. Budget allowances and overall project goals will be the primary factor when considering large-scale survey or search effort. For example, occupancy monitoring can give you an indication of population gains or declines within a region at a relatively low cost (MacKenzie and Royle 2005, Woodbridge and Hargis 2006); however, resulting data are less detailed than those obtained from abundance studies (MacKenzie and Royle 2005). Finding goshawk nests can be a daunting task even with the knowledge that goshawks prefer large, mature stands of trees with a high percent of canopy cover for nesting habitat (Reynolds et al. 1992, Patla 1997, Anderson et al. 2005) because the species breeds at low densities in landscapes that are difficult to access and traverse (Woodbridge and Hargis 2006). Often goshawk nesting site studies begin with known territories and supplement their sample size with opportunistic findings or systematic searches (Bright-Smith and Mannan 1994, Patla 1997, Reich et al. 2004, Patla 2005, Zarnetske et al. 2007, Beier et al. 2008). Therefore, there is a possibility habitat data collected at these sites contain biases related to the purpose behind the original project (e.g., timber sale surveys). If the primary goal of a project is to find new goshawk nests and territories, we believe using GIS to determine landscape features that select preferred nesting habitat can greatly improve the chances of finding goshawk nests. However, the data collected to determine preferred habitat should be collected at locations found by using a probabilistic sample.

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Table 1. Final call station categorization and completion summary for Northern Goshawk (*Accipiter gentilis*) surveys conducted in the Wyoming Range, 2013-2013.

Surveyed		2012	2013	Total
Season	Nestling			
	Fledgling			
Total surveyed		2,196	1,737	3,933
Not surveyed				
GIS [a]	Habitat	5,565	0	5,565
	Burn	1,044	0	1,044
	Nest	1,678	5	1,683
Technician [b]	Habitat	274	91	365
	Inaccessible	72	67	139
	Burn	4	352	356
	Logging	85	0	85
	Other	0	9	9
Project coordinator [c]	Habitat	0	104	104
	Inaccessible	0	229	229
Uncategorized [d]				1,126
Total not surveyed				10,705
			Grand total	14,638

[a] Call stations were eliminated from the survey effort by ArcGIS based on habitat suitability (slope <36% and <150 m away from forest cover), the burn perimeter of the Fontenelle Fire, and distance from historic and newly found nests.
[b] Call stations were eliminated from the survey effort by technicians in the field based on habitat suitability, accessibility, and safety.
[c] The project coordinator further eliminated call stations based on ArcGIS, satellite imagery, and experience and knowledge of the study area.
[d] Uncategorized call stations are points that were not surveyed or assessed in the field before the end of the project time period and that do not fall within an above-mentioned category.

Table 2. Surveyed Primary Survey Units (PSU) and call stations during the June-August 2012 Northern Goshawk (*Accipiter gentilis*) nest search and monitoring field season in the Wyoming Range. Technicians or GIS eliminated call stations that were located in unsuitable or unsafe areas or areas that were inaccessible due to surrounding terrain. PSUs had a ≤120 call stations, but fewer were possible if the PSUs were located on the study area boundary. * indicates a PSU with detections.

PSU ID	Survey date	Points surveyed	Points eliminated	Total points
WY-BT-NOGO1	15 Jun, 18 Jun, 19 Jun	41	5	46
WY-BT-NOGO2	11-15 Jun	101	0	101
WY-BT-NOGO3	19 Jun, 20 Jun	10	62	72
WY-BT-NOGO4	5 Jul, 8 Jul	55	65	120
*WY-BT-NOGO5	27 Jun, 30 Jun, 1-3 Jul	87	33	120
WY-BT-NOGO7	4 Aug, 5 Aug, 7 Aug	87	33	120
WY-BT-NOGO8	21 Jun, 22 Jun, 25 Jun, 26 Jun	119	1	120
WY-BT-NOGO9	5-7 Jul, 9 Jul	100	20	120
WY-BT-NOGO11	8 Aug, 14 Aug, 15 Aug	44	76	120
WY-BT-NOGO13	20 Jun	19	53	72
WY-BT-NOGO14	11 Jun	13	107	120
WY-BT-NOGO15	26 Jun, 20 Aug, 21 Aug	32	88	120
WY-BT-NOGO16	29 Jun, 10 Jul, 11 Jul, 12 Jul	70	50	120
WY-BT-NOGO17	9-11 Jul	52	10	62
WY-BT-NOGO20	2-4 Jul	89	31	120
WY-BT-NOGO21	17-19 Jul, 21 Jul, 22 Jul	75	45	120
WY-BT-NOGO23	16 Aug, 17 Aug	34	86	120
WY-BT-NOGO29	26 Jul, 27 Jul	68	4	72
WY-BT-NOGO30	12 Jun, 14 Jun, 17 Jun, 20 Jun	96	24	120
WY-BT-NOGO31	25 Jun, 26 Jun, 18 Aug	76	44	120
WY-BT-NOGO32	2 Aug, 3 Aug	99	21	120
*WY-BT-NOGO33	4 Aug, 6 Aug	74	46	120
*WY-BT-NOGO35	21 Aug	15	0	24
*WY-BT-NOGO36	8 Jul, 9 Jul	79	41	120
WY-BT-NOGO37	23 Jul, 25 Jul	23	97	120
WY-BT-NOGO42	8 Aug	10	15	25
WY-BT-NOGO45	27 Jul, 29-31 Jul	119	1	120
*WY-BT-NOGO49	7 Aug, 8 Aug, 14 Aug	106	14	120
WY-BT-NOGO51	9 Aug	26	94	120
WY-BT-NOGO52	15 Jul	6	6	12
WY-BT-NOGO54	21 Jun	19	101	120
WY-BT-NOGO56	2 Jul, 3 Jul	38	82	120
WY-BT-NOGO58	19 Jun, 20 Jun, 21 Jun, 24 Jun	75	45	120
WY-BT-NOGO68	1 Jul, 9 Jul, 12 Jul	49	71	120
WY-BT-NOGO73	15 Aug, 17 Aug	54	66	120
WY-BT-NOGO83	17 Jul	21	30	51
*WY-BT-NOGO88	15 Jul, 16 Jul, 18 Jul, 19 Jul	104	16	120
WY-BT-NOGO108	11 Jul	11	109	120
Total		2196	1692	3897

Table 3. Surveyed Primary Survey Units (PSU) and call stations during the June-August 2013 Northern Goshawk (*Accipiter gentilis*) nest search and monitoring field season in the Wyoming Range. Technicians or ArcGIS eliminated call stations that were located in unsuitable or unsafe areas or areas that were inaccessible due to surrounding terrain. PSUs had ≤120 call stations, but fewer were possible if the PSUs were located on the study area boundary. * indicates a PSU with detections.

PSU ID	Survey date	Points surveyed	Points eliminated	Total points
WY-BT-NOGO12	3 Jul, 4 Jul	23	97	120
WY-BT-NOGO22	2 Aug, 3 Aug	32	88	120
WY-BT-NOGO24	5 Jul, 6 Jul	32	88	120
WY-BT-NOGO25	22 Aug, 23 Aug	35	13	48
WY-BT-NOGO26	28 Aug	19	101	120
WY-BT-NOGO27	1 Aug, 2 Aug	21	99	120
WY-BT-NOGO28	25 Jul, 26 Jul, 31 Jul	40	80	120
*WY-BT-NOGO35	31 Jul, 1 Aug	22	2	24
WY-BT-NOGO40	8 Jul, 9 Jul	24	96	120
WY-BT-NOGO41	21 Aug, 22 Aug	31	9	40
WY-BT-NOGO43	26 Jul, 2 Aug, 3 Aug	35	85	120
WY-BT-NOGO44	23-25 Jul	62	58	120
WY-BT-NOGO53	13-15 Aug	41	79	120
WY-BT-NOGO54	20 Aug	7	94	101
WY-BT-NOGO55	8 Aug, 9 Aug	28	92	120
WY-BT-NOGO57	19 Jun, 20 Jun, 21 Jun	98	17	115
*WY-BT-NOGO60	7 Jul, 8 Jul	35	17	52
WY-BT-NOGO63	21 Aug	6	18	24
WY-BT-NOGO65	25 Jun, 26 Jun	18	54	72
WY-BT-NOGO66	26 Aug, 27 Aug	26	11	37
WY-BT-NOGO69	26 Jun, 27 Jun, 2 Jul	99	21	120
WY-BT-NOGO76	6 Aug	23	1	24
*WY-BT-NOGO80	17-19 Jul	45	75	120
WY-BT-NOGO83	7-9 Aug, 14 Aug	72	29	101
WY-BT-NOGO84	7 Jul	24	96	120
WY-BT-NOGO89	21 Jun, 25 Jun	57	63	120
WY-BT-NOGO91	10 Jun, 11 Jun	42	78	120
WY-BT-NOGO95	18 Jul	20	100	120
WY-BT-NOGO96	5-7 Jul	100	20	120
WY-BT-NOGO97	14 Aug, 16 Aug, 17 Aug	51	69	120
WY-BT-NOGO100	9 Jul	8	112	120
WY-BT-NOGO103	11 Jun, 12 Jun, 18 Jun, 19 Jun	72	48	120

Table 3. Continued.

PSU ID	Survey date	Points surveyed	Points eliminated	Total points
WY-BT-NOGO104	16-18 Jul	71	45	116
WY-BT-NOGO105	15 Aug	14	106	120
WY-BT-NOGO109	5 Jul	5	92	97
WY-BT-NOGO117	4 Jul	1	111	112
WY-BT-NOGO125	9 Jul, 16 Jul, 17 Jul	104	16	120
WY-BT-NOGO134	23-25 Jul	55	65	120
WY-BT-NOGO135	6 Aug, 7 Aug	24	96	120
WY-BT-NOGO140	3 Jul, 4 Jul	79	41	120
WY-BT-NOGO143	19 Jul, 23 Jul, 24 Jul	82	38	120
WY-BT-NOGO145	18 Jul, 19 Jul	56	64	120
WY-BT-NOGO148	8 Jul	20	100	120
Total		1,759	2,684	4,443

Table 4. Summary of Northern Goshawk (*Accipiter gentilis*) detections and nests found during the 2012 survey effort in the Wyoming Range. Locations are considered sensitive information and have not been included in this report.

PSU ID	Initial detection	Detection type	Nest found	No. young
WY-BT-NOGO5	3 Jul 2012	Active Nest, Visual	3 Jul 2012	unk[a]
WY-BT-NOGO33	6 Aug 2012	Aural, Visual	6 Aug 2012	3
WY-BT-NOGO49	7 Aug 2012	Active Nest, Aural, Visual	17 Aug 2012	1
WY-BT-NOGO88	16 Jul 2012	Aural, Visual	23 Aug 2012	3
WY-BT-NOGO2	11 Jun 2012	Aural [b]		
WY-BT-NOGO36	9 Jul 2012	Aural, Visual[c]		
WY-BT-NOGO35	21 Aug 2012	Aural, Visual		1

[a] Two defensive adults; movement seen in nest but unable to count nestlings.
[b] False detection (mimicking jays).
[c] Non-defensive sub-adult.

Table 5. Summary of Northern Goshawk (*Accipiter gentilis*) detections and nests found during the 2013 survey effort in the Wyoming Range. Locations are considered sensitive and have not been included in this report.

PSU ID	Initial detection	Detection type	Nest found	No. young
WY-BT-NOGO80 [a]	17 Jul 2013	Aural, Visual	28 Aug 2013	2
WY-BT-NOGO35	31 Jul 2013	Visual		
WY-BT-NOGO65	25 Jun 2012	Aural, Visual		

[a] Associated nest located in adjacent PSU (WY-BT-NOGO56).

Table 6. Northern Goshawk (*Accipiter gentilis*) nest tree habitat data collected 2012-2013 in the Wyoming Range. Elevation, aspect, and slope were determined using GIS. All GIS elevation figures are within 15 m of GPS readings. All GIS aspect figures are within 10° of compass readings by technicians. All GIS slope figures are within 5° of clinometer reading by technicians.

	WY-BT-NOGO5	WY-BT-NOGO33	WY-BT-NOGO49	WY-BT-NOGO56	WY-BT-NOGO88
Tree species	Douglas-fir	Limber pine	Lodgepole pine	Lodgepole pine	Lodgepole pine
Nest tree alive?	Yes	Yes	No	No	Yes
Topographic location	Upper 1/3	Lower 1/3	Lower 1/3	Middle 1/3	Lower 1/3
Tree height (m)	21	23.5	22.9	18.6	20.7
Nest height (m)	13.4	14	17.4	17.4	10.7
Nest aspect	215°	60°	202°	59°	235°
Elevation (m)	2,543	2,526	2,595	2,644	2,510
Slope aspect	353°	356°	50°	354°	39°
Slope	13° (23%)	16° (29%)	16° (29%)	13° (23%)	8° (14%)
DBH (cm)	61.5	62.7	32.3	24.4	37.8
Age (years)	275	131	165	199	113
Tree canopy cover	85%	50%	-	-	70%
Live canopy height (m)	12.8	14.6	n/a	n/a	10.7

Table 7. Northern Goshawk (*Accipiter gentilis*) nest area habitat summary data collected 2012-2013 in the Wyoming Range, Wyoming. Douglas-fir (DF; *Pseudotsuga menziesii*), Engelmann spruce (ES; *Picea engelmannii*), lodgepole pine (LPP; *Pinus contorta*), limber pine (LMP; *Pinus flexilis*), and subalpine fir (SAF; *Abies lasiocarpa*). When listed, standard errors are within parenthesis.

	WY-BT-NOGO5	WY-BT-NOGO33	WY-BT-NOGO49	WY-BT-NOGO56	WY-BT-NOGO88
Canopy cover	76%	61%	79%	24%	69%
No. of seedlings	2497	2041	2908	14332	3194
Downfall	420	138	331	263	516
Mean ground cover height (cm)	9	10	12	30	13
Dominant ground cover	Arnica	Grass	Arnica	Vaccinium	Senecio
No. of live trees	459	700	452	1281	803
No. of live mature trees	166	295	191	359	420
No. of dead trees	752	461	140	829	510
Live mature tree average DBH (cm)	30.2 (3.3)	33.1 (1.6)	35.2 (1.9)	27.8 (1.3)	29.1 (1.2)
Dead tree average DBH (cm)	13.2 (1.6)	25.8 (3.7)	21.5 (3.0)	22.71 (2.2)	19.29 (1.5)
Live stand basal area (m^2/ha)	17	15	23	28	18
Live mature stand basal area (m^2/ha)	14	13	20	24	15
Dead stand basal area (m^2/ha)	19	18	14	20	18
Live SAF average DBH (cm)	10.1 (-)	11.4 (2.2)			16.4 (2.6)
Live LPP average DBH (cm)	24.7 (4.1)	30.5 (-)	25.5 (2.8)	21.0 (1.3)	28.9 (1.2)
Live ES average DBH (cm)		26.0 (3.7)			
Live LMP average DBH (cm)		36.6 (4.4)			
Live DF average DBH (cm)	14.8 (2.0)	13.9 (3.2)	16.0 (1.7)	15.0 (2.4)	18.2 (1.6)
Dead LPP average DBH (cm)	32.6 (3.9)	30.4 (-)	25.9 (3.2)	22.7 (2.2)	22.8 (1.4)
Dead DF average DBH (cm)	8.3 (0.6)	7.0 (0.4)	6.8 (0.8)		7.1 (0.5)

Table 8. New and historical Northern Goshawk (*Accipiter gentilis*) nest (n = 12) topographical summaries in the Wyoming Range. All data were determined using ArcGIS. Nests were active ≥1 year between 2009 and 2013.

Variable	Average	SE	SD	Minimum / maximum	Range
Elevation (m)	2,554	15.0	51.8	2,453 / 2,644	627
Aspect (°)	16	7.4	25.5	340 / 67	87
Slope (%)	23	2.9	10.0	5 / 45	40

Table 9. Comparison of Northern Goshawk (*Accipiter gentilis*) nest tree and plot (0.217 ha) field data to GIS layers after the 2012 field season in the Wyoming Range. Douglas-fir (DF; *Pseudotsuga menziesii*), Engelmann spruce (ES; *Picea engelmannii*), lodgepole pine (LPP; *Pinus contorta*), limber pine (LMP; *Pinus flexilis*), and subalpine fir (SAF; *Abies lasiocarpa*).

Nest site	Plot habitat	Nest tree species	LANDFIRE[a]	NWGAP[b]	BT-Cover[c]
MDG		LPP	ES	ES, SAF	SAF
MDP		DF	ES	LPP	LPP
MB		DF	ES	LPP	LPP
NPC		LPP	ES	LPP	LPP
SFC		LPP	ES	LPP	DF
SPC		DF	DF	LPP	n/a
TP		LPP	ES	ES, SAF	SAF
WY-BT-NOGO5	DF (64%), LPP (33%), SAF (3%)	DF	ES	ES, SAF	SAF
WY-BT-NOGO33	ES (37%), SAF (34%), DF (21%), LMP (5%), LPP (3%)	LMP	ES	LPP	SAF
WY-BT-NOGO49	LPP (51%), DF (49%)	LPP	ES	LPP	SAF
WY-BT-NOGO88	DF (59%), LPP (35%), SAF (6%)	LPP	ES	LPP	LPP

[a] LANDFIRE 2012.
[b] NWGAP 2008.
[c] USDA 2007.

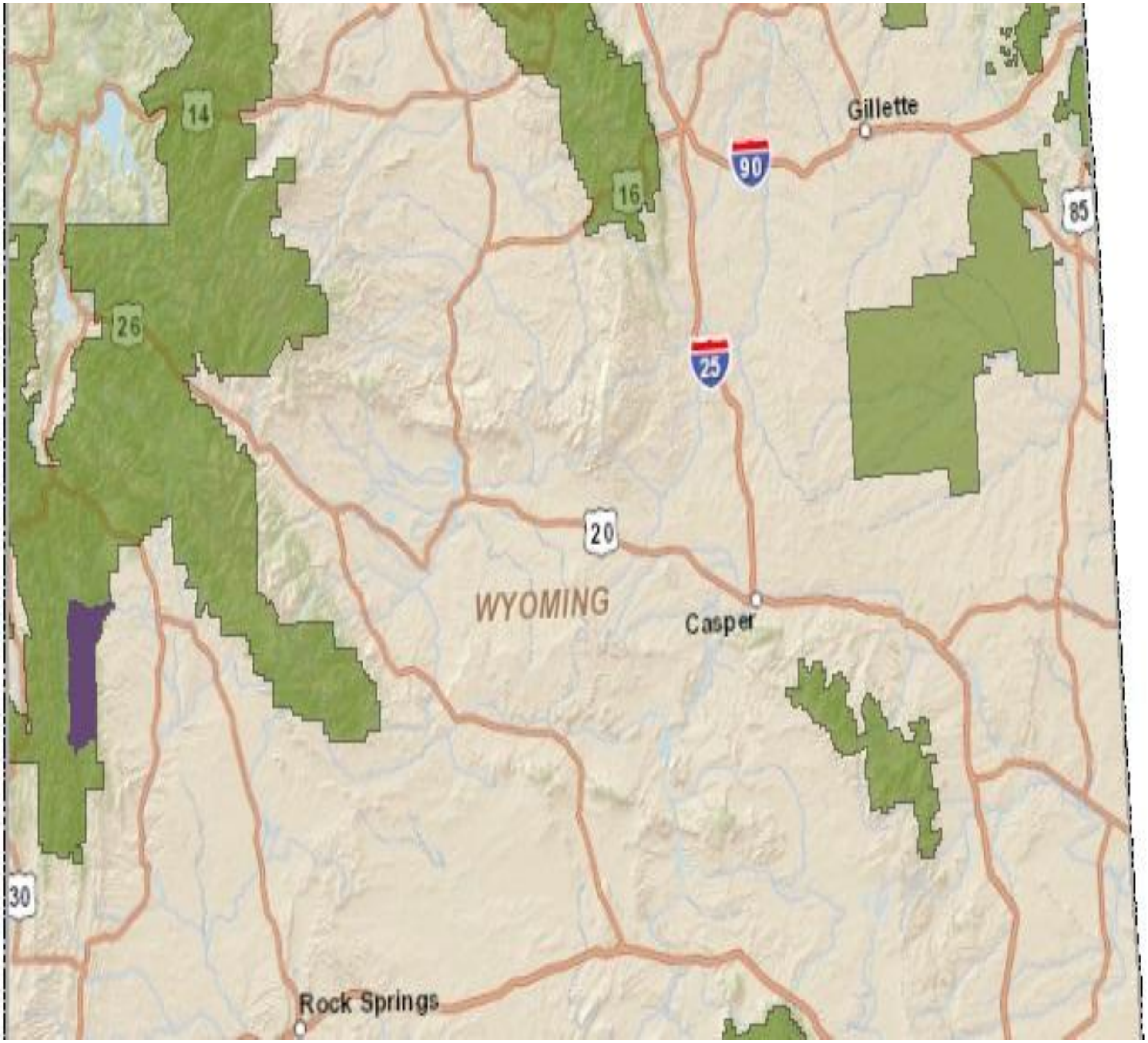

Figure 1. The Northern Goshawk (*Accipiter gentilis*) nest search and monitoring study area in the Wyoming Range, 2012-2013. Scale is 1:3,500,000.

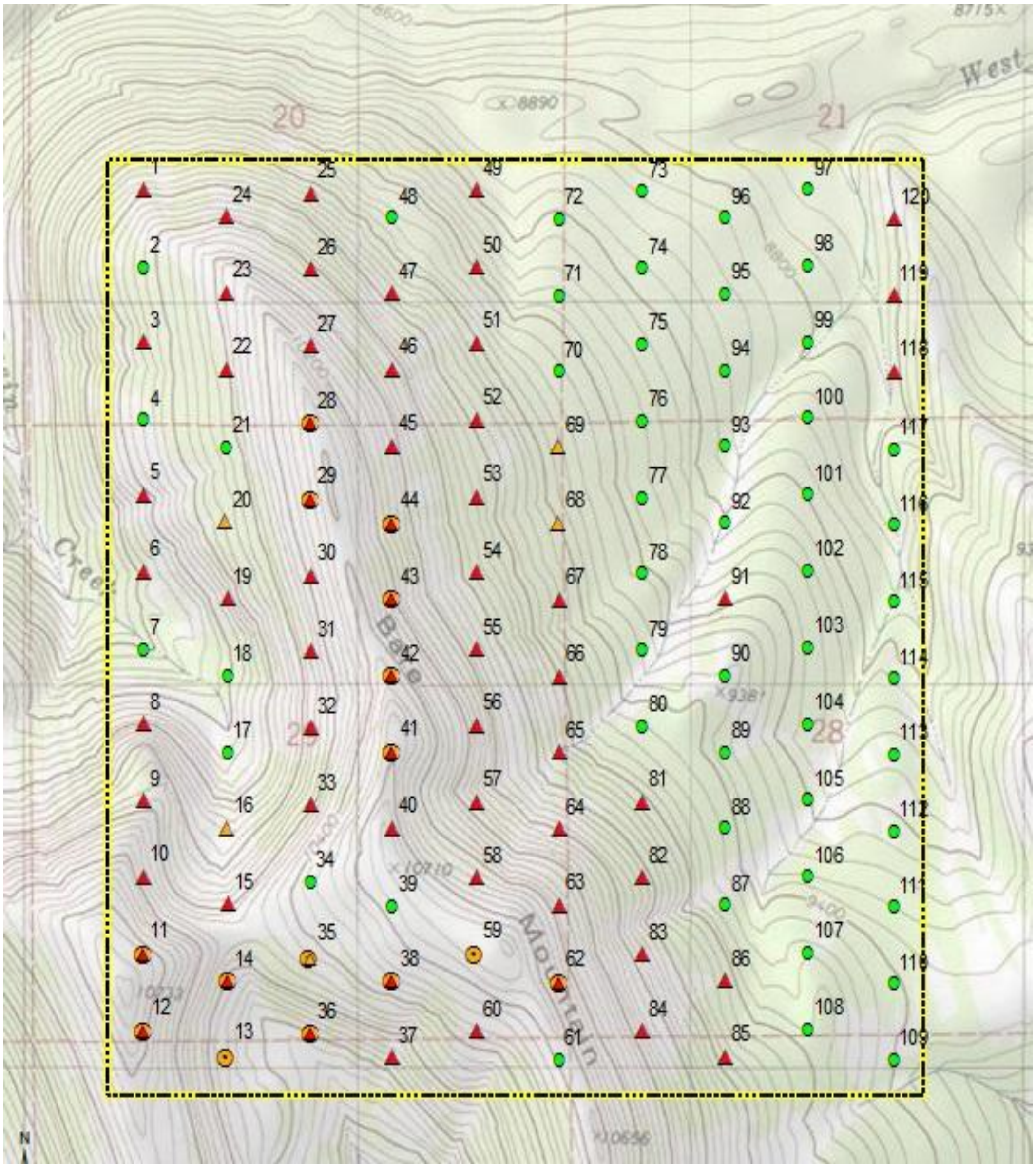

Figure 2. Primary Sampling Unit for Northern Goshawk (*Accipiter gentilis*) surveys in the Wyoming Range, 2012-2013. Scale is 1:20,000.

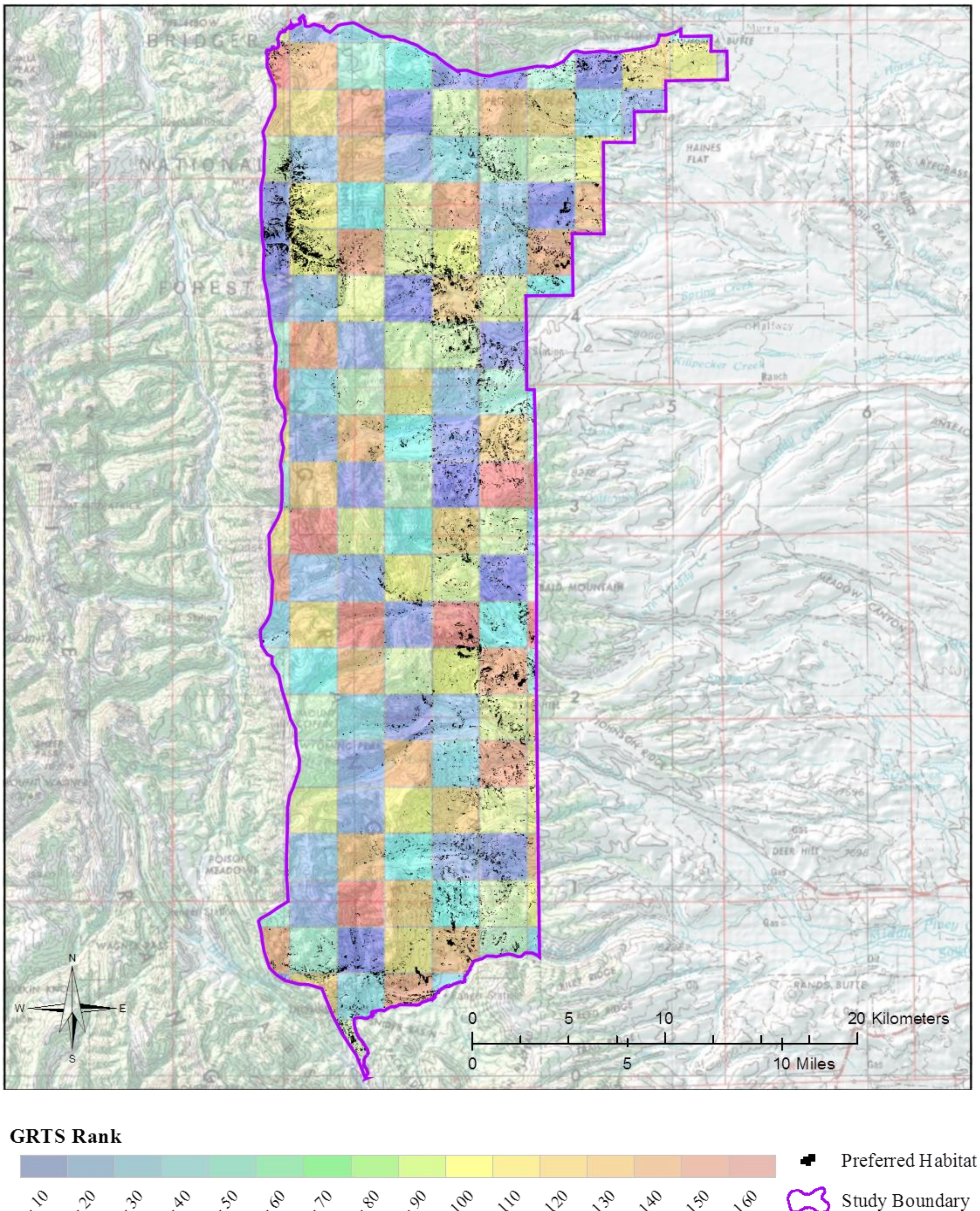

Figure 3. Primary Sampling Unit ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by generalized random-tessellation stratification function in R, Wyoming Range, 2012. Scale is 1:265,000.

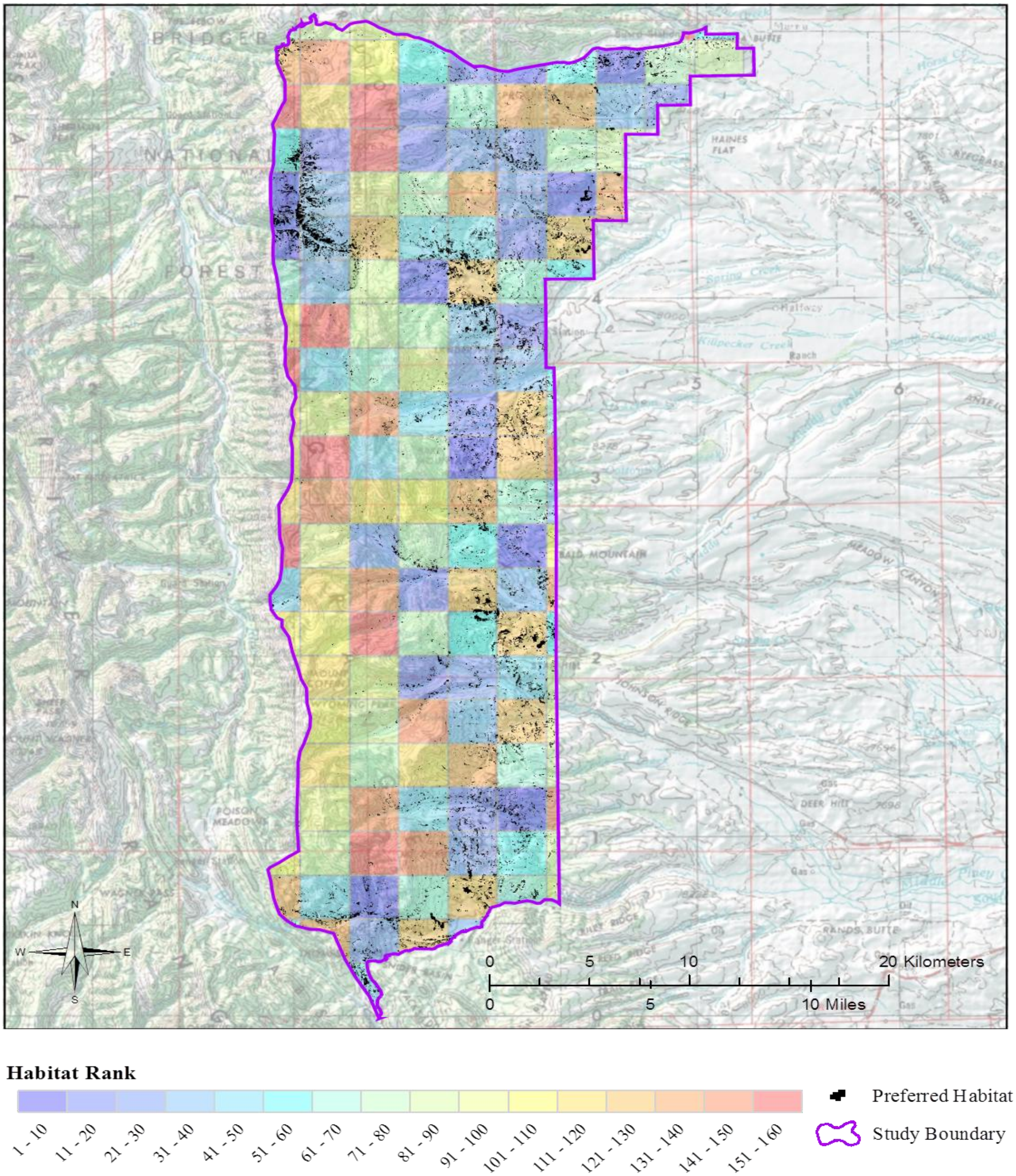

Figure 4. Primary Sampling Unit ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by generalized random-tessellation stratification and habitat weighting, Wyoming Range, 2012. Preferred habitat for Northern Goshawks includes Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) stands. Scale is 1:265,000.

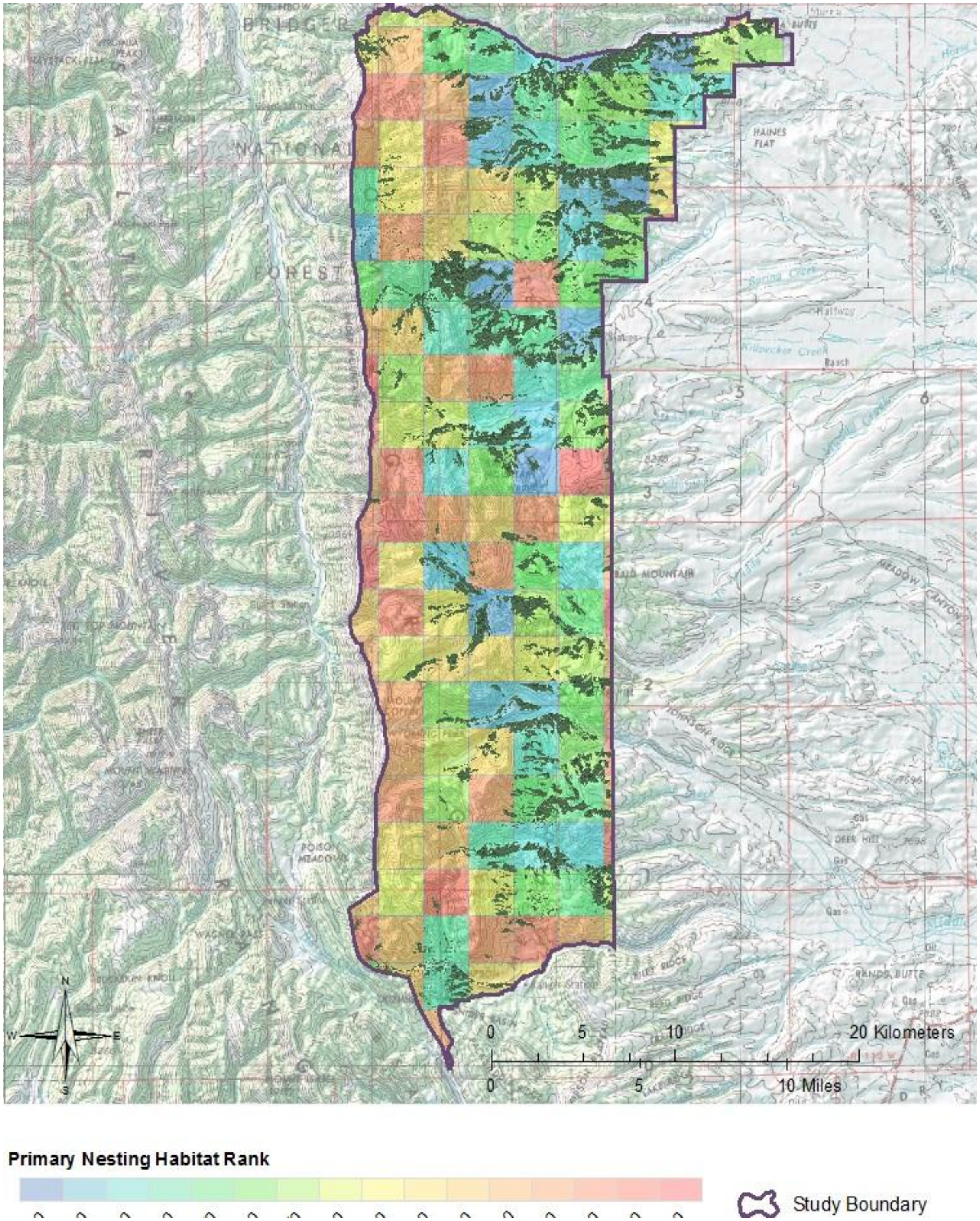

Figure 5. Primary Sampling Unit ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by generalized random-tessellation stratification and primary nesting habitat weighting, Wyoming Range, 2013. Scale is 1:265,000.

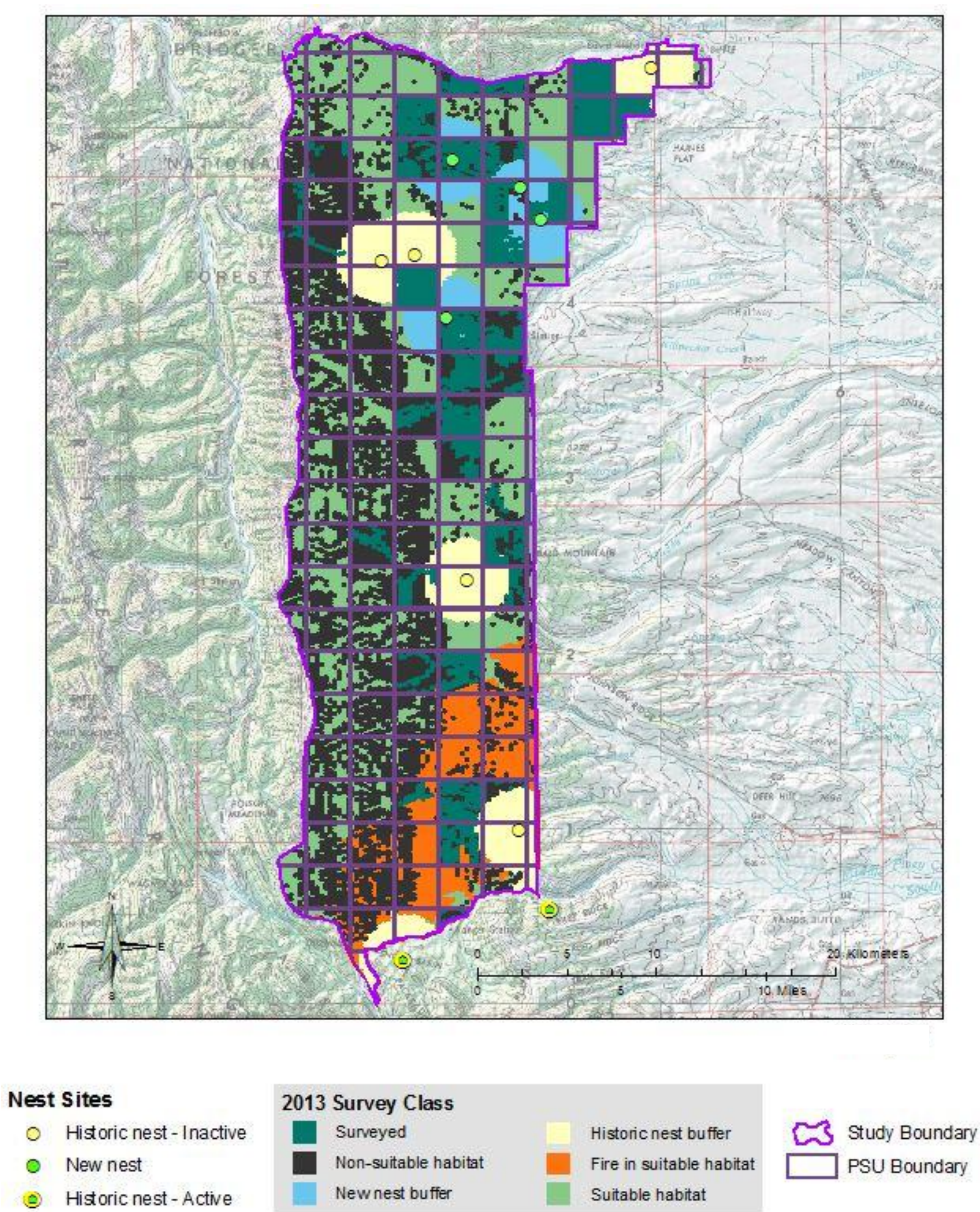

Figure 6. Survey class results determined by Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, during the 2012 field season, 10 June-21 August. Scale is 1:265,000.

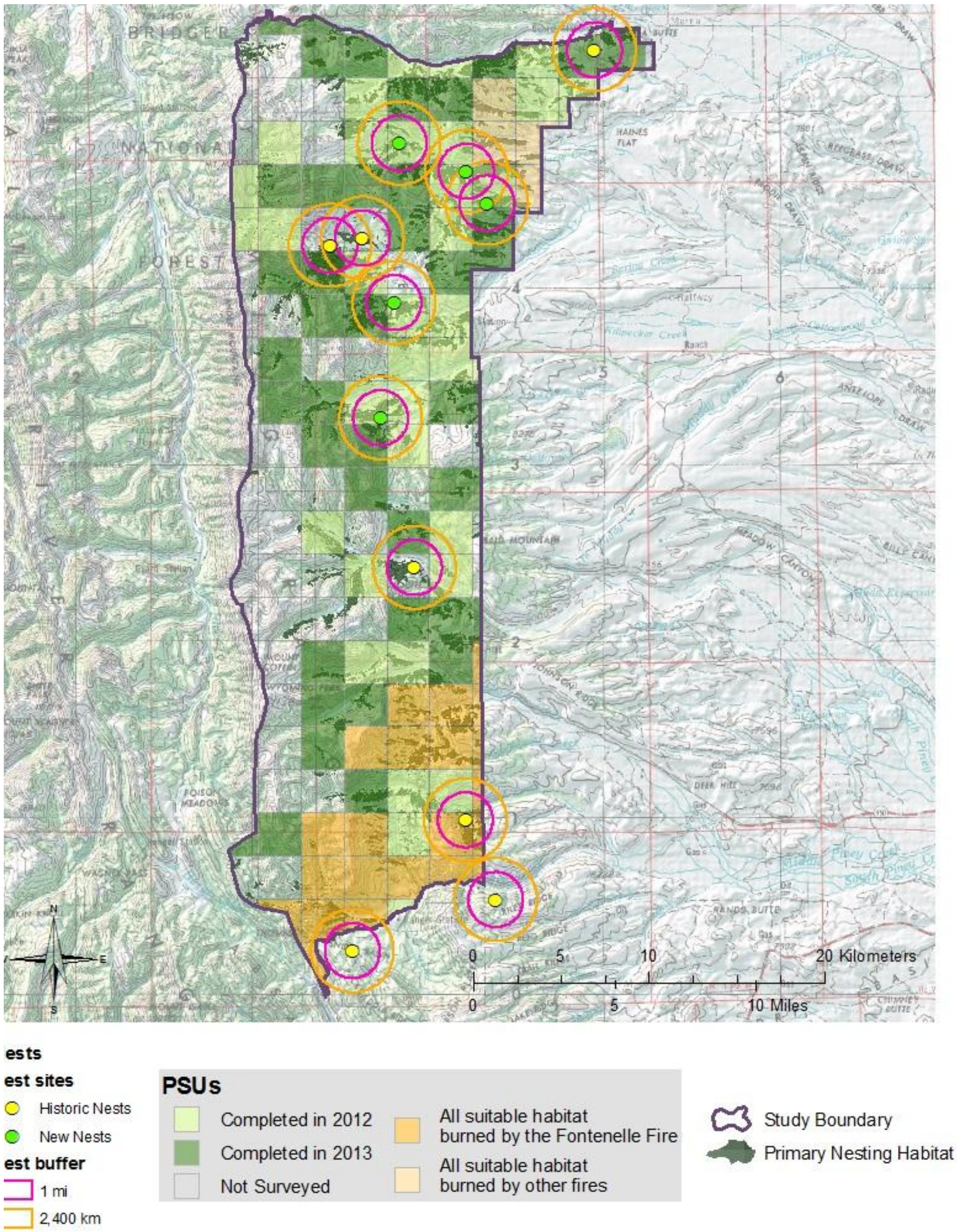

Figure 7. Final survey effort by Primary Sampling Unit for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, during the 2012 and 2013 field seasons. Scale is 1:265,000.

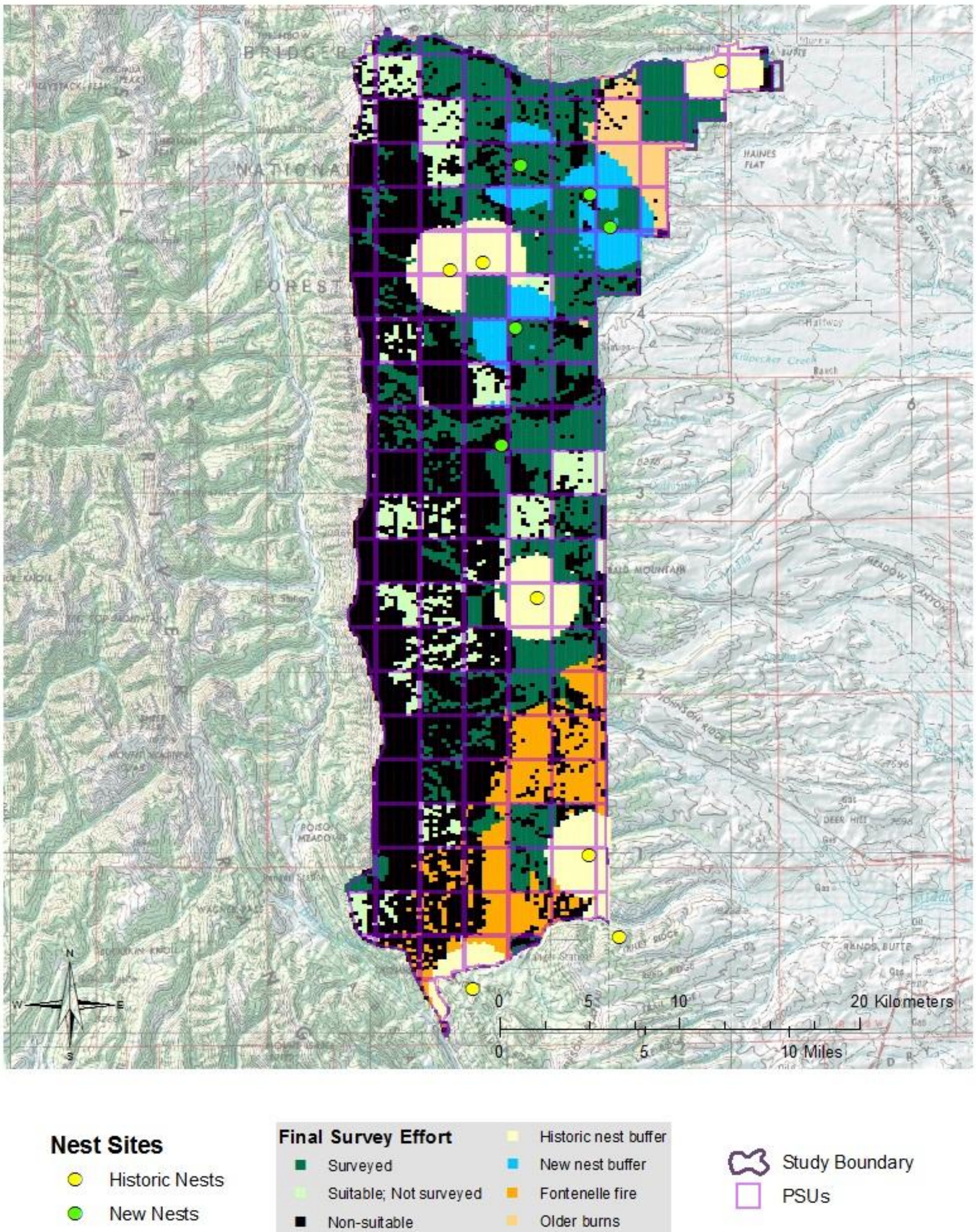

Figure 8. Final survey class results determined by Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, during the 2013 field season, 10 June-28 August. Scale is 1:265,000.

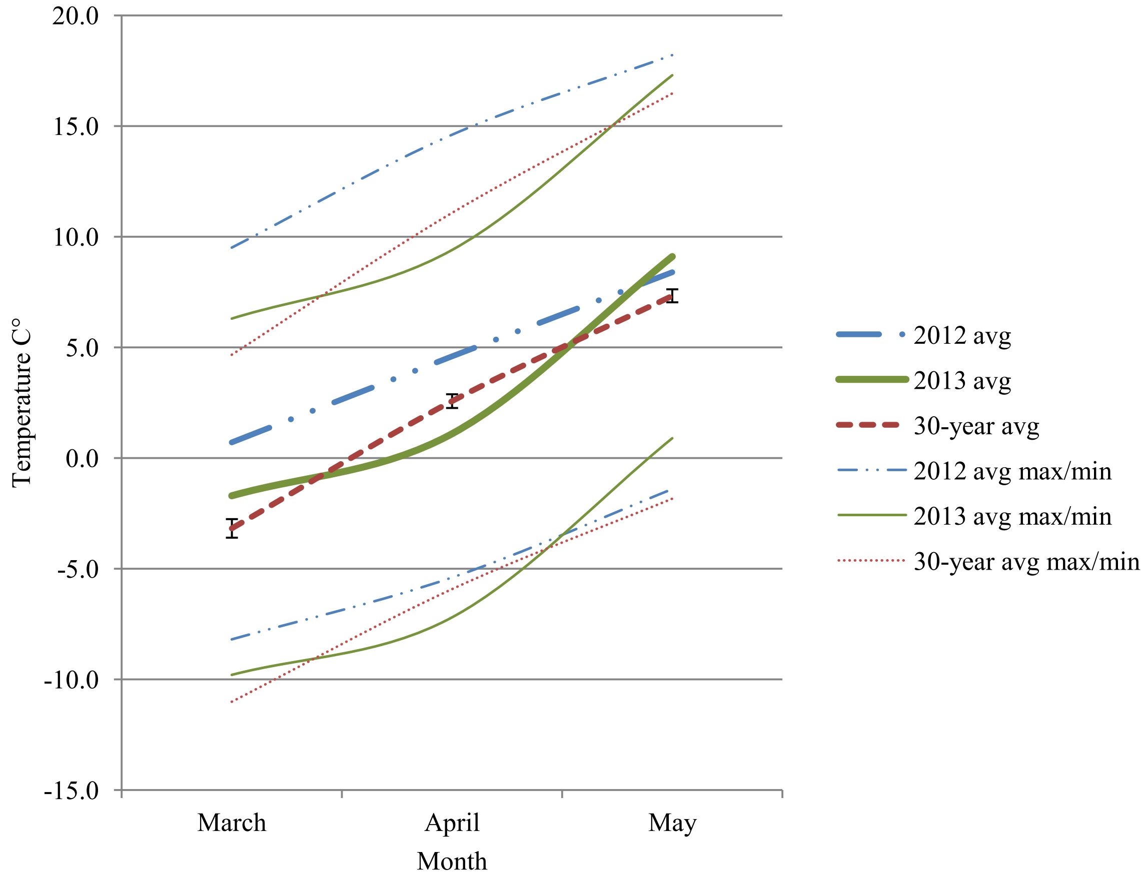

Figure 9. Monthly mean temperatures for the minimum, maximum, and average temperatures for March-May. Data recorded at the Big Piney, Wyoming weather station, UTM: Zone 12, 573067 m E, 4715097 m N, elevation 2,125 m.

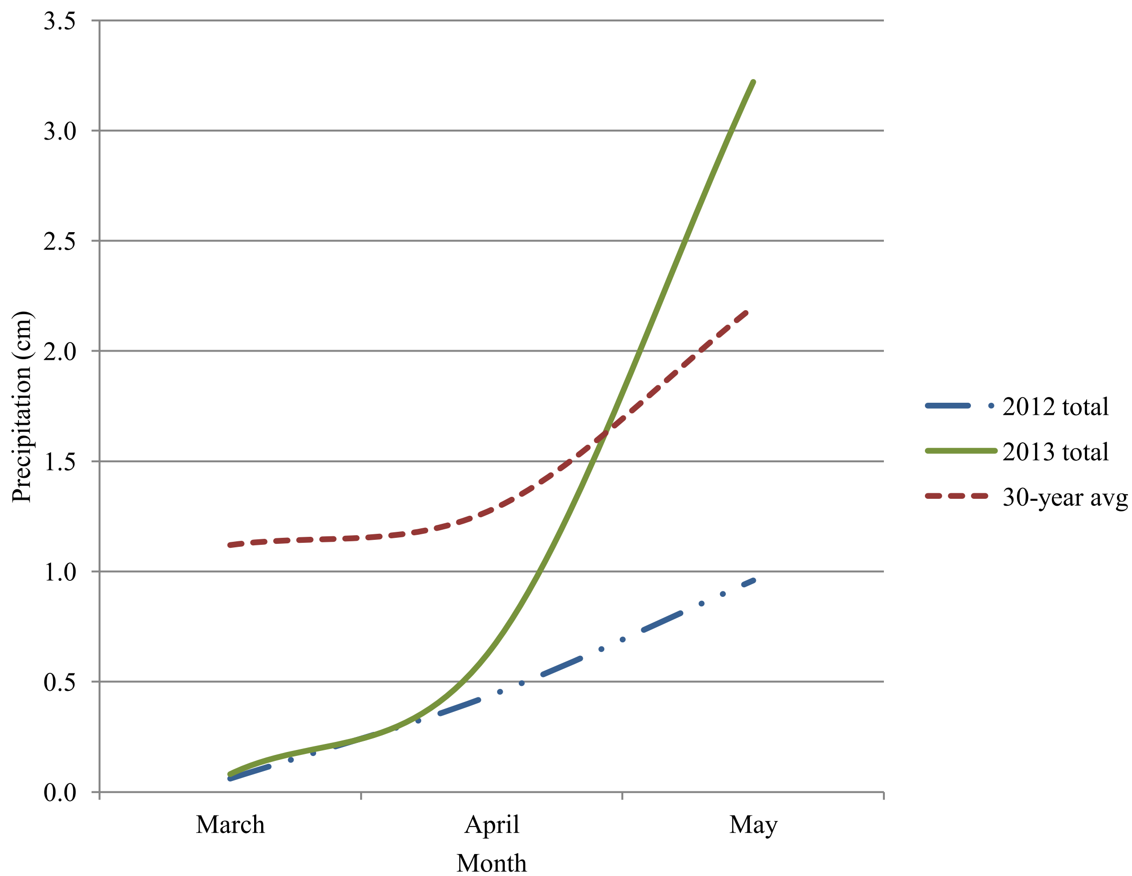

Figure 10. Total monthly precipitation for March-May 2012 and 2013 compared to 30-year average. Data recorded at the Daniel Fish Hatchery, Wyoming weather station, UTM: Zone 12, 571203 m E, 4753171 m N, elevation 2,236 m.

INITIATION OF A LONG-TERM POPULATION MONITORING PROGRAM FOR MOUNTAIN PLOVER (*CHARADRIUS MONTANUS*) AND UPLAND SANDPIPER (*BARTRAMIA LONGICAUDA*) IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Mountain Plover and Upland Sandpiper

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 April 2013 – 30 September 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Jeffrey Coyle, Nongame Technician

ABSTRACT

Habitat loss and fragmentation due to land conversion, industrialization, the spread of exotic species, urbanization, fire suppression, and an altered species composition have transformed and imperiled the Great Plains grasslands (Samson and Knopf 1996, Samson et al. 1998; Fellows and Jones 2009). Four Species of Greatest Conservation Need are characterized as either grassland endemic or associate species—the Mountain Plover (*Charadrius montanus*), Upland Sandpiper (*Bartramia longicauda*), Long-billed Curlew (*Numenius americanus*), and Burrowing Owl (*Athene cunicularia*)—and are classified as Species of Greatest Conservation Need by the Wyoming Game and Fish Department (WGFD 2010). These needs lead to the initiation of an accurate, standardized, and repeatable monitoring program for these four species. In 2013, we focused on the Mountain Plover and Upland Sandpiper, and established permanent survey routes encompassing the range of these species within Wyoming. Our efforts resulted in 17 routes in 6 of the Wyoming Game and Fish Department Regions for the Mountain Plover and 16 routes in 3 Regions for the Upland Sandpiper. The routes will be used to determine distribution, estimate abundance, and monitor long-term population trends of each species, which will enable us to obtain statistically reliable information to better assess population status and distribution of these Species of Greatest Conservation Need. All routes will utilize road-based survey techniques outlined by species-specific monitoring protocols.

INTRODUCTION

Land conversions from native prairie to agricultural uses, habitat loss and fragmentation, industrialization including wind energy and natural resources extraction, the introduction and spread of invasive and noxious plants, urbanization, fire suppression, and the removal of native grazers have transformed the grasslands of the Great Plains into one of the most imperiled ecosystems in North America (Samson and Knopf 1996, Samson et al. 1998; Fellows and Jones 2009). Two endemics and two grassland associates—the Mountain Plover (*Charadrius montanus*), Long-billed Curlew (*Numenius americanus*), Burrowing Owl (*Athene cunicularia*), and Upland Sandpiper (*Bartramia longicausa*), respectively—are classified as Species of Greatest Conservation Need (SGCN) in the Wyoming State Wildlife Action Plan (SWAP; WGFD 2010). As such, we focused our attention for this project on these four species to establish an accurate, standardized, and repeatable monitoring program for each species throughout its range in Wyoming.

The Mountain Plover (plover) is classified as a Native Species Status Unknown, Conservation Tier I, Species of Greatest Conservation Need (SGCN) in Wyoming because population status and trends are unknown, species-specific monitoring is needed, limiting factors (habitat and human activities) are severe and continue to increase in severity, and the species is sensitive to human disturbance during the nesting season (WGFD 2010). It inhabits dry, open, prairie and semi-desert habitats characterized by flat slope ($\leq$5%), low vegetation height ($\leq$10 cm), and bare ground ($\geq$30%; Knopf 1996). Mountain Plovers can be elusive and difficult to detect using the standard Breeding Bird Survey (BBS) protocol. Plovers are often missed on BBS routes because they have a very soft call that may not be heard by observers, they do not vocalize repeatedly to advertise territories or attract mates like songbirds do, and they may remain hidden unless an observer forces a reaction by stepping out of a vehicle. Mountain Plovers are unaffected by vehicular traffic, but are intolerant of people traveling on-foot and may conceal their presence without being detected. Therefore, a unique survey protocol is required to adequately determine distribution and estimate abundance.

Currently, the rangewide Mountain Plover population is estimated at 24,000-3,192,200 individuals (Knopf 2008). In Wyoming, the current minimum population estimate is 3,393 plovers (Plumb 2005). We determined that road-based surveys with count points spaced every 400 m are the preferred method for monitoring Mountain Plovers (Knopf and Orabona 2013). Although some previous survey methods placed count points every 800 m, we concluded that placing count points every 400 m reduces the number of plovers that are undetected, hence making less variation in data which results in more accurate population estimates.

In 2012, we received funding to initiate the development of permanent survey routes for Mountain Plovers across their breeding range in Wyoming (Knopf and Orabona 2013). Previous survey work and habitat assessments led to permanent survey routes located around Big Horn Basin, Great Divide Basin, Mexican Flats, Shirley Rim, and Laramie Plains (Knopf and Orabona 2013). In 2013, we identified plover habitat and developed additional survey routes in the Moneta, Lysite, Arminto, Bucknum Road, Medicine Bow, Shirley Basin, and Thunder Basin National Grasslands areas (Fig. 1).

The Upland Sandpiper (sandpiper) is classified as a Native Species Status Unknown, Conservation Tier II, SGCN in Wyoming because population status and trends are unknown and the species is sensitive to human disturbance during the nesting season (WGFD 2010). Upland Sandpipers prefer open grassland habitats, including prairies, meadows, pastures, hayfields, alfalfa fields, and highway rights-of-way. They require large areas of short grasses for foraging and courtship, interspersed with or adjacent to taller grasses for nesting, and short to medium grasses for brood cover. Upland Sandpipers are considered uncommon in Wyoming and are on the western edge of their breeding range. Results from the nationwide BBS can be used for rangewide conservation management. However, specific population information is needed, making a more intensive monitoring scheme necessary (Vickery et al. 2010). Previous work conducted by Wyoming Game and Fish Department (Department) Nongame Program personnel while developing a grassland plan for Wyoming produced four survey routes in suitable sandpiper habitat near Sheridan, Glendo Reservoir, and Douglas (WGFD 2006; Krueger 2007, 2008). These areas as a whole do not cover the entire breeding range of the Upland Sandpiper in Wyoming. To develop a more comprehensive population monitoring plan, we used previous detections and conducted site visits to identify sandpiper habitat, then added several more survey routes near Hulett, Newcastle, Gillette, Lusk, Moorcroft, and Torrington (Fig. 2). The data we collect from the new and previously established routes will be more representative of the distribution, abundance, and population trend of Upland Sandpipers on their breeding range in Wyoming.

METHODS

This grassland SGCN monitoring program is utilizing roadside survey methods modified from the Breeding Bird Survey protocol. The total number of count points we established on all survey routes combined for each of the focal grassland SGCN are representative of the entire breeding range of these species within Wyoming. We selected count points and survey routes for the plover and sandpiper based on preferred habitat, historical presence, detections on BBS routes, and recent sightings in Wyoming.

For this monitoring program, we will conduct Mountain Plover surveys during the brood-rearing phase (21 June – 7 July) either from local sunrise to 1000 or from 1730 to local sunset (Knopf and Orabona 2013). These two survey windows take advantage of periods of horizontal light to facilitate spotting the white breast of adult plovers. We selected one survey window per route, depending on the orientation of each and whether morning or evening sun will more conducive for detecting plovers.

To conduct Mountain Plover surveys, we will use the protocol presented in Knopf and Orabona (2013). The observer stops the vehicle at each count point, exits the vehicle and walks out approximately 6 m and around the vehicle, and then walks back to the vehicle. Plovers with chicks will become agitated during the walking phase. The observer uses binoculars to search for plovers by scanning in a 360^{o} circle around the vehicle for 3 min. Scanning may be done from either outside but close to the vehicle or inside the vehicle. The number of adult and juvenile plovers is recorded, and the distance from the observer to each plover is estimated (preferably with a laser rangefinder). The standard Mountain Plover survey data sheet is used to record all information (Fig. 2).

Upland Sandpiper surveys for these routes will be conducted from June to mid-July from 20 minutes before sunrise and completed within 5 hours of start time. At each stop an observer will step out of the vehicle and start a 5-minute listening and observation period; separated into 2 count segments, 0-3 minutes and 3-5 minutes. Standing outside the vehicle is preferred over staying inside the vehicle with the windows down. A listener can detect bird vocalizations at a farther range in front of and behind the vehicle, whereas wind and window glass can have a muffling effect on the bird calls. If possible, survey routes should be completed on days with a wind speed less than 24 kph.

RESULTS

Mountain Plovers surveys were conducted on a sampling of locations across Wyoming in six Department Regions. A total of 58 adults and 16 chicks were detected during this survey effort. Most of the detections fell into a few types. The first type was a casual detection, when a bird was easily spotted with binoculars or by the naked eye in the open. This was fairly common for single adults and for adult with chicks. Casual detections usually have more success during the brood-rearing phase because plovers are very active all day (Knopf and Orabona 2013). The second type of detection was startling a resting plover as the observer stepped out of the vehicle and walked in a circle around the vehicle, as described in the methodology. This type of detection often startles single birds and causes adults with chicks to move, which facilitates detection and is frequently the primary way to find bird nests during the nesting phase (Knopf and Orabona 2013). During the brood-rearing phase, adult plovers will often move their broods from open areas to the edges of sagebrush stringers to take advantage of insect production and cover (Knopf and Orabona 2013). Many of the detections of adult with chicks were found feeding or roosting on the edge of a sagebrush stringer or among scattered sagebrush. In some cases, adult with chicks were found in the open around active prairie dog towns with the absence of sagebrush cover.

Some of the more common species we observed during the 2013 surveys included pronghorn (*Antilocapra americana*), black-tailed prairie dogs (*Cynomys ludovicianus*), white-tailed prairie dogs (*Cynomys lecucurus*), Horned Larks (*Eremophila alpestris*), cactus (*Opuntia spp*.), and sagebrush (*Artemisia spp*.). In most cases, we observed grass and sagebrush height to be less than 10 cm. The exception was related to seasonal variations in precipitation and grazing pressure. In some cases, greater precipitation and a lack of grazing in a particular area might result in grass height >10 cm. However, if we detected plovers during the brood-rearing phase in locations with grass cover >10 cm it is likely that the birds nested in the area earlier in the season when the grass height was <10 cm (Knopf and Orabona 2013).

To site Upland Sandpiper survey routes, we focused on a spectrum of locations near Sheridan, Hulett, Newcastle, Gillette, Lusk, Moorcroft, and Torrington. We detected sandpipers at 88 survey points during the route set-up phase, with most birds detected by vocalizations. Many of the birds were beyond visual detection range; e.g., behind a hill, in a small irrigation depression, in tall grasses, or around a fence post. The most common visual detections were the results of alarm calls of birds in flight; however, we often heard vocalizations before sandpipers were visually detected. Future observers should anticipate that many of their sandpiper detections will be from vocalizations because individuals can be difficult to visually detect due to landscape or terrain features.

During the 2013 effort, we found Upland Sandpipers in flat and hilly terrain, sagebrush grasslands, dried ponds with meadow reed or foxtail barley, near marshy ponds, on agricultural fields with alfalfa or oats, on hayfields, and in pastures with light grazing. We observed sandpipers perched on telephone poles and fence posts, and we often detected them in pastures with low intensity cattle grazing. Some of our visual detections were of sandpipers feeding on recently plowed fields or fields that had been hayed. Some of the common grasses we noted at sandpiper locations were blue grama (*Bouteloua gracilis*), foxtail barley (*Hordeum jubatum*), junegrass (*Koeleria macrantha*), Kentucky blugrass (*Poa spp*.), Needle-and-thread (*Hesperostipa comate*), reed canarygrass (*Phalaris arundinacea*), smooth bromegrass (*Bromus inermis*), timothy (*Phleum prantense*), and various species of *Agropyron spp*. These species only represent what we casually observed; we may have overlooked some additional dominant species. Many of the grass species and habitat characteristics we noted are consistent with other Upland Sandpiper breeding habitat descriptions (Ailes 1974, Vickery et al. 2010).

DISCUSSION

These roadside survey methods for the Mountain Plover and Upland Sandpiper are part of an effort to establish a long-term monitoring program for grassland SGCN, and will eventually include the Long Billed Curlew (*Numenius americanus*) and Burrowing Owl (*Athene cunicularia*). Over time, data collected from these surveys will be used to estimate occupancy, abundance, and population trend for each species.

Mountain Plover populations can fluctuate due to direct habitat loss, shifting/altered habitat characteristics, climate change, and long-term cyclic droughts (Andres and Stone 2010). Wyoming has the second highest population of breeding Mountain Plovers (Andres and Stone 2010); therefore, we have a responsibility to both monitor the species and ensure breeding habitat remains viable. Mountain Plovers are known to have high fidelity to breeding sites (Knopf and Orabona 2013); thus, permanent survey routes conducted over the long-term are an ideal approach to manage plover populations.

The Upland Sandpiper is an uncommon species in Wyoming. Their preferred breeding territory size is 100-200 hectares (Vickery et al 2010), which can lead to absent detections when birds might be present in an area that is fairly large. The sandpiper survey routes we established will augment existing, but limited, data from the Breeding Bird Survey (USGS 2011).

ACKNOWLEDGEMENTS

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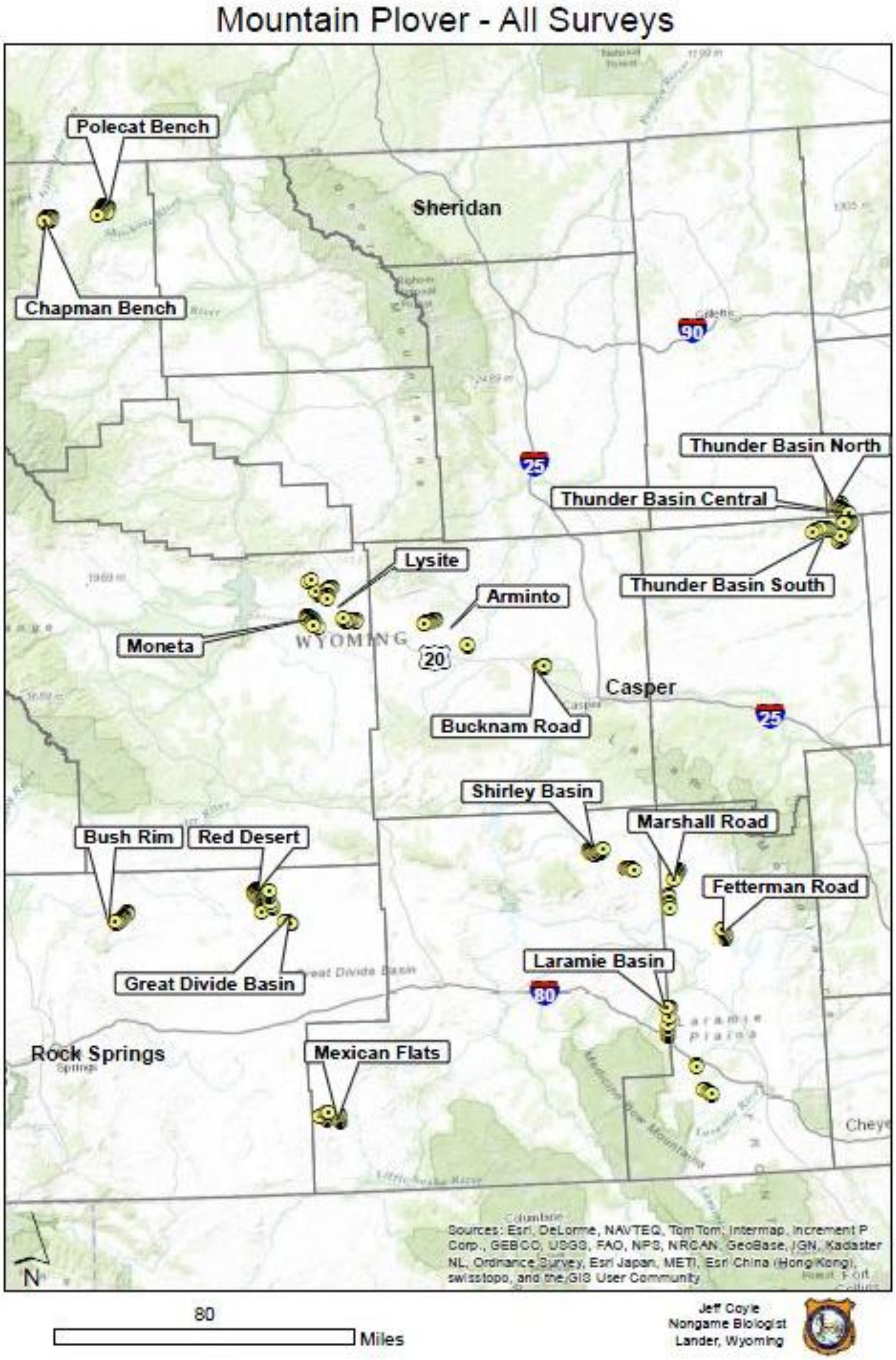

Figure 1. Location of Mountain Plover (*Charadrius montanus*) survey routes we identified for long-term monitoring.

Figure 2. Standard Mountain Plover (*Charadrius montanus*) survey data sheet we developed for the statewide, long-term monitoring program.

MOUNTAIN PLOVER SURVEY DATA SHEET

Survey Route Name and Code:____________________ **Survey Date:**____________________ **Page**_____**of**_____

Route Location Description:____

Observer's Name:____________________ **E-mail Address:** ____________________ **Phone #:**____________________

Point Code	NAD 83, Zone___T		Start Time	Number of Mountain Plovers Detected				Habitat	Comments/Other Species Detected
	UTM-E	UTM-N		# of Adults	Distance (meters)	Distance Aide	# of Juveniles		

Habitat: SG=shortgrass, BG=bunchgrass, FO=forbs, OS=Opuntia spp., SS=scattered shrubs, ST=shrub stringer, PD=prairie dogs, BA=bare ground, FA=fallow ground, PF=plowed field, BR=on bench/rim, TA=stock tank, OT=other.

Distance Aide: 1=laser rangefinder, 2=paced, 3=tape measure, 4=estimated.

Notes:____

WGFD WOS Database:__________

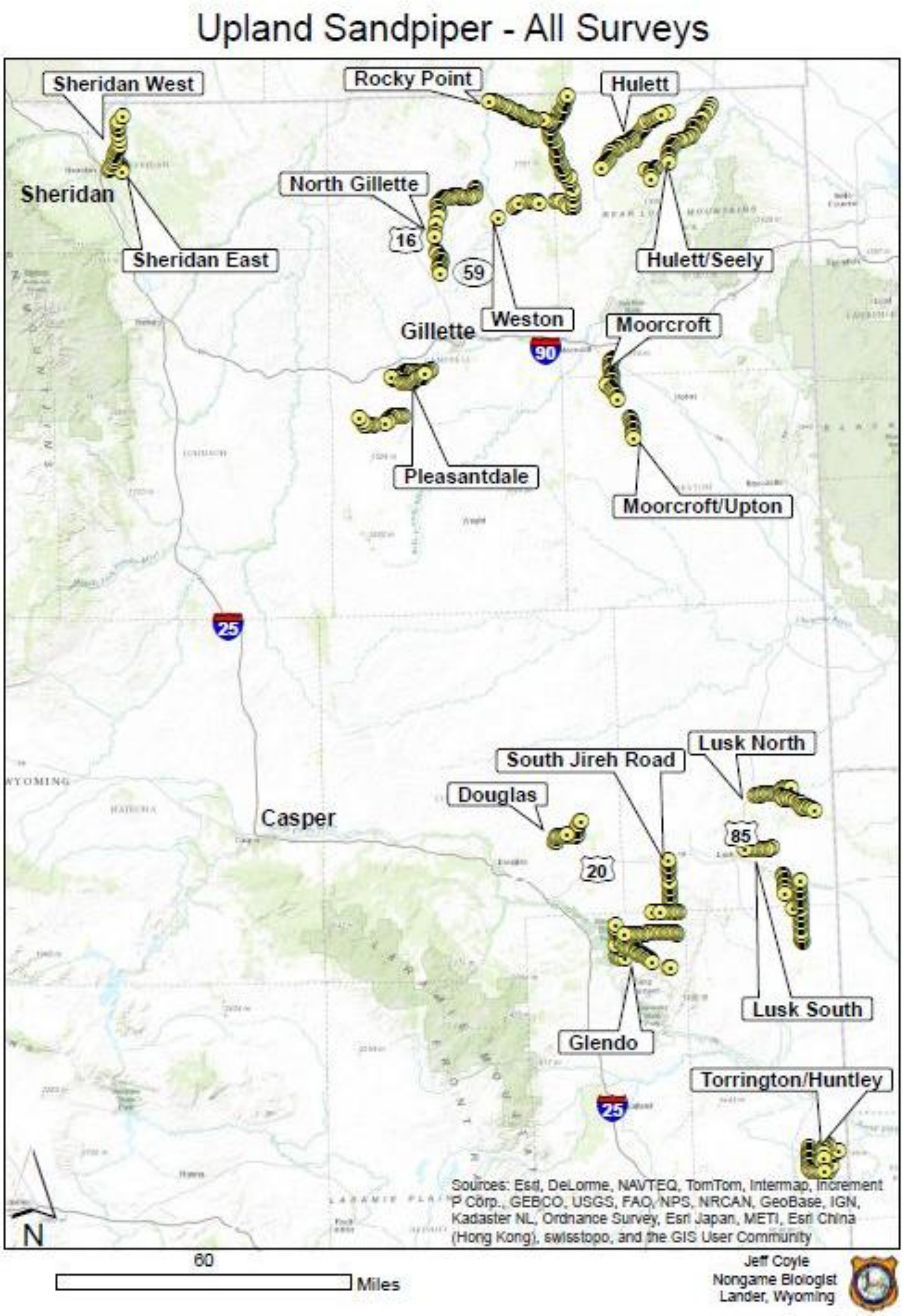

Figure 3. Location of Upland Sandpiper (*Bartramia longicauda*) survey routes we identified for long-term monitoring.

Figure 4. Standard Upland Sandpiper (*Bartramia longicauda*) survey data sheet we developed for the statewide, long-term monitoring program.

UPLAND SANDPIPER SURVEY DATA SHEET

Survey Route Name and Code: **Survey Date:** **Page** **of**

Route Location Description:

Observer's Name: **Email:** **Phone:**

Point Code	NAD 83, Zone____T		Start Time	≤400 meters		≥400 meters		Total UPSA	Habitat/ Land Use	Temp. (°F)	Wind	Sky	Comments/Other Species Detected
	UTM-E	UTM-N		0-3 min.	3-5 min.	0-3 min.	3-5 min.						

Habitat/Land Use: NGG = native grassland grazed, NGU = native grassland ungrazed, TPI = tame pasture irrigated, TPD = tame pasture dryland, CLI = cultivated land irrigated, CLD = cultivated land dryland, OHU = other habitat or use (note in comments).

Beaufort Wind Speed: 0 = smoke rises vertically; 1 = wind direction shown by smoke drift; 2 = wind felt on face, leaves rustle; 3 = leaves and small twigs in constant motion, light flag extended; 4 = raises dust and loose paper, small branches are moved; 5 = small trees with leaves sway, crested wavelets on inland waters.

Sky: 0 = clear or a few clouds, 1 = partly cloudy or variable sky, 2 = cloudy or overcast, 3 = sand or dust storm, 4 = fog or smoke, 5 = drizzle, 6 = snow, 7 = snow/sleet, 8 = showers.

Notes:

UPSA Survey Total: **WGFD WOS Database:**

EVALUATING POPULATION TRENDS OF LONG-BILLED CURLEWS (*NUMENIUS AMERICANUS*) IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Long-billed Curlew

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Nichole Cudworth, Nongame Biologist

ABSTRACT

Long-billed Curlew (*Numenius americanus*) populations declined in Wyoming in the late 19th and early 20th centuries due to uncontrolled hunting, habitat conversion, and pesticides, all of which have contributed to their classification as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department. To monitor curlew populations, the Wyoming Game and Fish Department initiated annual roadside surveys in 1991 in western Wyoming during the breeding season. In 2013, we detected 70 unique individuals on 4 pre-determined survey routes. In general, curlew numbers have remained relatively stable among survey years, particularly from the mid- to late 1990s until the present, although the relatively poor fit of trendlines and high variability among years suggests these results should be interpreted cautiously. We are currently revising protocols that would include measures of detection probability in order to increase precision of trend estimates, estimate abundance, and allow for inclusion of site and survey specific variables that may be influencing trends of curlews.

INTRODUCTION

Long-billed Curlews (*Numenius americanus*; curlews) are found throughout much of Wyoming during migration. However, curlews only breed in areas with suitable habitat, which includes a variety of grasslands with short vegetative structure, typically near water (Cochrane and Anderson 1987, WGFD 2010). Uncontrolled hunting in the late 19th and early 20th centuries, widespread conversion of prairie to agricultural fields in the 1930s, and the use of organochlorine pesticides resulted in significant declines in curlew populations throughout the state (Nicholoff 2003). As a result, the Long-billed Curlew is classified as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department (Department; WGFD 2010).

Our objective for surveys of curlews in 2013 was to continue to accumulate annual count data for curlews along four of the five established survey routes in western Wyoming where breeding populations are known to occur (the National Elk Refuge route was not conducted in 2013 due to habitat improvements taking place on the refuge). We then added these data to data collected since 1991 to further evaluate trends over time and investigate any changes in curlew populations.

METHODS

We conducted surveys for curlews along four pre-defined routes in northwestern Wyoming. Although the length of each route was dependent upon the amount of available habitat, survey protocol generally followed that of the Breeding Bird Survey (Robbins and VanVelzen 1967). We initiated surveys 20 min before sunrise and observed curlews at stops located every 0.8 km. At each stop, we recorded the number of curlews seen and heard during a 5-min period, but did not recount individuals observed at previous stops. We also recorded the number of individuals observed while driving between stops. We divided the total number of curlews detected by distance driven to estimate the number of curlews per km for each survey route. For routes that were surveyed more than once, we used data from the survey that detected the most curlews. This differs from analyses in reports prior to the 2011 field season; however, we feel that using the maximum number of recorded individuals, as opposed to the mean number of curlews between surveys, is a more appropriate analysis. We believe that averaging values between surveys under-represents the number of curlews that are known to occur at a site and tends to introduce more variation in data resulting from variation in survey conditions. Using the maximum number of curlews detected in analyses tended to be more susceptible to years with outliers, but did not change the direction of trends and increased the precision of the estimate overall (i.e., larger R^2 value) for over half of the analyses.

We attempted to conduct surveys between 21 April and 15 May to correspond with the US Fish and Wildlife Service (USFWS) and US Geological Survey (USGS) range-wide survey and monitoring guidelines for curlews (Jones et al. 2003, Stanley and Skagen 2007). However, surveys were not conducted when observers were unavailable or weather conditions were not conducive (e.g., rain).

Four of the survey routes, Horse Creek, New Fork, Chapman Bench, and Grand Teton National Park (GTNP) Hayfields, have been surveyed since the early 1990s; the National Elk Refuge (NER) route was surveyed from 2008-2011. To evaluate trends, we developed a 3-year average of curlew detections per km for each route with a minimum of 15 years of data in order to account for variability in survey results. We excluded the 1987 survey, which only recorded the number of curlews seen, and the 2004 survey that was conducted by the USFWS from our analysis. This ensured that only those years in which methods of detection were consistent were used in analyses. We report the slope and R^2 value of trendlines to investigate population trends for each survey route.

The Breeding Bird Survey (BBS) is used to monitor trends of breeding birds across North America. The BBS is sponsored jointly by the USGS – Biological Resources Division (USGS-BRD; formerly the USFWS) and the Canadian Wildlife Service. The USGS-BRD has reviewed and analyzed data collected from the BBS since the survey's inception in 1966 in the East and 1968 in the West. Volunteers typically conduct BBS routes in June, when most species of birds are breeding and most vocal. To evaluate trends of curlews statewide, we plotted the mean number of curlew detections per BBS route (27 total routes) since 1991 and reported the slope and R^2 value for BBS data in Wyoming. Only routes that were surveyed in a given year are included in analyses.

RESULTS

We surveyed the Horse Creek and New Fork routes twice and the Chapman Bench and GTNP Hayfields routes once in 2013 during the breeding season (Table 1). All curlew survey data (number of curlews seen, heard, as well as comments made during each survey) are located in the Nongame Bird Biologist's files at the Department's Lander Regional Office.

Slight declines in the number of curlews detected occurred on three of the four routes. Horse Creek demonstrated a decline of 0.38 individual curlews per km per 3-year interval (R^2=0.52; Fig. 1), Chapman Bench showed a decline of 0.17 individuals per km per 3-year interval (R^2=0.28; Fig. 2), and GTNP Hayfields had a decline of 0.04 individuals per km per 3-year interval (R^2=0.18; Fig. 3). New Fork curlew populations appear to be stable, with a slight increase of 0.04 individuals per km per 3-year interval (R^2=0.01; Fig. 4).

Participants detected curlews on 27 BBS routes since initiation of the BBS in Wyoming in 1968. Counts in previous years have fluctuated from a low of 1 curlew detected on 1 of 15 routes surveyed in 1998 to a high of 19 curlews detected on 8 of 16 routes surveyed in 1999. Overall, BBS routes have shown a slight increase of 0.02 individuals per route per year (R^2=0.12; Fig. 5) since 1991. BBS data from 2013 were not yet available, so we were unable to include them in this report.

DISCUSSION

Curlews have been detected on 27 BBS routes in Wyoming since 1980; however, the timing of the BBS during the month of June corresponds with the latter stages of the curlew breeding cycle. Consequently, detections of curlews during this time may reflect a clumped distribution, which could increase variance and decrease precision of trend estimates (Fellows and Jones 2009). Although the number of curlews detected on BBS routes appears to be increasing over time, this increase is slight, and the trend is masked by the high variance in number of detections and number of routes surveyed per year. These results suggest that surveys specifically designed for detecting and monitoring curlews are warranted, as we are unable to use BBS results alone to accurately determine population trends.

Cochrane (1983) first used BBS techniques (Robbins and VanVelzen 1967) to conduct species-specific, roadside surveys for curlews in 1982. Over time, we have made multiple modifications to the guidelines provided by Cochrane and Oakleaf (1982) to reflect updated survey techniques. Although the modifications to our survey methodology were intended to maximize detections of curlews and conform to range-wide recommendations, our results are confounded by variations in weather conditions, observer availability, modifications to the length of some survey routes, and noise levels, all of which influence our ability to locate curlews and determine population trends accurately. Additionally, an estimate of detection probability is needed to determine abundance or population size. We are currently developing protocols that will utilize an occupancy modeling approach to address issues of detection and allow for the inclusion of covariates, such as vegetation structure and composition, weather, and distance to important landscape features (Jones et al. 2003).

Although the trendline fit well for the Horse Creek route, with year explaining 51.9% of the variation in curlew numbers, the trendline did not fit the other survey routes as well. The New Fork and Chapman Bench routes in particular appear to be heavily influenced by 1 or 2 years of data. We recorded 10.6 individuals per km in 1997 on the New Fork route, which greatly increased our estimate as well as our variance for 1997-1999. Removing this point increases both our trend estimate and precision to an increase of 0.15 individuals per km per year ($R^2 = 0.26$). Chapman Bench is more problematic, with 3.6 and 1.9 individuals detected per km in 1992 and 1993, respectively (Fig. 2). These numbers are significantly higher than any surveys since. Removing these two years changes the direction of our trend estimate from a decreasing population to slight increases of 0.06 individuals per km per year ($R^2 = 0.42$). This drastic drop in detections between 1993 and 1994 along the Chapman Bench route may indicate a decrease in availability or suitability of nesting habitat, but the subsequent increases in curlew detections may be promising, although the low R^2 value still suggests this trend should be interpreted with caution.

Current threats to breeding populations of curlews primarily include habitat loss and fragmentation due to conversion to agriculture, urbanization, and encroachment of woody vegetation (Jones et al. 2003). In fact, productivity is often highest in areas with short-growing vegetation and lowest in areas with disturbances during the nesting season related to agricultural practices, including grazing, dragging hay meadows to break up manure, and field fertilization (Cochrane and Anderson 1987, Pampush and Anthony 1993). The Horse Creek route not only consistently records the greatest number of curlews annually, it also displays the steepest declines over time. This may result either from modifications in timing of conducting the routes since the inception of the survey program, habitat alterations due to climate change and/or land management practices, or observer bias resulting from changes in observers over time. Incorporating these survey and habitat variables are likely critical to understanding the cause of this decline in curlew detections. Trend estimates of curlew populations can reflect changes in habitat availability or suitability, and recording and including variables pertaining to habitat in further surveys can help assess how these changes are currently impacting curlew occupancy and abundance.

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Table 1. Survey information from four routes surveyed for Long-billed Curlews (*Numenius americanus*) in western Wyoming, 2013, including route name, length, number of stops, survey dates, and total number of curlews (LBCU) detected along each route. GTNP represents Grand Teton National Park. Only one survey was conducted on the Chapman Bench and GTNP Hayfields routes in 2013. The National Elk Refuge route was not conducted in 2013.

Route	Length (km)	Survey stops (*n*)	First survey		Second survey	
			Date	LBCU detected (*n*)	Date	LBCU detected (*n*)
Horse Creek	12.8	17	30 April	48	11 May	25
New Fork	6.4	9	2 May	15	31 May	5
Chapman Bench	12.8	17	11 May	6	n/a	n/a
GTNP Hayfields	17.6	20	17 May	1	n/a	n/a

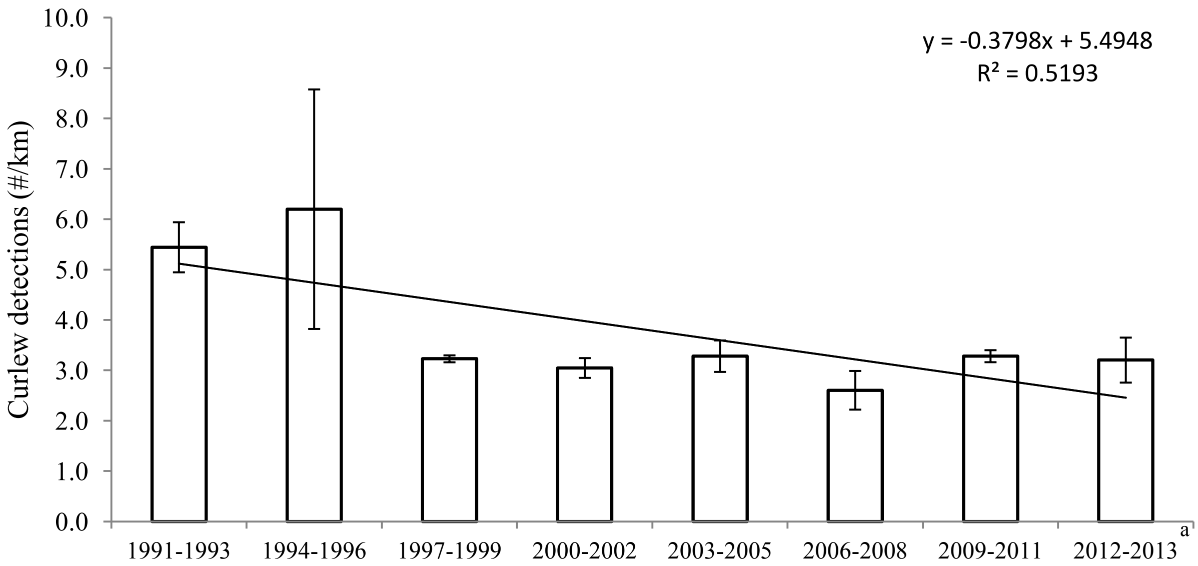

Figure 1. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Horse Creek survey route (12.8 km) in western Wyoming, 1991-2013. [a] Indicates a average over only 2 years. The trendline is shown for reference.

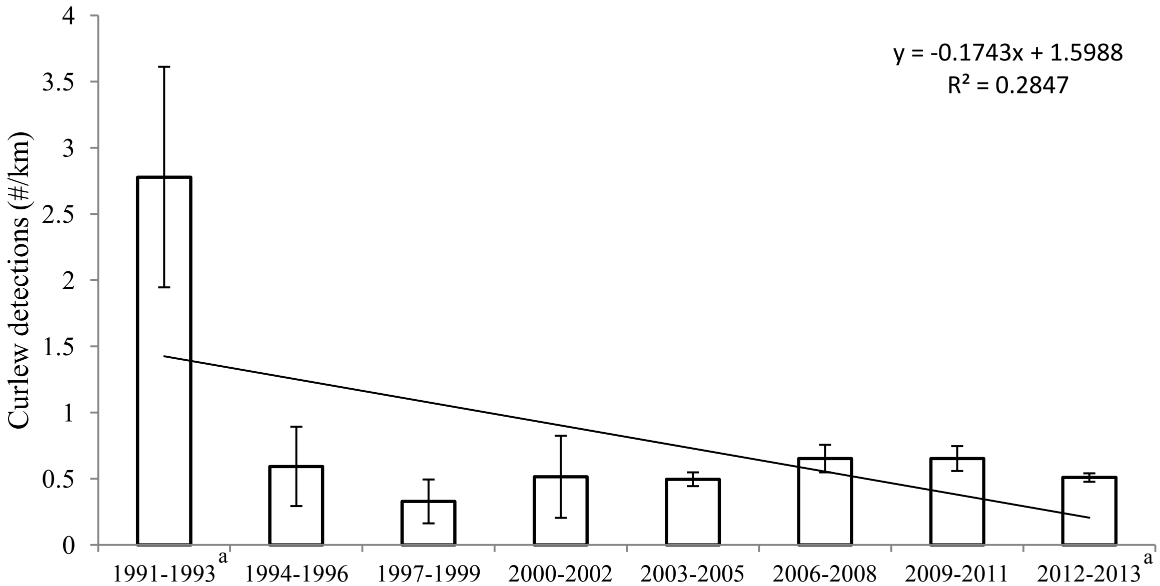

Figure 2. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Chapman Bench survey route (12.8 km) in western Wyoming, 1991-2013. [a] Indicates an average over only 2 years. The trendline is shown for reference.

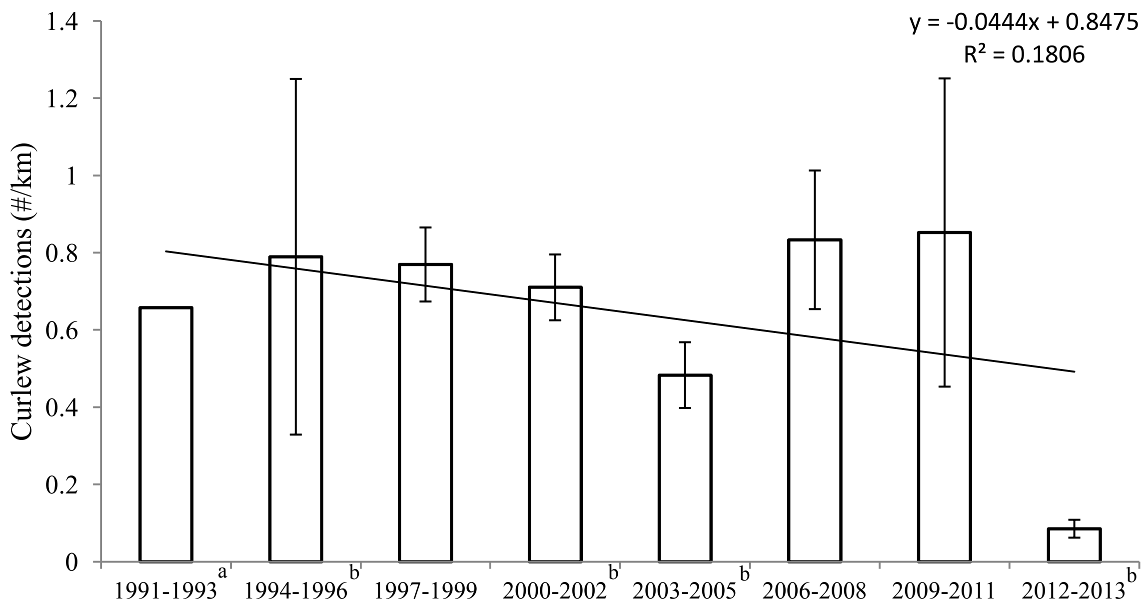

Figure 3. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Grand Teton National Park (GTNP) Hayfields survey route (17.6 km) in western Wyoming, 1991-2013. [a] Indicates only one survey in the 3-year span. [b] Indicates an average over only 2 years. The trendline is shown for reference.

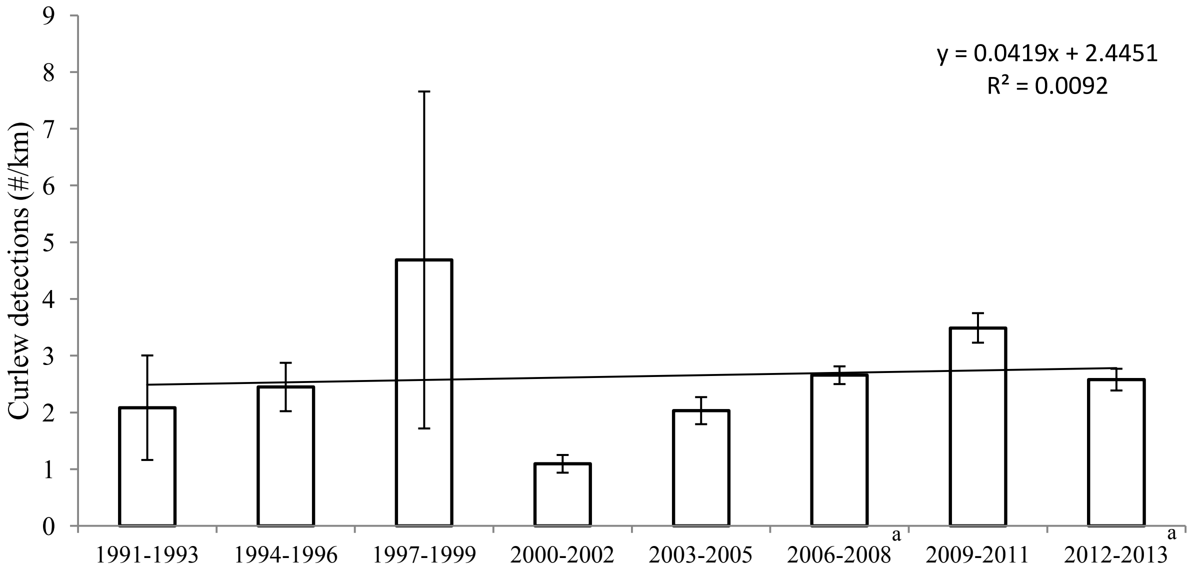

Figure 4. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the New Fork survey route (6.4 km) in western Wyoming, 1991-2012.
[a] Indicates an average over only 2 years. The trendline is shown for reference.

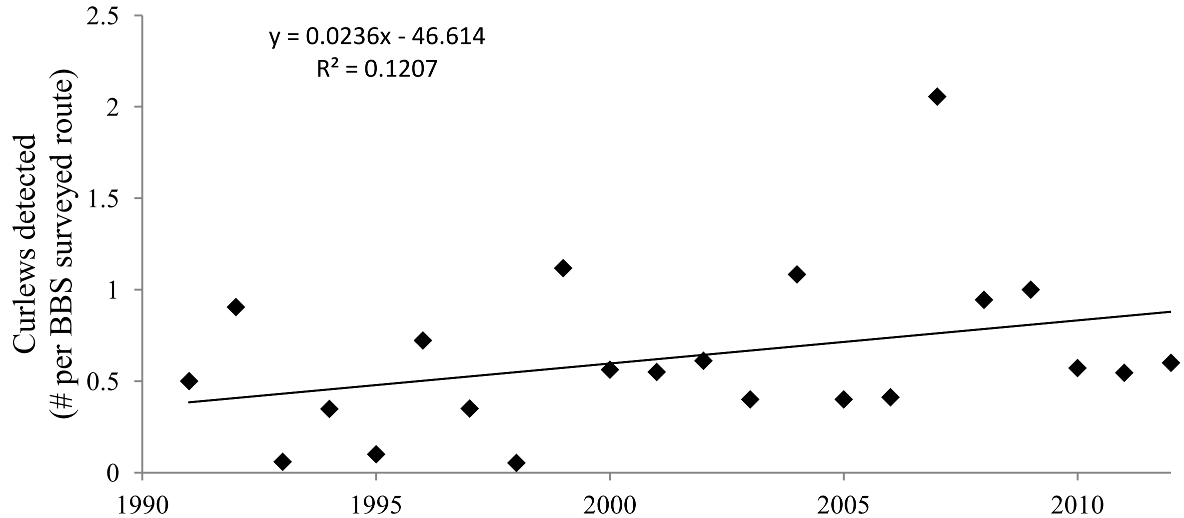

Figure 5. Average number of Long-billed Curlews (*Numenius americanus*) detected per Breeding Bird Survey (BBS) route in Wyoming, 1991-2012. Only routes that have resulted in a curlew detection since surveys were initiated in Wyoming in 1968 were included. Data from 2013 were not yet available for this report. The trendline is shown for reference.

OCCUPANCY, NEST SUCCESS, AND HABITAT USE OF GREAT GRAY OWLS IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Conservation Need – Great Gray Owl

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 January 2013 – 31 December 2015

PERIOD COVERED: 1 January 2013 – 31 December 2013

PREPARED BY: Bryan Bedrosian, Avian Program Director, Craighead Beringia South
Susan Patla, Nongame Biologist

ABSTRACT

In 2013, we initiated a multi-year study on Great Gray Owls (*Strix nebulosa*) in northwestern Wyoming near Jackson. The Great Gray Owl is designated a Species of Greatest Conservation Need in Wyoming, but little information has been collected on nesting ecology and habitat requirements in this part of its range. The main objectives of this study are to gain an understanding of habitat use by Great Gray Owls in both summer and winter, to determine prey use, and to develop and validate a habitat suitability model for predicting potential nesting habitat in western Wyoming. We will compare current demographic data with the few historic datasets for this species in the US to determine population status and health. We will also test our habitat suitability model in the third breeding season by surveying for new nesting territories in areas predicted by the model. With the aid of GPS and VHF transmitters, we will be able to assess seasonal habitat use and document migration and dispersal from western Wyoming if it occurs. We will measure habitat influences and nest success and create a framework to help predict effects of future habitat changes on these parameters. Finally, we will utilize nesting platforms to help determine if habitat is limiting population size and to help determine nesting habitat preference. In 2013, we surveyed 7,335 ha (73.35 km^2) of potential nesting habitat and recorded 66 calling Great Gray Owl detections, among many other owl species. We estimated 10 territories occurred within the study area, with a 60% nest initiation rate and 50% nest success. We have marked and tracked nine Great Gray Owls with satellite and/or VHF transmitters and will continue to mark and monitor more owls in the coming years. In summer 2013, we surveyed small mammals within each nesting territory. In late fall, we also began placing man-made nesting platforms within the study area to examine if nest sites may be limiting the number of nesting pairs. Data collection will continue throughout the 2014 and 2015 nesting seasons.

INTRODUCTION

The Great Gray Owl (*Strix nebulosa*) is classified as a Species of Greatest Conservation Need with a Native Species Status Unknown (Tier I) in Wyoming. Population status and trends are unknown but suspected to be stable, and habitat is restricted and vulnerable (WGFD 2010). Overall, we have very little population or habitat data on this species in Wyoming. One historic study conducted in eastern Idaho and western Wyoming found this species to be associated with older age boreal forests (Franklin 1988). Anecdotal nesting data exist from other studies (e.g., Craighead and Craighead 1969, the US Forest Service, and public reports), but no data exist on densities or movements of this species in the Rocky Mountain region. Wyoming is the southernmost extent of this species' range in the Rocky Mountains (Bull and Duncan 1993), and the typical habitats associated with Great Gray Owls may be at risk due to both natural and anthropogenic disturbances such as wildfire, disease outbreak, drought, climate change, and logging.

Studies from the Northwest indicate this species typically occupies older-aged Douglas-fir (*Psuedotsuga menziesii*) forest stands, and owl nests can be ≥430 m apart (Bull et al. 1988a). Great Gray Owls do not build nests and rely on existing structures for nesting, such as mistletoe (*Arceuthobium* spp.), broken snags, and existing nests from other raptors or corvids (Bull and Henjum 1990). In Wyoming during the early 1980s, 60% of Great Gray Owl nests were located on broken snags, and 40% were in old stick nests, typically built by Northern Goshawks (*Accipiter gentilis*; Franklin 1988). In a 6-year study of nesting Northern Goshawks on the Caribou-Targhee National Forest in the 1990s, Great Gray Owls were found nesting in 8 of 27 goshawk territories; 17 out of 18 alternate goshawk nests used were in Douglas fir and 1 in an Englemann spruce (*Picea engelmannii*; Patla 1997). Great Gray Owls usually avoid clear-cuts for nesting (Bull et al. 1988, Fetz et al. 2003), but such areas may be important for foraging (Franklin 1988).

The main objectives of this study are to gain an understanding of habitat use by Great Gray Owls in both summer and winter, to determine prey use, and to develop and validate a habitat suitability model for predicting potential nesting habitat in western Wyoming. We will compare current demographic data with the few historic datasets for this species in the US (Franklin 1988, Bull and Henjum 1990) to determine population status and health. We will also test our habitat suitability model in the third breeding season by surveying for new nesting territories in areas predicted by the model. With the aid of GPS and VHF transmitters, we will be able to assess seasonal habitat use and document migration and dispersal from western Wyoming if it occurs. We will measure habitat influences and nest success and create a framework to help predict effects of future habitat changes on these parameters. Finally, we will utilize nesting platforms to help determine if habitat is limiting population size and to help determine nesting habitat preference.

METHODS

The primary study area for 2013 included the base of the Teton Mountain Range from Teton Village to the Snake River Canyon (Fig. 1). The typical forest habitats consisted of

Douglas fir, lodgepole pine (*Pinus contortus*), sub-alpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*). Both mesic and sagebrush (*Artemesia* spp.) meadows occurred throughout the study area. The study area was expanded during the survey period to include the Snake River corridor, which is predominantly mixed coniferous-cottonwood (*Populus angustifolius*) forests, and the Shadow Mountain area. Subdivisions are common throughout the study area but rarely extend beyond 1.5 km from the valley floor.

During the courtship period of Great Gray Owls (mid-February-April), we conducted call-back surveys to record the presence of Great Gray Owls across the study area. We followed the USFS-BLM protocol (Quintana-Coyer et al. 2004) with slight modifications to better suit the study area as described below.

To determine call-back locations, we first used the existing Bridger-Teton National Forest (BTNF) habitat layer to delineate any forest stand (regardless of species) with an average diameter at breast height (DBH) of 25 cm, as the average DBH of Great Gray Owl nest trees was 52.7 cm in previous studies (Franklin 1988). Within that layer, we placed survey points to completely cover the habitat, using a 200 m radius detection distance. Therefore, survey locations were every 400 m in suitable habitat. Locations were visited from 13 March-25 April 2013 and surveys began no earlier than ½ hr after sunset. We played calls for both Great Gray Owls and Boreal Owls (*Aegolius funereus*). Each calling period consisted of a 2-min listening period, Boreal Owl territorial call, 1-min listening period, Great Gray Owl territorial call, 1-min listening period, Great Gray Owl call, and a final 2-min listening period. We recorded all owl species detected, and we estimated distance to and direction of each owl. To help with distance estimates, we played owl calls at typical volumes for each species at known distances in training sessions. We also re-surveyed a proportion of the calling locations to determine detectability.

We conducted backcountry surveys in teams of two, typically on skis or snowshoes. We surveyed areas surrounding neighborhoods and roads singly, using vehicles. We also used snow machines on designated routes when possible with two snow machines for safety. All vehicles were turned off and there was no movement or talking from surveyors during the survey period to maximize detectability.

After we finished the night call-back surveys, we searched for nests in all areas where Great Gray Owls were detected during call-back surveys. We exhaustively searched all habitat patches for old stick nests, witches brooms (mistletoe), and broken snags large enough for an owl nest. Any potential nesting structure was recorded and searched for signs of occupancy (e.g., an incubating bird, feathers, whitewash, or pellets). We also used the male contact call or begging call to regularly call for owls and fledglings while nest-searching. All tracks were recorded so we could map our effort and determine if particular areas were not adequately searched.

In all areas where we detected Great Gray Owls during the night call-back surveys or in suitable habitat patches, we also conducted fledgling call-back surveys during August. Fledgling surveys were conducted in a similar fashion to the night call-back surveys, covering the entirety of suitable nesting habitat, 400 m apart, and using a mixture of contact and begging calls.

We opportunistically located regurgitated pellets while conducting all forms of surveys. Each pellet was collected, labeled with date and location, and stored for later analysis. We searched areas below and directly surrounding nest sites and associated roosting locations to collect pellets from nesting pairs.

We conducted mark-recapture small mammal trapping at all known and suspected nesting territories during August and September 2013. We selected one meadow site as close to the nest as possible and one forest site that was representative of the forest type near the nest. We used a 10-m interval 5 × 5 trapping grid in each site for a total of 3 days at each site. Traps were checked dawn and dusk and captured animals were identified to species, sexed, weighed, and individually marked using non-toxic markers (Pauli et al. 2004).

We captured Great Gray Owls and outfitted them with either a VHF transmitter or a GPS datalogger with affixed VHF transmitter. We targeted one owl of each known nesting pair and every individual, non-nesting owls encountered for captures. We used both backpack style (GPS and VHF) and tail mount attachments (VHF). We custom-made data-loggers for this study, which were pre-set to gather GPS locations once every 4 hrs for ca. 4-6 months. VHF transmitters had a typical lifespan of 2 years.

We used bal-chatri traps or bownets (Bloom et al. 2007) with mice or gerbils as bait to capture owls. We banded owls with a USGS and custom-made blue plastic alphanumeric leg flag. We took standard ornithological measurements of each individual and collected a blood sample for later genetic analysis. Sex was determined using a small portion of the blood sample (Zoogen DNA Services, Davis, California).

We attempted to relocate each marked owl ≥1× weekly throughout the study. Relocations were obtained via homing techniques and locations were recorded within 100 m of the owl without disturbing it. If owls could not be located, the entire study area was searched on foot and via fixed-winged aircraft when possible.

To help determine if nesting structures are limiting the breeding population of Great Gray Owls, we began installing nesting platforms in the study area in fall 2013. Nesting platforms were made following Bull and Henjum (1990). We used a random design to assign locations of nesting platforms. First, we delineated the area in which we had adequately surveyed for nesting owls both by call-back surveys and fledgling surveys so we could accurately describe nesting density in 2013. We divided this area into two sections: a control and a treatment area. The control area was defined so natural fluctuations in owl density could be compared with any changes in density as a result of increasing nesting substrate options in the treatment area. In the treatment area, we used a GAP habitat layer to identify any forest patch with >25-cm DBH to define potentially available nesting habitat. We then randomly projected points within this layer that were a ≥100 m from the nearest edge and ≥400 m from the nearest neighboring point. We projected 40, 60, and 100 points in this manner. We determined that 40 locations was inadequate, as several large forest tracts did not have any points, and the 100 location layer placed too many locations near the forest edge to abide by the 400 m inter-point distance rule. So, we chose 60 random points, which adequately covered the treatment area without missing any large forest tracts.

When placing platforms, we chose a tree of the species representative of that forest tract, with ≥40 cm DBH, and with an adjacent tree in which we could place a motion/thermal-triggered trail camera to monitor the platform for use. We chose the tree nearest to the random location that met this criterion.

RESULTS

With the help of BTNF survey crews, we visited 584 individual call locations, and re-surveyed 215 of those, for a total of 799 survey locations (Fig. 1). Assuming each call location has detectability for a 200-m radius, we effectively surveyed a total of 7,335 ha. It took 84 team-nights to complete the surveys from 13 March to 24 April 2013. It appeared that Great Gray Owls reduced calling towards the last few days of the survey period, so call-back surveys were ended on 25 April 2013.

We recorded a total of 320 detections from 7 different owl species (Fig. 2). The most frequently detected owl species was Great Horned Owls (*Bubo virginianus*; 93), followed by Boreal Owls (n = 74), Northern Saw-Whet Owls (*Aegolius acadicus*; 70), Great Gray Owls (66), Long-eared Owls (*Asio otus*; 9), Northern Pygmy Owls (*Glaucidium gnoma*; 6) and Barred Owls (*Strix varia*; 2). To the greatest extent possible, we documented when detections occurred at adjacent call locations, and removed these from the dataset, keeping only the initial detection. In several instances, observations among different survey days were clumped, indicating that the detections may have been of the same pair or territorial bird (Fig. 3). After accounting for the clumped distribution, we estimated there were at least nine Great Gray Owl territories within the survey area.

We exhaustively searched for nest sites within each of the nine suspected nesting territories and found four occupied Great Gray Owl nests, two in old goshawk nests, one in a broken-top cottonwood snag, and one in a mistletoe clump. Great Gray Owls were regularly found in the remaining territories, leading us to believe that the owls either were pairs that did not nest or were non-breeding individuals or juvenile owls. Overall, we suspected four territories were occupied by pairs, but the owls did not nest in 2013.

While searching for Great Gray nests, we also located active nests for Great Horned Owl (3), Red-tailed Hawk (*Buteo jamaicensis*; 2), Sharp-shinned Hawk (*Accipiter striatus*; 2), Canada Goose (*Branta canadensis*; 2), Common Raven (*Corvus corax*; 2), and Northern Goshawk (1). We documented an additional 25 unoccupied stick nests and 14 mistletoe and 9 broken snags with evidence of bird use (e.g., feathers or pellets in or below structure).

We completed 136 fledgling call-back surveys in August (Fig. 4) and located 1 additional Great Gray Owl family group that was not located during the nest searches. The 3 successful pairs we found fledged an average of 1.67 young per nest. Using the 4 nests found and additional family group located during fledgling surveys, the average nest success rate was 60%.

While nest searching, we documented locations and signs of raptors whenever possible. We collected 80 Great Gray Owl feathers, 21 Great Horned Owl feathers, 4 Long-eared Owl feathers and 4 Accipiter feathers (Fig. 5). We also recorded 106 visual locations of unknown Great Gray Owls. It is likely that some of these observations were of owls that were later captured, so it is unknown how many individuals this represents.

We collected 63 owl pellets for prey analysis. Pellets were gathered opportunistically, so we are uncertain if all pellets were from Great Gray Owls, but we recorded if feathers were located nearby and the species from which they belonged. Efforts were made to search around all known perch and nest sites of Great Gray Owls. Analysis of pellets will be completed later.

We trapped small mammals at nine known or suspected nesting territories in the fall of 2013. We placed 50 traps in each territory (25 in forest and 25 in meadow habitats), for 1,200 trap days. We captured 123 individuals and had 50 recaptures. The most abundant species trapped were chipmunks (*Neotamias* spp*.;* 75), followed by deer mice (*Peromyscus maniculatus;* 29), southern red-backed vole (*Clethrionomys gapperi;* 16), dwarf shrew (*Sorex nanus;* 2), long-tailed vole (*Microtus longicaudus;* 1), and northern flying squirrel (*Glaucomys sabrinus;* 1)

We captured and tagged a total of 10 Great Gray Owls during 2013 and placed transmitters on 9 of those individuals (Table 1). We lost one transmitter after it was molted, and one young owl was hit by a vehicle shortly after capture, leaving seven individuals with working transmitters at the end of 2013. We captured three owls that had successful nests (two females, one male), one non-nesting adult female, and five juvenile or sub-adult owls. We did not tag any nestlings from the known nests in 2013.

We originally designed this project to utilize solar-powered satellite GPS transmitters but did not pursue that option after speaking with the manufacturers and other researchers utilizing solar-powered transmitters on other owl species. We determined that solar-powered transmitters would not adequately work on Great Gray Owls due to feathers covering the solar panels. We designed and deployed store-on-board GPS transmitters that gather 1 location every 4 hrs for 4-6 months for testing on several owls in 2013. After evaluating results obtained in 2013, we will deploy more GPS units in 2014.

As of 31 December 2013, we gathered 145 relocations on all of the marked owls (Fig. 5). However, five of the seven marked owls either left the study area or were otherwise unable to be relocated starting in late September or early October. The owls remained missing through December 2013. We are anticipating they will return to territories in the spring of 2014 when we can recapture the owls to retrieve the GPS loggers and determine wintering locations.

Excluding the owl that was only relocated once, we gathered an average of 18 relocations per individual (range = 11-39) during 2013. The average minimum convex polygon (MCP) home-range estimate was 521 ha (range = 902-1334; Fig. 5), but this home-range size does not include wintering locations for the five owls that are currently missing since fall.

We set up 24 nesting platforms during fall 2013 (Fig. 6). The platforms were constructed with the aid of local Boy Scout and Girl Scout troops as part of our community outreach and education program. The remaining 36 platforms will be set up in the summer and fall of 2014. We also placed one remote camera near each of the platforms. These cameras were placed in an adjacent tree at the same height as the platform (10.6 m). Test cameras were deployed at our offices to monitor battery life of the units, and batteries will be replaced as necessary. Nine platforms were placed in lodgepole pine, five in Douglas-fir, four in aspen, and three in Englemann spruce trees. We will check cameras when the batteries die or after the nesting season has begun, whichever is first. Checking cameras after nesting has begun will allow us to assess if any owls found the platforms but decided not to use them.

DISCUSSION

During 2013 we made significant progress initiating this multi-year project. We documented many aspects of the breeding biology and movement behaviors of Great Gray Owls in western Wyoming. Bull et al. (1988b) found typical MCP home ranges for Great Gray Owls in Oregon of 6,730 ha and 15,700 ha for adults and juveniles, respectively. Owl home ranges in California were smaller, with an average Kernel home range size of ca. 2,350 ha for juveniles and 350 ha for adults (no MCP estimates reported; van Ripper and van Wagtendonk 2006). The home ranges reported for our study are incomplete estimates for most owls, since many were missing for the late fall-early winter period. Further data collection and retrieval of the GPS loggers should help reveal where these owls went to winter.

Shortly after approval of this project, we learned that BTNF was planning a large forest-treatment project (Teton to Snake Fuels Treatment Project) towards the southern extent of our Great Gray Owl study area. We have focused survey and monitoring efforts in and adjacent to this potential treatment project area with the goal of potentially setting up a long-term study that may be able to assess the influence of forest treatments on Great Gray Owls, including changes in distribution, density, and movements. We focused the first year of data collection within the proposed treatment area towards the Fall Creek and Fish Creek areas near Wilson. Gathering data in the area prior to treatments may allow for post-treatment comparisons if this project goes forward as planned.

In 2014, we are planning to expand the study area to the north and will focus efforts based on knowledge gathered during 2013. Specifically, we will change call-back survey protocols to be more efficient by reducing the area surveyed at higher elevation, back-country sites where Great Gray Owls were not detected in 2013. We will install the remainder of the nesting platforms in 2014 and continue with small mammal mark-recapture techniques within known territories. We will also explore methods on surveying pocket gopher (*Thomomys* spp.) abundance throughout the study area, as this can be a key prey species for Great Gray Owls (Franklin 1988, van Ripper et al. 2013).

We will continue to explore options to improve GPS tracking and likely continue to use VHF transmitters on a sub-set of owls as well (e.g., fledglings or previously marked owls). We will target breeding adults (either sex) for tagging efforts in the spring prior to nesting to enable us to more efficiently find nest sites.

ACKNOWLEDGEMENTS

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Table 1. Capture data for Great Gray Owls (*Strix nebulosa*) in northwestern Wyoming, 2013.

Capture date	General location	Color band	Age	Sex	Weight	Transmitter	Cause	Date stopped
28-Jan-13	Ely Springs	Blue A1	Juvenile	Male	1,220	None		
30-Apr-13	Poison Creek	Blue A3	Adult	Female	1,220	Tail Mount VHF	Dropped trans	20-Aug-13
14-Jun-13	Riverview Meadows	Blue A4	Subadult	Male	1,080	GPS/VHF		
18-Jun-13	Taylor	Blue A5	Adult	Female	1,240	GPS/VHF		
4-Jul-13	Bluebell - Paintbrush	Blue A6	Adult	Male	990	GPS/VHF		
16-Jul-13	Resor	Blue A7	Adult	Female	940	Backpack VHF		
23-Jul-13	Red Top	Blue A8	Adult	Male	1,070	Backpack VHF		
24-Aug-13	Trail Creek	Blue A9	Subadult	Male	1,120	GPS/VHF		
30-Sep-13	Paintbrush/Crescent H	Blue C1	Subadult	Male	950	Backpack VHF		
28-Oct-13	Mead Ranch	Blue C2	Juvenile	Female	1,000	Backpack VHF	Hit by car	31-Oct-13

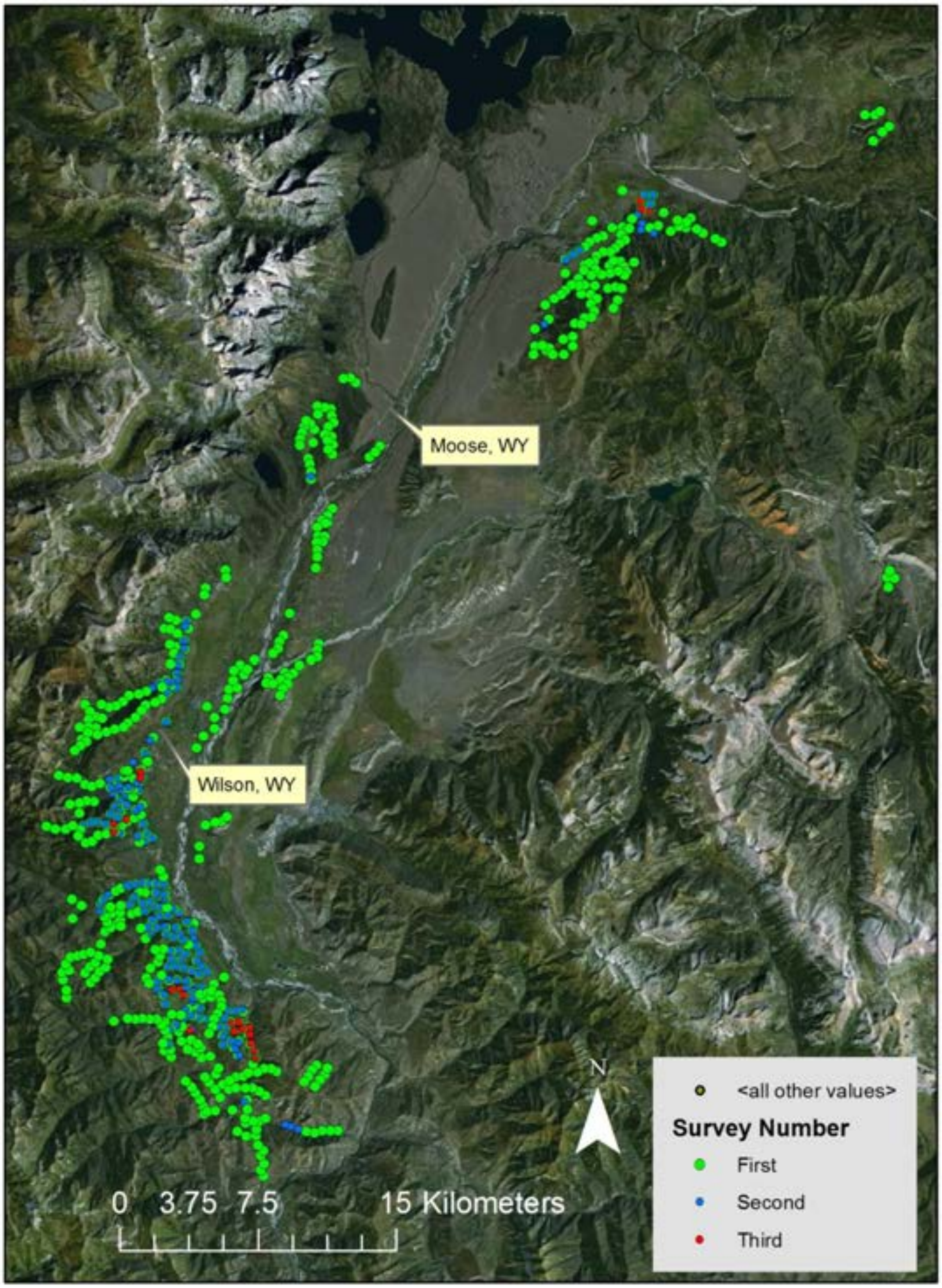

Figure 1. 2013 nighttime call-back owl survey locations. Green dots indicate locations surveyed once, blue dots twice, and red dots three times. Surveys were completed from 13 March-25 April 2013.

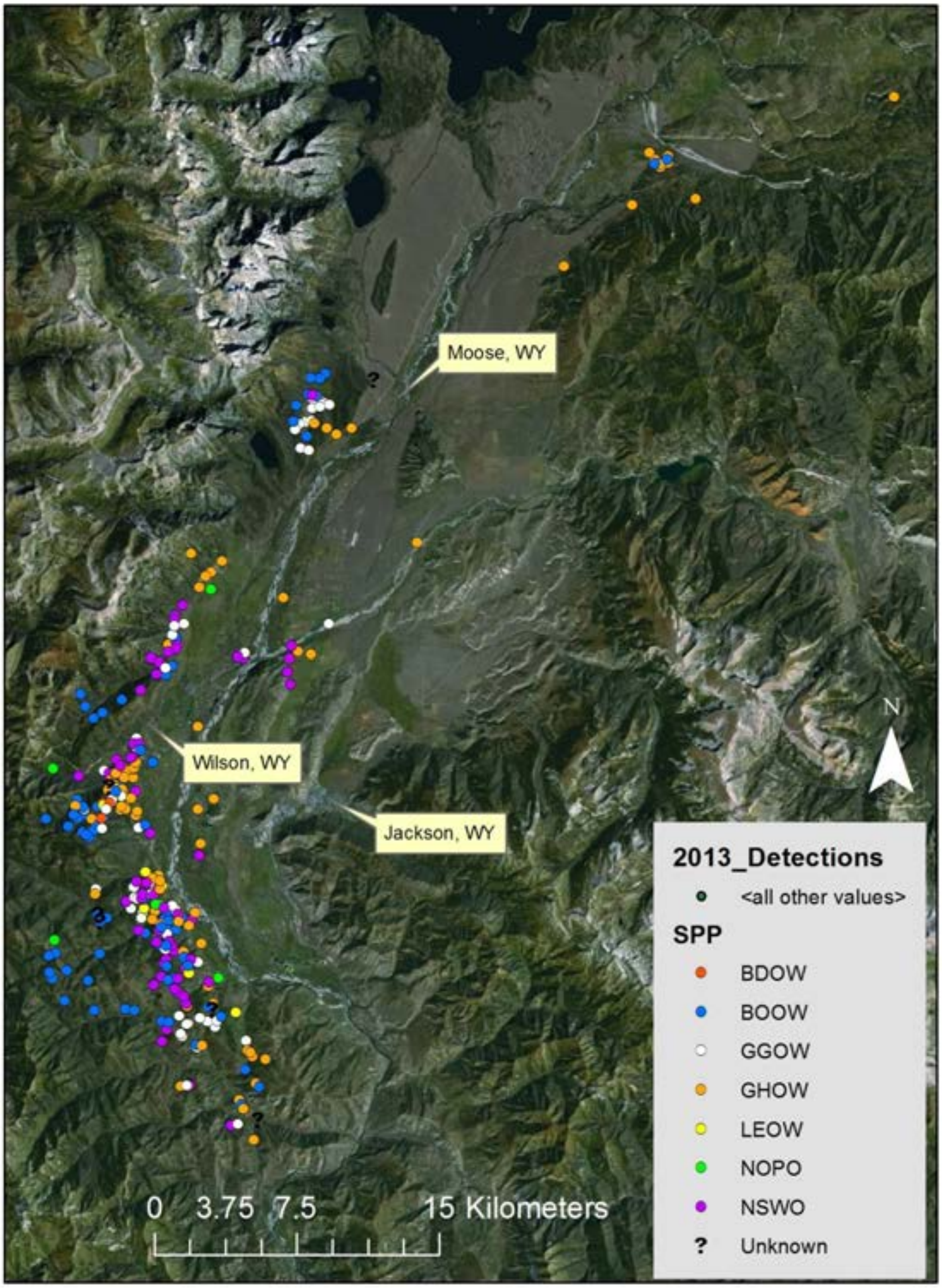

Figure 2. All owl detections during spring call-back surveys from 13 March – 25 April, 2013 in western Wyoming.

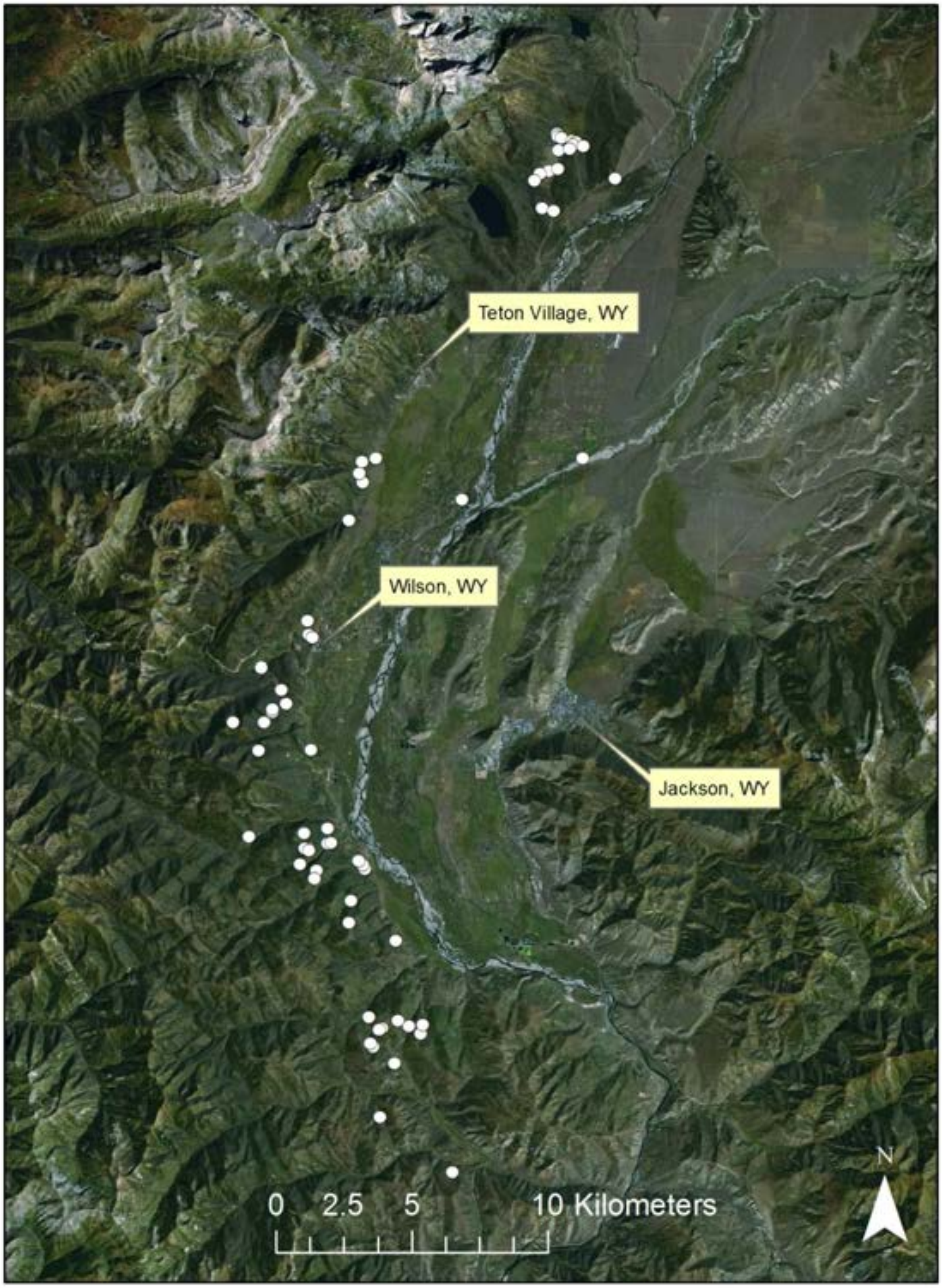

Figure 3. 2013 Great Gray Owl (*Strix nebulosa*) detections during spring call-back surveys in western Wyoming.

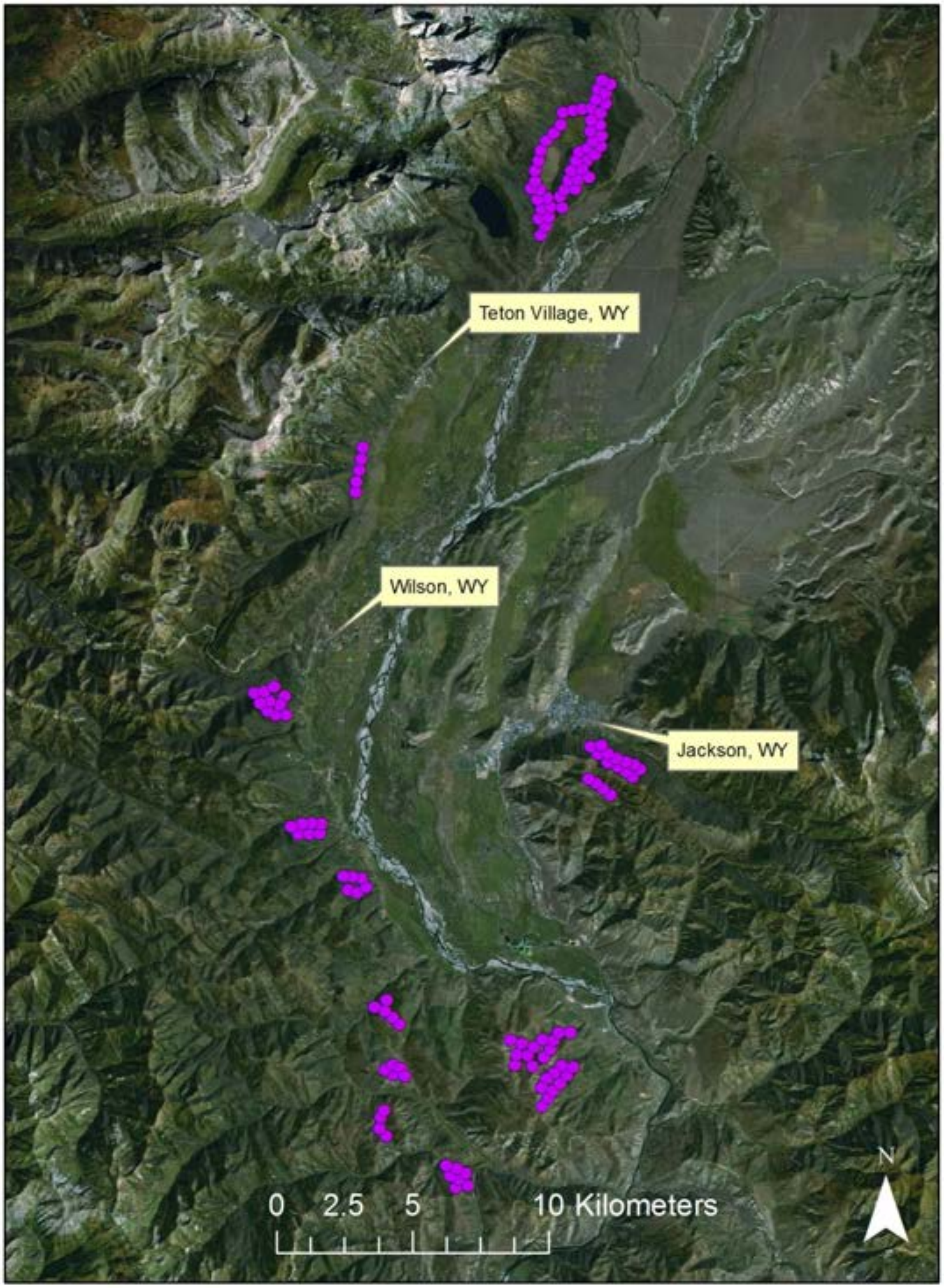

Figure 4. Fledgling call survey locations in 2013 used to help detect successful nest sites not located during nesting surveys. Locations were chosen based on previous records, sightings, and call-backs of Great Gray Owls (*Strix nebulosa*) within the study area.

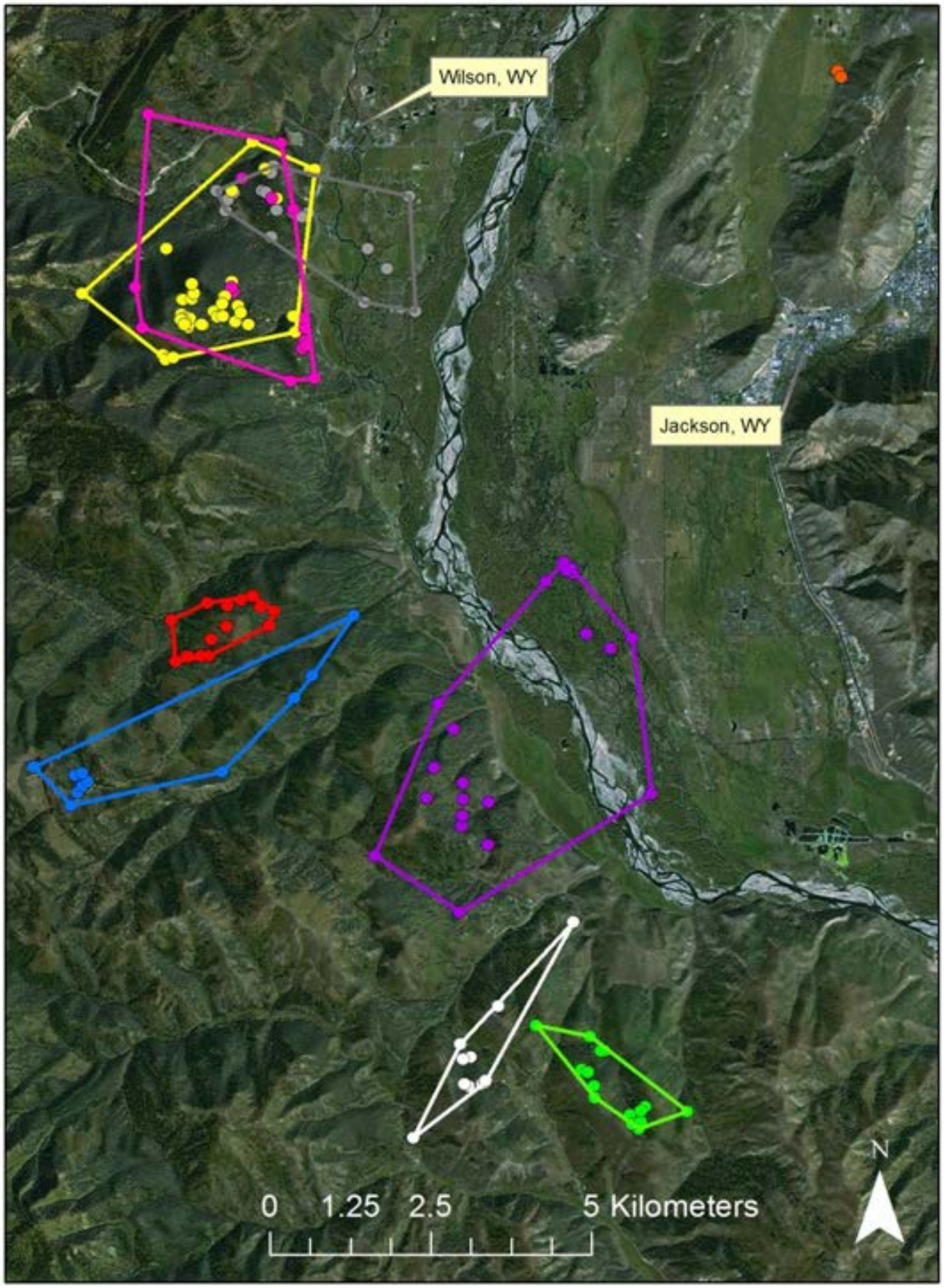

Figure 5. Relocations and minimum convex polygon home-range estimates of radio-marked Great Gray Owls (*Strix nebulosa*) tracked in 2013. Owls were tracked ≥1× per week, but several owls left the study area in late November or early October and were not relocated again in 2013, so the data are not representative of annual home ranges for all birds.

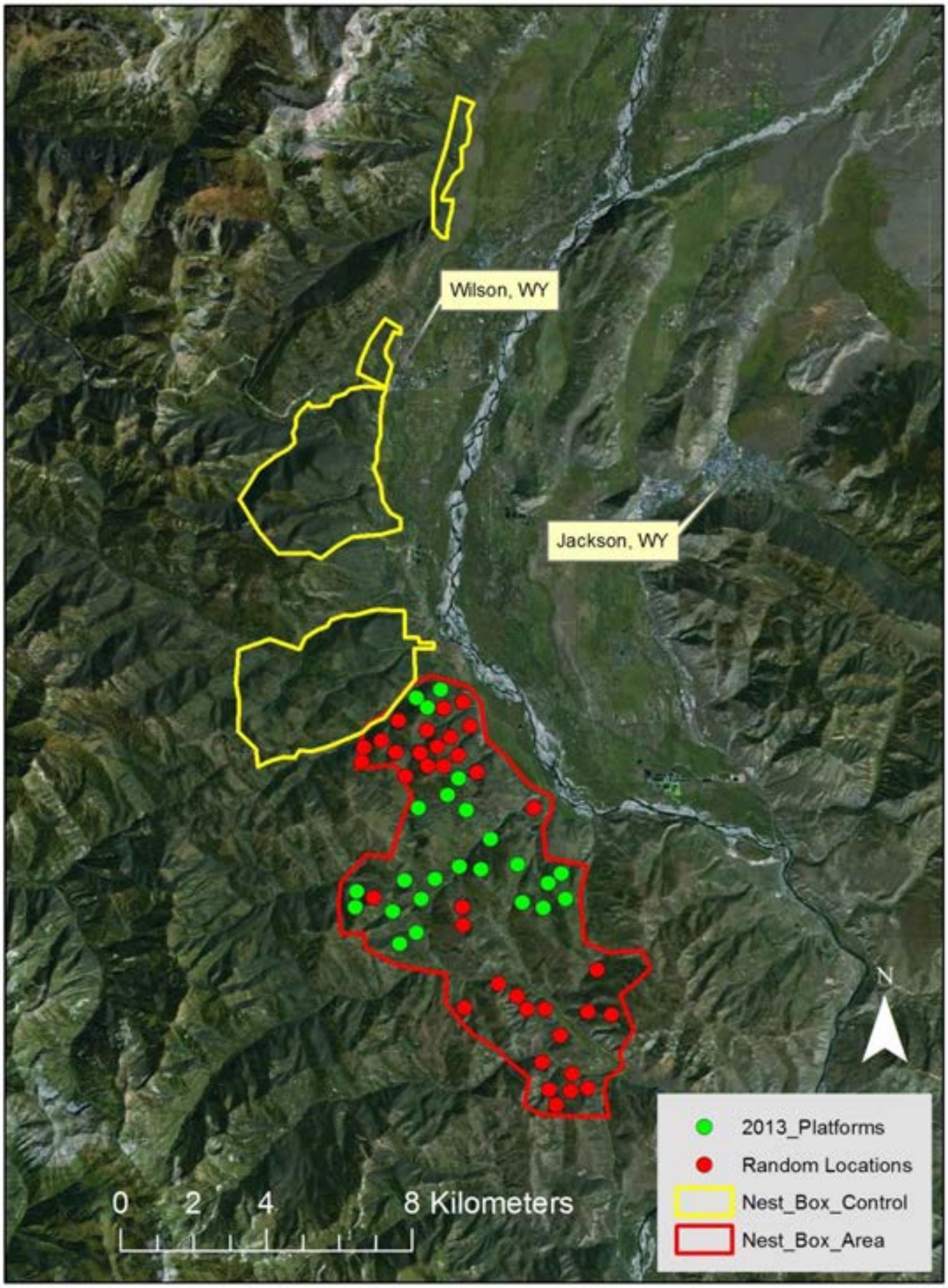

Figure 6. Control and treatment areas for Great Gray Owl (*Strix nebulosa*) nesting platform study. Red dots indicate locations where platforms will be placed in 2014, and green dots are locations of platforms erected in 2013.

SURVEYS FOR BLACK-BACKED WOODPECKERS (*PICOIDES ARCTICUS*) ON THE LARAMIE AND BIGHORN MOUNTAINS, WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Conservation Need – Black-backed Woodpecker

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 10 June 2013 – 21 June 2013

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Ian Abernethy, Wyoming Natural Diversity Database
Gary Beauvais, Wyoming Natural Diversity Database
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ABSTRACT

In Wyoming, the Black-backed Woodpecker inhabits the Greater Yellowstone Ecosystem south along the Wyoming Range, and a disjunct population exists in the Black Hills of Wyoming and South Dakota. The Black-backed Woodpecker is classified as a Species of Greatest Conservation Need in Wyoming due to unknown population status and trends and habitat-related limiting factors that are severe. Isolated populations of Black-backed Woodpeckers in the Black Hills of Wyoming and in Oregon and California were petitioned for protection under the Endangered Species Act in 2012. In 2013, the United States Fish and Wildlife Service issued a positive 90-day finding indicating that the petition presented substantial scientific evidence to support listing these populations. The Black-backed Woodpecker is associated with boreal and montane coniferous forests. It generally occurs at low densities in mature, unaltered forests but is often associated with recently burned forests, with much higher densities observed within burned forests than unburned forests. While the Black-backed Woodpecker has not been documented in Wyoming's Bighorn Mountains or the Laramie Range, potentially suitable habitat exists, recent fire activity has been relatively high, and these large fires occurred within irruptive distances observed for this species. The Wyoming Natural Diversity Database and Wyoming Game and Fish Department cooperatively used call-playback surveys to document presence or absence of Black-backed Woodpeckers in post-fire habitat outside of their known range in the Bighorn Mountains, Casper Mountain, and near Laramie Peak. At each survey location, we listened passively for $\geq$1 min, then broadcasted a 30-sec sequence of a Black-backed Woodpecker drumming and calling followed by 1 min of silence. We recorded the type of response, species responding, and confidence of species identification. We conducted 191 surveys and detected 79 woodpeckers representing 7 species, but did not document any Black-

backed Woodpeckers at any location during the study. Although negative survey results do not conclusively rule out presence of the species, evidence from other studies shows that the Black-backed Woodpecker responds readily to broadcast calls, meaning that it is likely to be detected using this method if present in the vicinity of the survey location. Our results suggest that Black-backed Woodpecker distribution in Wyoming is limited to the northwestern mountains and the Black Hills.

INTRODUCTION

The Black-backed Woodpecker (*Picoides arcticus*) is widely distributed across the boreal forests of northern North America. The species' distribution extends south along the Cascade and Sierra Nevada Ranges in Washington, Oregon, and California and also along the northern Rocky Mountains into Wyoming (Fig. 1). In Wyoming, Black-backed Woodpeckers can be found throughout the Greater Yellowstone Ecosystem south along the Wyoming Range (Fig. 2). A disjunct population also exists in the Black Hills of Wyoming and South Dakota. The Black-backed Woodpecker is classified as a Species of Greatest Conservation Need in Wyoming due to unknown population status and trends and habitat related limiting factors that are severe and continue to increase in severity (WGFD 2010).

The isolated population of Black-backed Woodpecker in the Black Hills, along with isolated populations in Oregon and California, were petitioned for protection under the Endangered Species Act (ESA) in 2012 (Hanson et al. 2013, USFWS 2013). In 2013, the US Fish and Wildlife Service (USFWS) issued a positive 90-day finding indicating that the petition presented substantial scientific evidence to support listing these populations. Currently, the USFWS is conducting a formal status review of these distinct population segments (USFWS 2013).

The Black-backed Woodpecker is associated with boreal and montane coniferous forest rangewide. The species generally occurs at low densities in mature, unaltered forests. However, the species is often associated with recently burned forests, with much higher densities of Black-backed Woodpeckers observed within burned forests than unburned forests (Mohren 2002). Typically, densities of Black-backed Woodpeckers are highest 1 to 3 years post-burn. Furthermore, evidence suggests that Black-backed Woodpecker irruptions result in colonization of burned areas within a few months after fire activity has ceased in the area (Dixon and Saab 2000). Additionally, relatively long distance irruptions of over 500 km have been observed in portions of the species range (Dixon and Saab 2000). This suggests that the species may colonize burned areas far from their current distribution within a relatively short time period.

While the Black-backed Woodpecker has not been documented in the Bighorn Mountains in north central Wyoming or in the Laramie Range in central Wyoming, potentially suitable habitat that is similar to that found in the Black Hills can be found in these mountain ranges. Also, fire activity has been relatively high in these mountain ranges in recent years. In 2012 alone, the Gilead Fire on the eastern edge of the Bighorns burned nearly 3,320 ha, while in the Laramie Range, multiple fires burned well over 40,470 ha. These large fires occurred well within irruptive distances observed for this species, increasing the odds that these areas may become occupied.

Because of these behavioral and life-history traits, the large and recent fires in northern and central Wyoming, and the emerging management importance of the Black Hills population of the species, the Wyoming Natural Diversity Database (WYNDD; University of Wyoming) and the Wyoming Game and Fish Department (Department) cooperatively used call-playback surveys to search for Black-backed Woodpeckers outside of their known range. Specifically, we conducted surveys in the Bighorn Mountains, on Casper Mountain, and in the vicinity of Laramie Peak (Figs. 3-6). The primary goal of these surveys was to document presence or absence of Black-backed Woodpeckers in suitable habitat outside of the known distribution of the species. This information could then be used to inform future research needs and the ESA listing decision.

METHODS

Site section varied based on location. All surveys were conducted within forested habitats that experienced wildfire in 2012. In the Bighorn Mountains, we conducted surveys within the Gilead Fire boundary. We placed sites across the burned area to ensure sampling occurred across the burn. Transects traversed suitable habitat and followed topographical features on the landscape.

In the Casper Mountain area, surveys were conducted within the Sheep Herder Complex Fire boundary. We placed transects within suitable habitat on private land accessible to the surveyor.

In the Laramie Peak area, surveys were conducted within the Cow Camp and Arapaho Fire boundaries. We randomly selected sites in a Geographic Information System (GIS) so sites were within these burn boundaries and on publically accessible land. Sites consisted of two parallel north-south or east-west transects 1 km in length separated by 250 m. Each transect consisted of five points placed 250 m apart. We also conducted surveys along publicly accessible roads within the burn boundaries.

For all call-playback surveys, observers navigated to the location of the playback survey and waited at least 1 min before beginning broadcasting an approximately 30-sec sequence of a Black-backed Woodpecker drumming and calling followed by 1 min of silence. Surveyors repeated this sequence four times at each survey point, and documented any response to the broadcast call from any woodpecker species. Observers recorded the type of response (visual, drum, call, or any combination of the three), the species that responded to the broadcast call, and the confidence of species identification (low, medium, or high).

RESULTS

In 2013, we conducted a total of 191 surveys for the Black-backed Woodpecker. During these surveys, observers detected 79 woodpeckers representing 7 species. No Black-backed Woodpeckers were heard or observed at any location.

We conducted a total of 30 call-playback surveys on four transects within the Gilead Fire boundary in the Bighorn Mountains. During these surveys, observers detected 15 woodpeckers of two species (Table 1).

We surveyed a total of five transects on Casper Mountain, and detected four woodpeckers representing two different species (Table 2).

We conducted a total of 156 call-playback surveys near Laramie Peak. Of these, 26 were mobile call-playback surveys. Twelve woodpeckers of four different species were detected during these surveys (Table 3). Additionally, we completed 130 call-playback surveys on 14 transects. During these surveys, we detected a total of 48 woodpeckers representing five species (Table 4).

DISCUSSION

The most notable result from these surveys was that no Black-backed Woodpeckers were detected. This suggests that the species may not occupy the areas surveyed. It is important to note that negative call-playback survey results do not conclusively rule out presence of the species. However, evidence from other studies shows that the Black-backed Woodpecker responds readily to broadcast calls, meaning that it is likely to be detected using this method if present in the vicinity of the survey location.

In general, call-playback surveys proved effective in eliciting responses from woodpeckers within these burned areas. We recorded a total of 79 woodpecker detections throughout this study. This suggests that woodpeckers in these areas are numerous. This also supports the notion that the Black-backed Woodpecker does not occur within the areas surveyed. Other researchers have noted frequent and intense interspecific interactions when Black-backed Woodpeckers are present (Short 1974, Dixon and Saab 2000). These interactions are often very conspicuous with loud vocalizations and other auditory and visual events (Short 1974). Furthermore, while the direction of these interactions varies with location and species, the Black-backed Woodpecker is often the aggressor and victor, displacing other woodpecker species. During nesting, the species maintains a relatively large territory and actively supplants other woodpeckers that enter their territory (Short 1974). Assuming behavior is similar across the species range, it is unlikely to observe high numbers of various woodpecker species if Black-backed Woodpeckers maintained a territory near our survey locations.

Results from these surveys suggest that Black-backed Woodpecker distribution in Wyoming is limited to the northwestern mountains and the Black Hills. While negative results are less satisfying than positive results, they are important nonetheless. The apparent absence of the species in the northern Laramie Mountains and the Bighorn Mountains may lead to different management priorities and practices in these areas.

ACKNOWLEDGEMENTS

Funding for this survey effort was provided by the Wyoming Governor's Office and the Wyoming State Legislature, for which we are extremely grateful. We would like to thank K. Lash, D. Thiele, and J. Binfet with the Department, and M. Wickens, S. Brandebura, and D. Keinath with WYNDD for conducting field work.

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Table 1. Woodpecker species and number we detected during call-playback surveys in the Bighorn Mountains, Wyoming in 2013.

Woodpecker species	Number detected
American Three-toed Woodpecker	11
Northern Flicker	1
Unknown woodpecker	3

Table 2. Woodpecker species and number we detected during call-playback surveys on Casper Mountain, Wyoming in 2013.

Woodpecker species	Number detected
Downy Woodpecker	2
Williamson's Sapsucker	2

Table 3. Woodpecker species and number we detected during mobile call-playback surveys near Laramie Peak, Wyoming in 2013.

Woodpecker species	Number detected
American Three-toed Woodpecker	1
Downy Woodpecker	3
Hairy Woodpecker	6
Northern Flicker	2

Table 4. Woodpecker species and number we detected during call-playback surveys near Laramie Peak, Wyoming in 2013.

Woodpecker species	Number detected
American Three-toed Woodpecker	2
Downy Woodpecker	3
Hairy Woodpecker	26
Lewis's Woodpecker	3
Northern Flicker	7
Red-naped Sapsucker	1
Unknown woodpecker	6

Figure 1. North American distribution of Black-backed Woodpecker (*Picoides arcticus*). Map adapted from Ridgely et al. (2005).

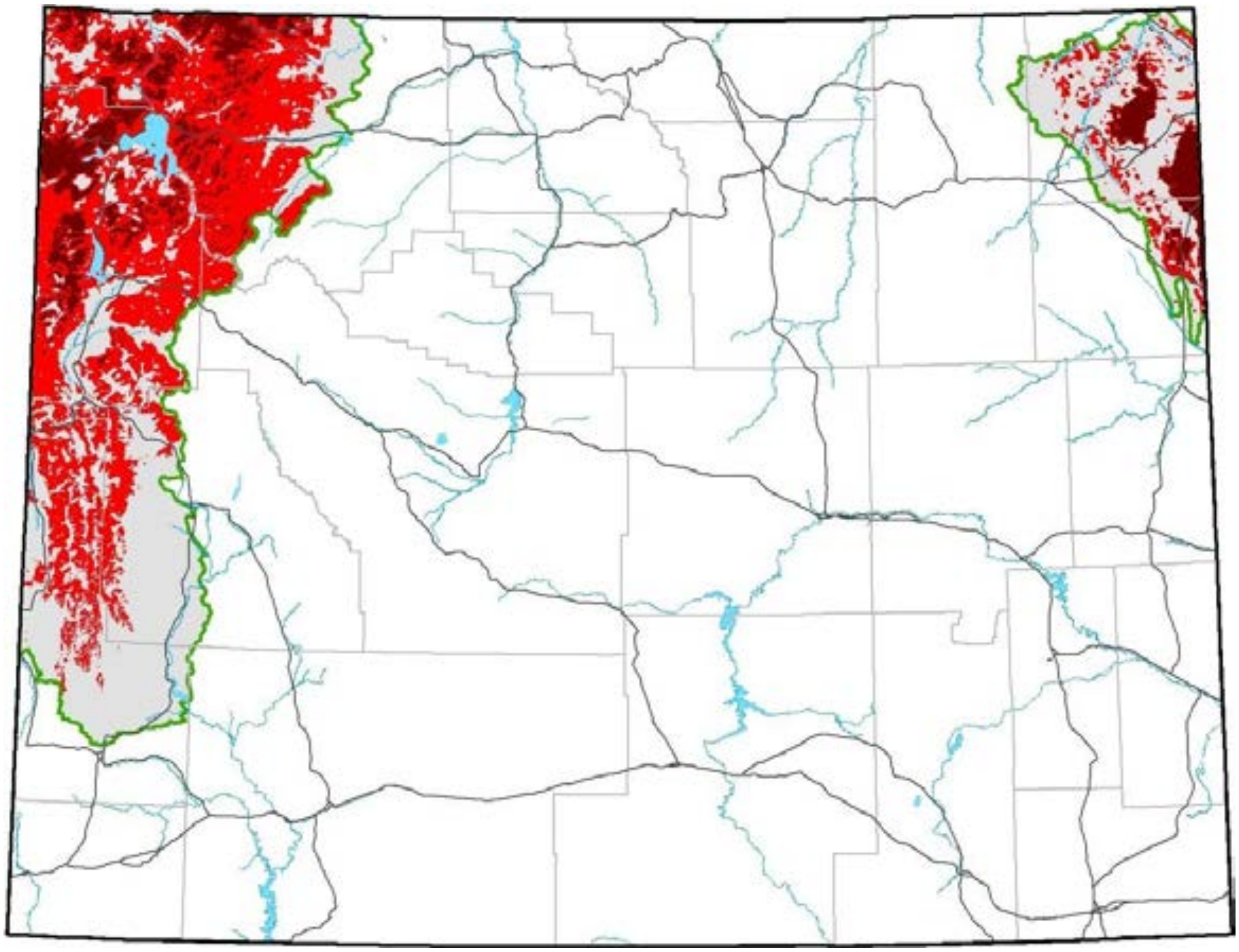

Figure 2. Range and predicted distribution of the Black-backed Woodpecker (*Picoides arcticus*) in Wyoming. Map from Keinath et al. (2010).

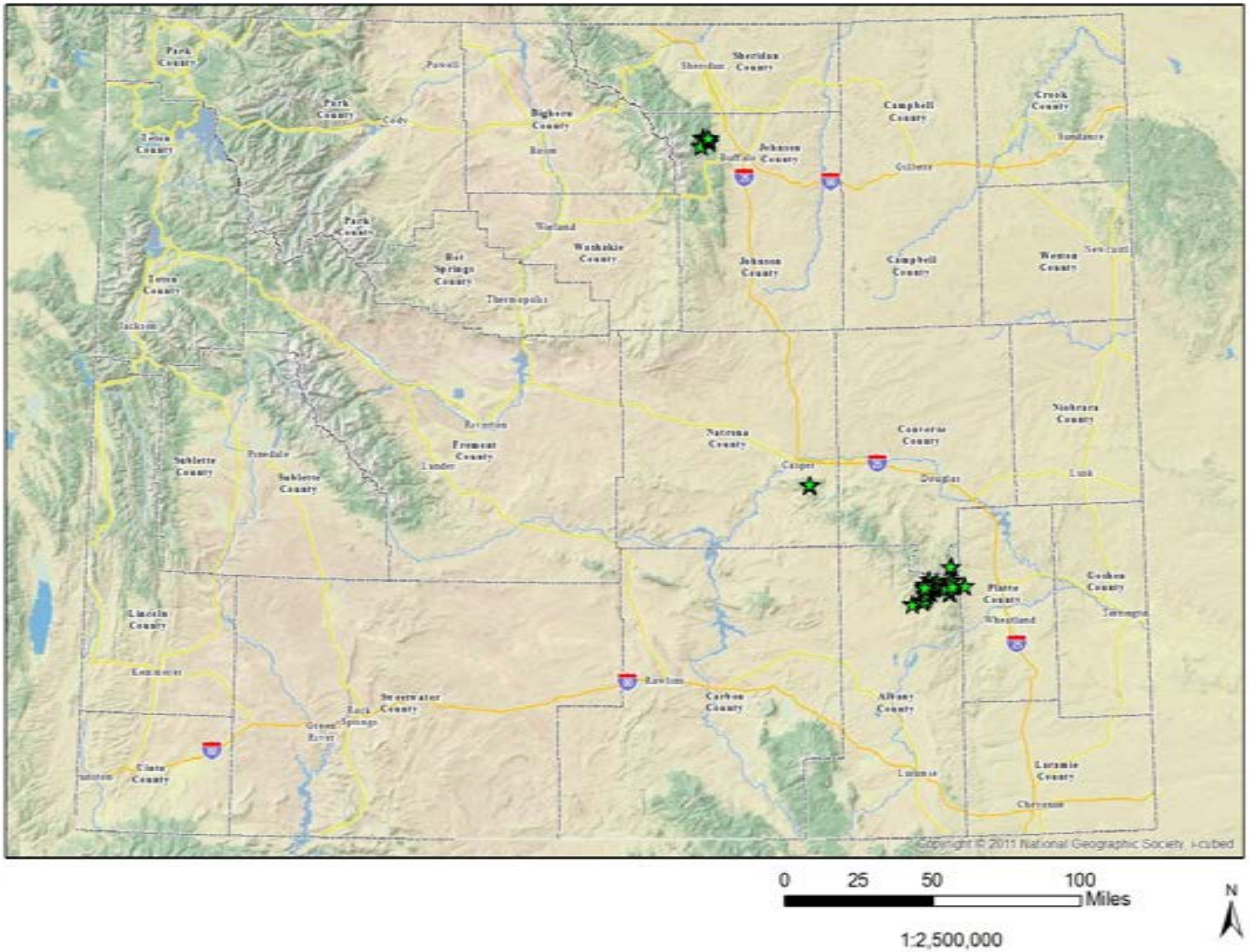

Figure 3. Locations of Black-backed Woodpecker (*Picoides arcticus*) surveys we conducted in Wyoming in 2013.

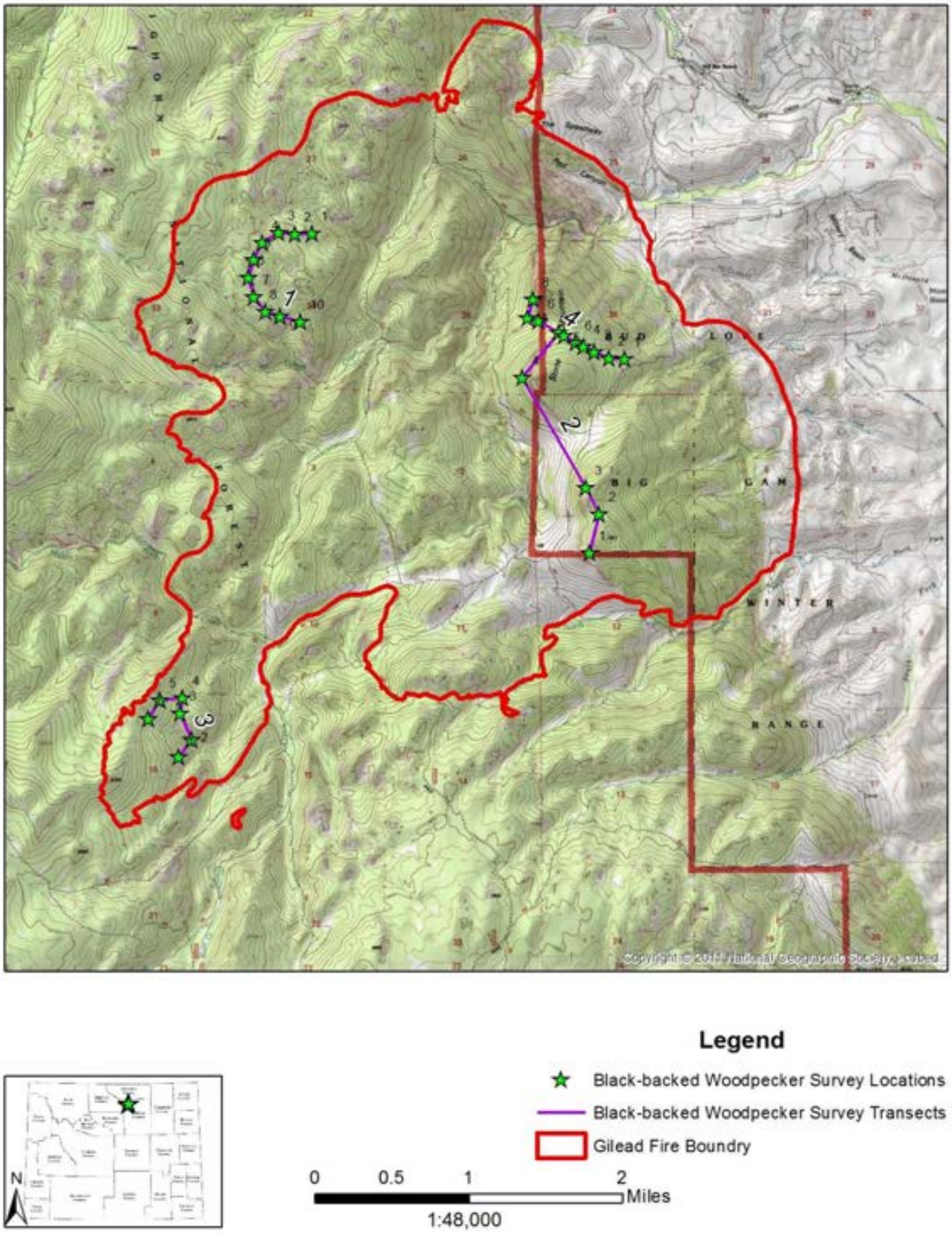

Figure 4. Black-backed Woodpecker (*Picoides arcticus*) surveys we conducted within the Gilead Fire in the Bighorn Mountains, Wyoming in 2013.

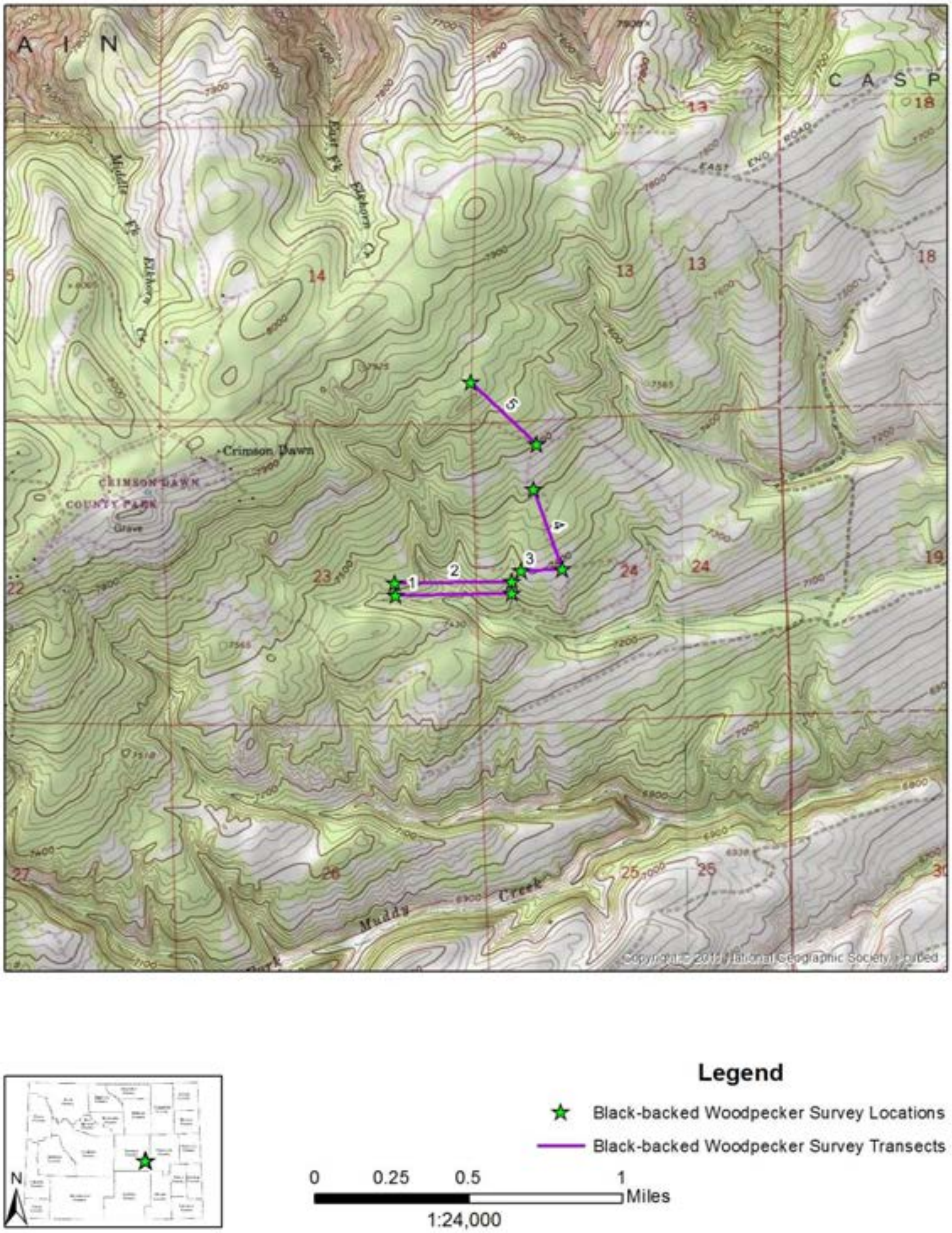

Figure 5. Black-backed Woodpecker (*Picoides arcticus*) surveys we conducted on Casper Mountain, Wyoming in 2013.

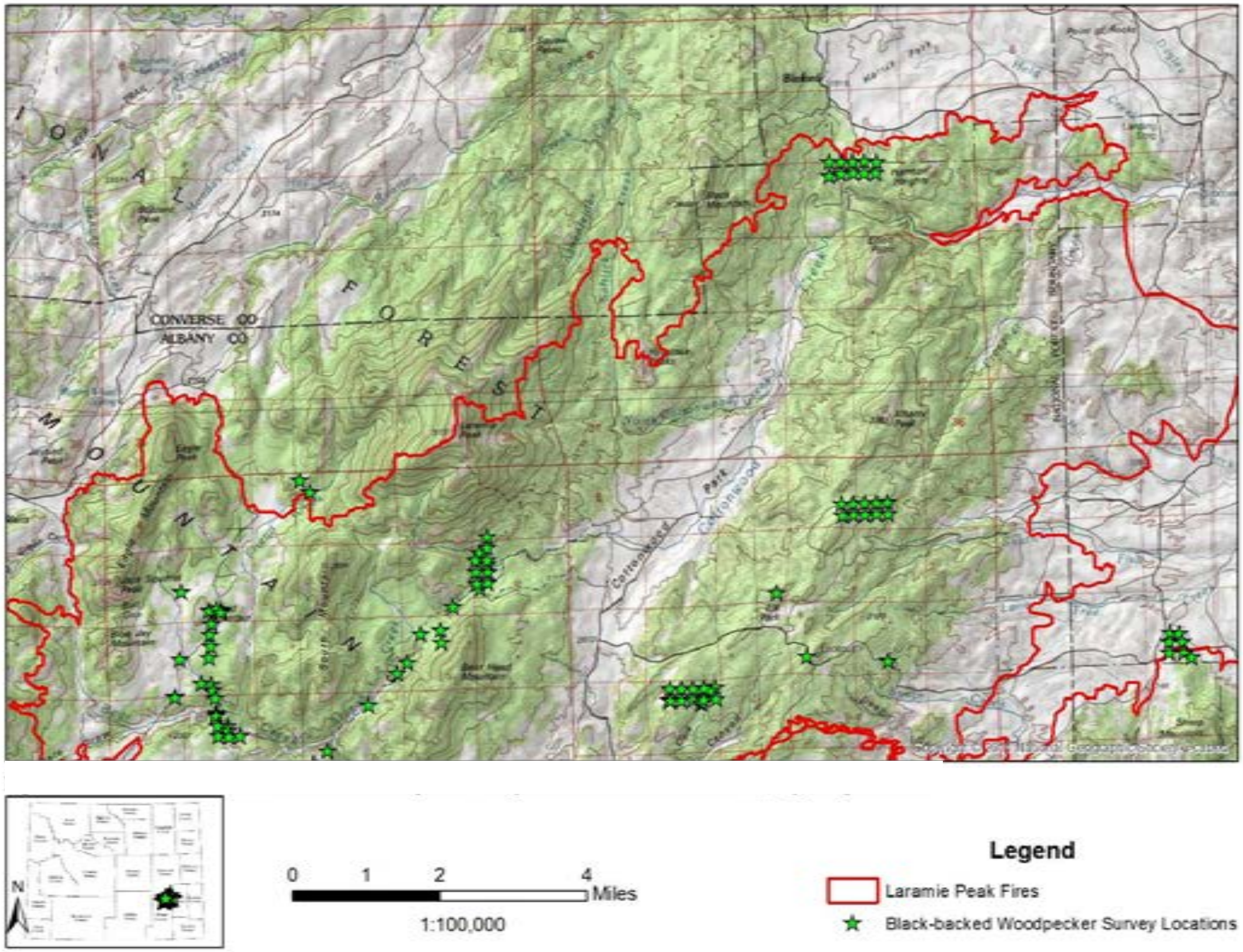

Figure 6a. Northern locations of Black-backed Woodpecker (*Picoides arcticus*) surveys we conducted near Laramie Peak, Wyoming in 2013.

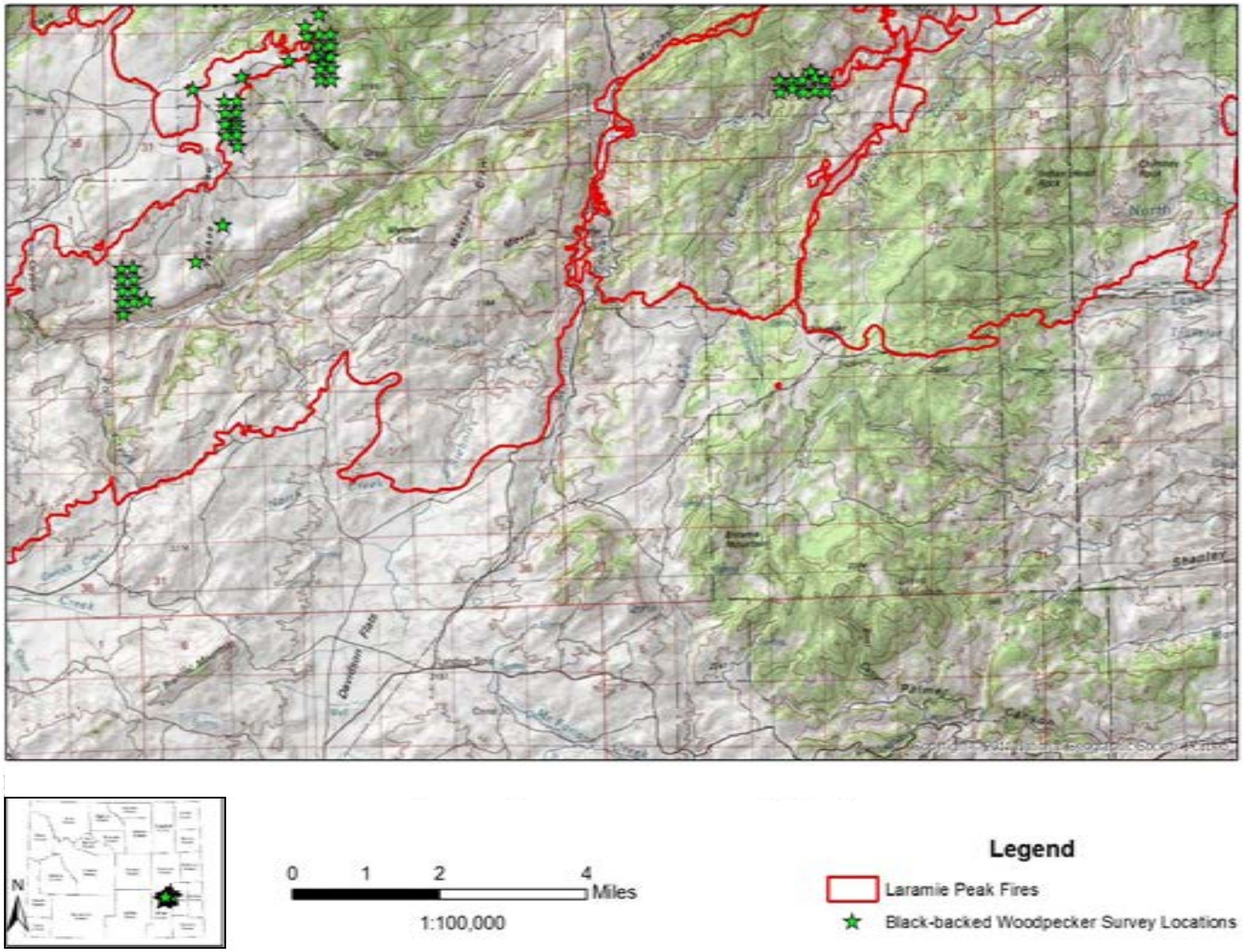

Figure 6b. Southern locations of Black-backed Woodpecker (*Picoides arcticus*) surveys we conducted near Laramie Peak, Wyoming in 2013.

PRODUCTIVITY OF PEREGRINE FALCONS (*FALCO PEREGRINUS*) IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Peregrine Falcon

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
United States Fish and Wildlife Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Bob Oakleaf, Nongame Coordinator
Susan Patla, Nongame Biologist
Doug Smith, Senior Wildlife Biologist, Yellowstone National Park

ABSTRACT

We have continued monitoring of nesting Peregrine Falcons (*Falco peregrinus*) in Wyoming since the species was removed from protection under the Endangered Species Act in 1999. In cooperation with the US Fish and Wildlife Service, Wyoming participated in the National Monitoring Plan for delisting of the American Peregrine Falcon every 3 years (2003, 2006, 2009, and 2012). We have also monitored nesting performance of Peregrine Falcons in Wyoming on an annual basis between these US Fish and Wildlife Service-sponsored surveys. In 2013, we found 36 of 43 (84%) nesting territories occupied, which fledged 51 young or 1.4 young per occupied site. Results are similar to long-term averages and remain well above recovery goals, indicating that the Peregrine Falcon nesting population is stable in Wyoming. We also conducted helicopter surveys of >1,063 km of cliffs in 2013 and located 18 new nesting territories, bringing the statewide total to 118 territories.

INTRODUCTION

In cooperation with The Peregrine Fund, Inc., the Wyoming Game and Fish Department (Department) developed plans from 1978-1980 to re-establish Peregrine Falcons (*Falco peregrinus*; peregrines) in Wyoming based on analysis of historical distribution and evaluation of potential habitat during survey work. Our goal of reintroduction was to establish and maintain a self-sustaining breeding nucleus in the wild. We set objectives to annually release approximately 15 peregrines and establish 30 breeding pairs in Wyoming by 1996. We coordinated the program with Idaho and Montana to ensure maximum results to re-establish this species. Peregrine reintroduction and monitoring efforts are detailed in previous Department Nongame

Wyoming, we released 384 peregrines from 1980-1995, with ≥325 (85%) surviving to dispersal (i.e., 1 month post-release). We have not released peregrines since 1995 because we attained objectives in 1994-1995, and the species was subsequently delisted at the national level in 1999. We do, however, continue monitoring efforts as populations are relatively limited. In cooperation with the US Fish and Wildlife Service (USFWS), Wyoming also participated in the National Monitoring Plan for delisting of the American Peregrine Falcon every 3 years with supplemental funding from the USFWS in 2003, 2006, 2009, and 2012 (Table 1). We have also monitored nesting performance of peregrines in Wyoming on an annual basis between these USFWS-sponsored surveys. Our objectives in 2013 were to continue annual monitoring at 30 randomly selected nesting sites throughout Wyoming to assess occupancy and productivity.

METHODS

We recorded potential peregrine nesting cliffs in Wyoming during baseline surveys from 1978-1980 and periodically checked them for occupancy during ground surveys. We collected data on occupancy and fledging from as many of the known peregrine territories as possible from 1984-2004. Since 2005, we have randomly selected 30 territories to survey. Ten sites were randomly selected annually for each of three areas: Yellowstone National Park, west of the continental divide outside of Yellowstone National Park, and the rest of Wyoming east of the continental divide. During the years of the National Monitoring Plan, 15 previously selected sites were automatically selected, and an additional 15 were randomly chosen so that we attempt to annually monitor ≥30 territories. We included additional sites that we observed as time allowed during travels to selected territories and sites observed by cooperators with interest in specific sites.

We determined occupancy for each of the selected territories during early season visits and recorded productivity during ≥1 observations of adults feeding young later in the season. Territories where we failed to locate a breeding pair (i.e., not occupied) were selected for repeated visits. These included ≥2 visits each of ≥4 hrs before the territory could be classified as not occupied. We determined nest success by ≥2 visits with the last visit timed to observe chicks ≥28 days old. We often revisited eyries after the young were fledged to assure a more complete count, especially eyries that were situated where it was difficult to observe young that had not fledged.

In 2012 and 2013, we repeated helicopter surveys of cliffs that we surveyed for peregrines during cooperative surveys with the Bridger-Teton, Shoshone, and Big Horn National Forests from 1978-1982. The recent surveys were conducted with a Bell 47 Soloy, while the early surveys were conducted with a Hiller 12E.

RESULTS AND DISCUSSION

No nesting pairs of peregrines were located in Wyoming during surveys from 1978-1983. The first nesting pair was documented in 1984. In 2013, we surveyed 27 of the 30 randomly selected nesting territories adequately to document reproductive performance. Twenty-one (78%) of the random territories were occupied. Occupied territories fledged 30 young, for an average of 1.4 young per occupied territory (Table 2). We also checked an additional 7 nesting territories in 2013, for a statewide total of 43 territories, 36 of which were occupied by breeding adults (Table 3). These 36 pairs fledged 51 young or 1.4 young per occupied territory. When we added survey data from 2013 to cumulative data collected since 1984, we have recorded ≥982 nesting attempts at 93 territories. These attempts have resulted in ≥1,499 young and a mean of 1.5 young fledged per nesting attempt.

We conducted helicopter surveys of over 1,063 km of cliffs in 2013. We found 18 new nesting territories and checked 48 known sites. We saw adults at 25 (52%) of the known sites and did not see anything with the first try at 23 sites (48%). Eleven sites were rechecked either from the ground or helicopter, and all 11 (100%) were occupied. This indicates that we probably missed another 18 new sites. Currently, there are >118 locations in Wyoming where peregrines have nested. Sixty-six of these nesting territories are located on the cliffs that we surveyed in 2013 where no peregrines were located during the original survey effort from 1978-1982. Of the 118 known locations, 56 of the cliffs were surveyed prior to locating peregrines. Thirty (54%) of these cliffs were occupied by nesting Prairie Falcons (*Falco mexicanus*) and 8 cliffs were occupied by Golden Eagles (*Aquila chrysaetos*) prior to the return of nesting peregrines. Typically, Prairie Falcons no longer occupy cliffs that are part of a peregrine nest territory. However, they have remained at three of the sites. Four of the eight sites previously occupied by Golden Eagles still have nesting eagles nearby.

The expanded data sets and results (Tables 2 and 3) are similar to long-term averages and remain well above recovery goals, suggesting that Peregrine Falcons are maintaining stable populations in Wyoming.

ACKNOWLEDGEMENTS

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Table 1. Peregrine Falcon (*Falco peregrinus*) productivity in Wyoming at National Survey Sites established by the US Fish and Wildlife Service. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of territories checked.

Year	No. territories checked	No. territories occupied	No. successful territories (%)	No. young fledged	No. young per occupied territory
2003	15	15	12 (80)	28	1.9
2006	14	14	11 (79)	26	1.9
2009	15	14	7 (54)	14	1.0
2012	14	13	6 (43)	13	0.9

Table 2. Peregrine Falcon *(Falco peregrinus)* productivity of 30 randomly selected sites in Wyoming, 2005-2013. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of occupied territories.

Year	No. territories checked	No. territories occupied	No. successful territories (%)	No. young fledged	No. young per occupied territory
2005	30	30	21 (70)	51	1.7
2006	30	30	22 (73)	49	1.6
2007	30	27	19 (70)	40	1.5
2008	22	22	13 (59)	30	1.4
2009	30	25	15 (60)	36	1.4
2010	28	24	19 (79)	42	1.7
2011	24	21	14 (68)	33	1.6
2012	29	23	15 (65)	37	1.6
2013	27	21	14 (67)	30	1.4
Mean	27.8	24.8	16.9 (67.9)	38.7	1.5
SD	3.3	3.6	3.6 (7.0)	7.9	0.1

Table 3. Peregrine Falcon *(Falco peregrinus)* productivity for all monitored sites in Wyoming, 1998-2013. Percent of successful territories are the number of territories that produced young to fledging divided by the total number of occupied territories.

Year	No. territories checked	No. territories occupied (%)	No. successful territories (%)	No. young fledged	No. young per occupied territory
1998	44	44 (100)	35 (79)	84	1.9
1999	42	42 (100	25 (59)	57	1.4
2000	46	46 (100)	40 (87)	83	1.8
2001	42	42 (100)	39 (93)	81	1.9
2002	60	59 (98)	49 (83)	97	1.6
2003	58	58 (100)	50 (86)	107	1.8
2004	66	65 (98)	56 (86)	130	2.0
2005	64	64 (100)	45 (70)	99	1.6
2006	61	61 (100)	44 (72)	101	1.7
2007	54	51 (94)	36 (71)	75	1.5
2008	29	29 (100)	19 (65)	45	1.5
2009	46	41 (89)	28 (68)	58	1.4
2010	42	36 (86)	30 (83)	66	1.8
2011	39	33 (85)	26 (79)	50	1.5
2012	45	38 (84)	25 (66)	61	1.6
2013	43	36 (84)	24 (67)	51	1.4
Mean	48.8	46.6	35.7 (76)	78	1.7
SD	10.9	11.8	10.8 (9.8)	24.3	0.20

EVALUATION OF IMPACTS OF WIND ENERGY DEVELOPMENT ON NESTING GRASSLAND BIRDS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need / Grassland Songbirds – Horned Lark and McCown's Longspur

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: Master's Thesis Research

PERIOD COVERED: 1 April 2012 – 31 March 2013

PREPARED BY: Anika Mahoney, Wyoming Cooperative Fish and Wildlife Research Unit
Anna Chalfoun, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

This is a Wyoming Cooperative Fish and Wildlife Research Unit Master of Science thesis project, and only the summary is presented here.

During this reporting period, we completed our second and final field season. In preparation for field data collection, we hired and trained three field technicians and made alterations to our study design, incorporating two control sites with no wind energy development, and a new wind facility, Dunlap Ranch. Dunlap Ranch replaced Seven Mile Hill for nest searching and monitoring because of the low number of grassland bird nests present in 2011 [Horned Lark (*Eremophila alpestris*; HOLA): $n = 2$, Vesper Sparrow (*Pooecetes gramineus*): $n = 2$].

In 2012, we conducted a total of 87 avian point counts across three wind farms (Dunlap Ranch, Seven Mile Hill, High Plains/McFadden Ridge) and two control sites. We searched for nests via rope-dragging and behavioral observation at two wind farms (Dunlap Ranch and High Plains) and at the two control sites, monitoring 128 nests of 5 species of birds (Table 1). We found Horned Lark and McCown's Longspur (*Rhynchophanes mccownii*; MCLO) in numbers adequate to facilitate statistical analysis of nesting productivity. We measured habitat characteristics at all nest sites.

Point count and nest data were entered, proofed, and organized for data analyses. We ran separate analyses for HOLA and MCLO, but grouped across year and site due to small sample size. We began by comparing nesting productivity between wind farm and control sites. We

selected three response variables to quantify nesting productivity: clutch size, nest survival rate, and number of young fledged.

We used a randomization test to compare mean clutch size and mean number of young fledged between wind farm and control sites. There was no evidence that clutch size (HOLA: P=0.594, MCLO: P=0.376) or number of young fledged (HOLA: P=0.981, MCLO: P=0.422) was smaller at wind farms. We also found no evidence of lower nest survival rates at wind farm compared to control sites (Fig. 1). Although productivity for these species does not appear lower on wind farms, the high variability in this system combined with the small number of replicates (wind farm: n = 2, control: n = 2) brings into question the strength of this conclusion. A finer-scale analysis within wind farms will provide greater insight into potential impacts and is the next step in our data analysis.

We presented our nesting productivity results at the 5th Annual North American Ornithological Conference (August 2012), The Wildlife Society's 19th Annual Conference (October 2012), and the Annual Meeting of the Wyoming Chapter of The Wildlife Society (November 2012).

Table 1. Total number of nests we found per species during the 2011 and 2012 nesting seasons in southeastern Wyoming.

Species	Number of nests	
	2011	2012
Horned Lark (*Eremophila alpestris*)	65	80
McCown's Longspur (*Rhynchophanes mccownii*)	31	43
Vesper Sparrow (*Pooecetes gramineus*)	10	1
Mountain Plover (*Charadrius montanus*)	1	3
Killdeer (*Charadrius vociferus*)	1	1
Common Nighthawk (*Chordeiles minor*)	1	0
Western Meadowlark (*Sturnella neglecta*)	1	0

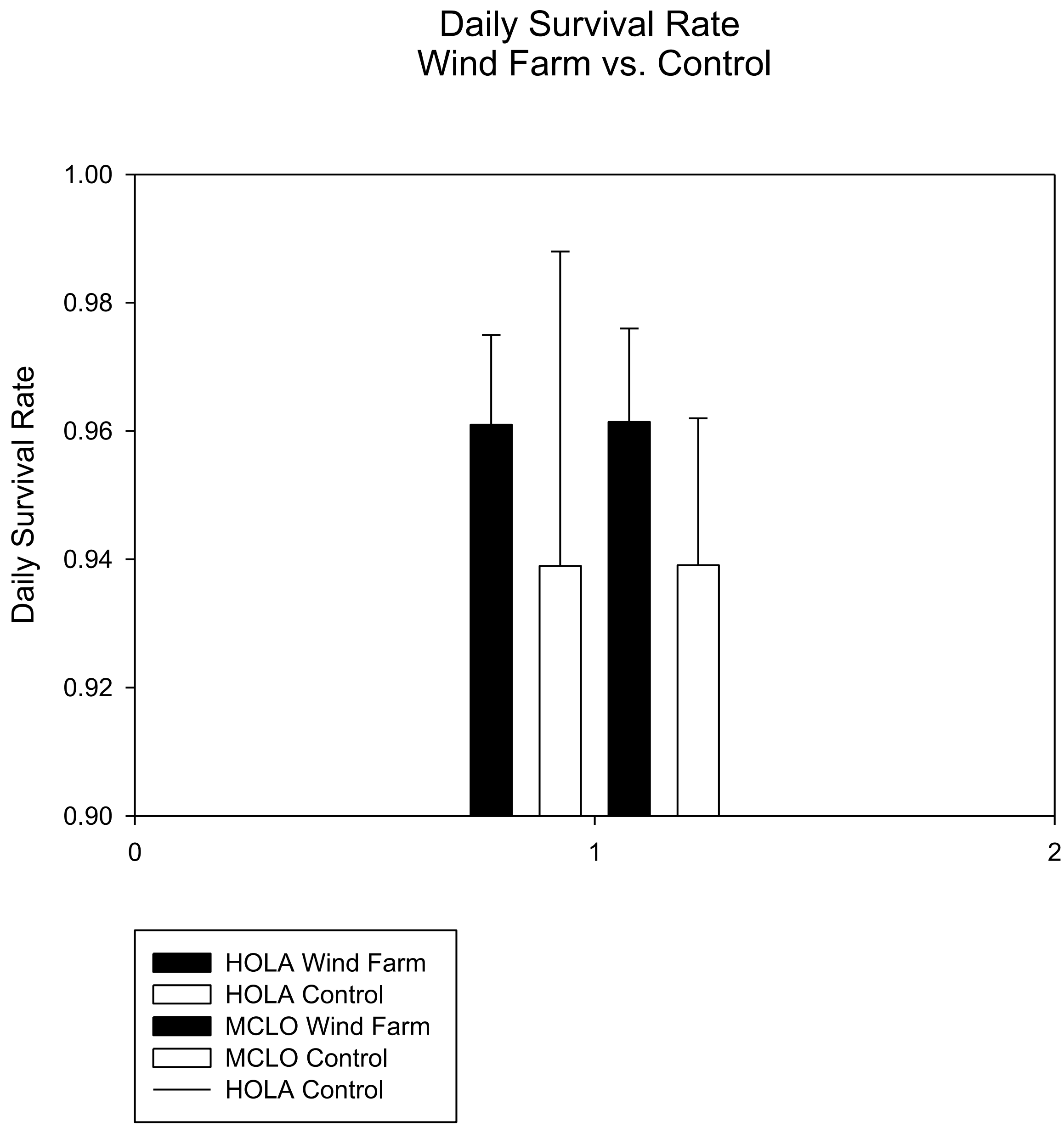

Figure 1. Horned Lark (*Eremophila alpestris*) and McCown's Longspur (*Rhynchophanes mccownii*) daily nest survival rates calculated for wind farm and control sites in southeastern Wyoming in 2011 and 2012. Error bars represent 95% confidence intervals.

SPECIES OF GREATEST CONSERVATION NEED – MAMMALS

INVENTORY OF BATS ASSOCIATED WITH CLIFF AND CANYON HABITATS OF WESTERN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Leah Yandow, Nongame Biologist
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ABSTRACT

Wyoming's varied geology supports a landscape marked by high ecological diversity. Features such as rock outcrops, cliffs, canyons, and caves are important for many of the bats (Order: Chiroptera) that occur in the state. For example, bats depend on these habitats for roosting, foraging, raising pups, and mating. Bats represent nearly 25% of all mammals classified as Species of Greatest Conservation Need in Wyoming. However, information about diversity, distribution, and abundance for bats associated with these habitats in Wyoming is lacking. Furthermore, because bats are difficult to survey, a lack of data makes conservation and management in the face of large-scale disturbances (i.e., disease, climate change, and land-use changes) particularly challenging. We used capture and acoustic surveys to detect bats and assess distribution, reproductive status, and diversity across 62 grids, 34 of which we surveyed during the second year of this project. In 2013, we captured 337 individuals, with 36% being female and 9% being juvenile. Approximately 17% of captured bats were reproductive, with all of them being females. Using acoustic survey equipment, we detected most species of bats that we captured. We occasionally detected some species that we did not capture, such as the pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), and the two peripheral myotis species, Yuma myotis, (*Myotis yumanensis*) and California myotis (*M. californicus*). The most commonly detected species using acoustic detectors were the western small-footed myotis (*M. ciliolabrum*) and big brown bat (*Eptesicus fuscus*), which were also among the most frequently captured species. The high level of diversity we detected supports the conclusion that cliff and canyon habitats are important to a wide variety of species of bats. Data from this two-year study will be used to update current databases, provide informed assessments on species status, as well as facilitate and prioritize management in response to large-scale disturbances.

INTRODUCTION

With >1,250 species worldwide, bats (Order: Chiroptera) are the second most diverse group of mammals in the world (BCI 2013). As a group, bats occupy a broad range of niches, a variety of habitats, and impact many types of prey. In North America and in Wyoming, bats consume tons of insects annually, which redistributes nutrients and provides a natural biological control of herbivorous pests (Duchamp et al. 2010). The economic value of bats that forage on herbivorous insects is estimated to be worth $3.7 billion per year to the continental US agricultural sector (Boyles et al. 2011). Because bats have important ecological impacts, the investigation and conservation of these species is essential for maintaining the health and functionality of Wyoming's diverse ecosystems.

Bats are particularly sensitive to large-scale disturbances due to several life history traits (Jones et al. 2009). They have low reproductive rates and are long-lived for animals of similar body size, typical of a "slow" life-history strategy (Racey and Entwistle 2000). Many species require specific and uncommon habitat features or environments. For example, some bats roost in caves and abandoned mines and often select areas with specific temperature and humidity profiles within each site (Davis 1970, Whitaker and Gummer 1992, Webb et al. 1996). These characteristics make bats particularly vulnerable to declines associated with anthropogenic impacts or diseases.

One of the primary threats to bats in North America is white-nose syndrome (WNS), which is a disease caused by the fungus, *Pseudogymnoascus destructans.* WNS has caused drastic declines in eastern populations of some cave and mine dwelling bats since its outbreak in New York in 2006 (Blehert et al. 2008, Cryan et al. 2010). The death toll of bats as of January 2012 was around 6 million individuals (USFWS 2012). WNS has steadily progressed westward, due to natural and anthropogenic reasons and was most recently confirmed in Kansas City, Missouri in January 2014 (WNS 2014; T. Elliot, pers. comm.). However, physiological and distributional limitations of the fungus are unknown in the West. Consequently, the pace and certainty of the spread of the fungus is yet to be determined. Differences in ecology of bats as well as the resilience of the fungus in alternative climates will determine the vulnerability of populations in the western US. Population declines in the East and fear that the disease will spread across the US have led to recent petitions to list two species of bats that are residents in Wyoming for additional protection under the Endangered Species Act. The little brown myotis (*Myotis lucifugus*) and the northern myotis (*M. septentrionalis*) are currently under review (Kunz and Reichard 2010, USFWS 2013). Information on diversity and distribution of bats in Wyoming will enhance our ability to respond effectively to these emerging issues.

While risk of WNS is currently the most apparent threat to bats in North America, other large-scale disturbances such as climate change and wind energy development must also be acknowledged (Arnett et al. 2008). Change in climate has the potential to influence several aspects of the ecology of bats. For temperate insectivorous species, timing of emergence from hibernation, parturition, roost selection, foraging behavior, and distribution all have the potential to be affected by climate change (Ransome and McOwat 1994, Christe et al. 2001, Adams and Hayes 2008, Rebelo et al. 2010, Sherwin et al. 2013). Furthermore, interactions of climate change with other large-scale disturbances (e.g., wind energy development) may create synergistic effects and confound the outcome of individual disturbances.

In Wyoming, 18 bat species are known to occur, 9 of which are considered Species of Greatest Conservation Need (SGCN) in the western half of the state (WGFD 2010). All of these bats either 1) primarily use cliff and canyon habitats for activities such as roosting, foraging, hibernating, and rearing offspring or 2) occasionally utilize resources within that habitat. Therefore, cliff and canyon habitats are considered important areas for gaining information about bat diversity, distribution, and abundance and are the focal habitats for this project. Our objective for the 2012 and 2013 field seasons was to use mist nets and acoustic detectors to collect data on distribution, reproductive status, and diversity of bats that occur in cliff and canyon habitats in western Wyoming. We have completed the second year of the two-year inventory. We report results for 2013 and provide a summary of the two-year survey effort.

METHODS

We used GIS (ArcGIS v10.1, Environmental Systems Research Institute, Redlands, CA, USA) to create a model identifying cliff and canyon habitat throughout western Wyoming. The model started with a base landcover layer that included several cover types applicable to cliff and canyon habitat. We constrained the model to only include areas with a slope >35° and within 0.40 km of water and excluded wilderness and private lands. We overlaid a template with 100-km^2 grids commonly known as the bat survey grid (P. Ormsbee, pers. comm.) and selected all grids that contained ≥4.9 ha of potential habitat according to the model, which produced 148 potential grids. From the potential grids, we randomly selected 30 priority grids across western Wyoming.

We overlaid the final target grid onto a map in Google Earth and found potential netting sites by identifying water sources and roost sites within or near each target grid prior to heading into the field. Once in the field, we selected netting and acoustic survey sites by choosing areas that were 1) accessible by survey personnel, 2) consisted of habitat characteristics and resource availability that would increase the likelihood of having high bat activity (i.e., water, potential roosts, and flyways), 3) among or adjacent to cliff or canyon habitat, and 4) suitable for setting up mist nets and/or acoustic detectors. We selected 30 grids randomly for survey. When there was no suitable survey site within a grid, we used a nearby grid as a replacement site.

We used a combination of mist-netting and acoustic detectors to maximize the likelihood of detecting a species at a survey site. Within each grid, we chose two sites to survey. At one of the sites, we used a combination of mist nets (Avinet, Inc., Dryden, NY, USA) and an acoustic detector (Song Meter SM2BAT, Wildlife Acoustics, Inc., Concord, MA, USA). We then chose a second site >100 m away from the netting site where we setup an acoustic detector that recorded calls passively. Data from the two sites were then combined to gain information about bats that occurred within that grid. There were three exceptions to this approach. At one of the grids, we only performed acoustic surveys because of lack of access to capture sites. At the other two grids, we only performed capture surveys because the equipment malfunctioned.

At each survey site, we used a GPS (GPSMap 62S, Garmin International, Inc. Olathe, KS, USA) to record location and elevation. We also characterized habitat (e.g., vegetation, type of site, etc.) as well as distance to nearest water. We recorded weather conditions, including temperature, barometric pressure, wind, relative humidity, and cloud cover at the beginning and end of each survey.

We used mist nets to capture bats and investigate bat activity, diversity, reproductive status, and morphometrics. We chose mist net configurations to optimize capture potential and used a net set of single high (2.6 m) or triple high (7.8 m) with varying lengths (2.6, 6, 9, 12, and 18 m) at a given netting site. The number, size, and placement of nets depended on local topography and habitat characteristics, such as water flow rate, water depth, vegetation, or size and shape of the entrance of the roost. No more than 30 min after sunset, we opened the mist nets and kept them open for ≥3 hrs after sunset unless our survey was truncated because of weather (Abel and Grenier 2013).

We checked nets every 10-15 min and removed captured bats from the nets as quickly as possible. We put each captured bat into a cloth bag for processing. We used techniques outlined by Abel and Grenier (2013) to collect our primary data of interest, which were species, sex, reproductive status, and age. We used the Dichotomous Key to Bats of Wyoming (Hester and Grenier 2005) to identify species. Early in the season (i.e., during June and early July), we gently palpated the lower abdominal area to check for pregnancy. We also assessed female reproductive status by looking for evidence of current or post-lactation. Females bearing young have large, hard, and hairless nipples, while females without young have hairy and inconspicuous nipples. Males were classified as reproductive if testes were distended and swollen; however, we were unable to detect these even late in the season when reproductive males should have been common. We classified each bat as adult or juvenile by illuminating the wing and examining the epiphyseal plates for ossification. We also measured forearm length, ear length, and determined wing damage score according to Reichard and Kunz (2009). We followed the WNS protocol according to Abel and Grenier (2011) and decontaminated equipment at the end of each survey.

To summarize the capture data, we counted the number of captures for each site as well as estimated the number of net m•hrs by multiplying the length of nets used during a survey by the number of survey hrs. We estimated captures per unit effort for each grid by dividing the number of captures by net m•hrs multiplied by 100 to provide an index of bat activity. We also counted species diversity for each site. We summarized all data by providing means (±SE) by region.

We deployed detectors at features such as ponds, lakes, streams, rivers, rock outcrops, cliffs, cave and mine entrances, and potential flyways where we expected high bat activity. The microphone was positioned 1-2 m above the ground pointing skyward between 0-65° depending on terrain and potential flight path of bats. We programmed detectors to start recording 30 min before sunset and record for 3-5 hrs.

For the acoustic analysis, we used Sonobat Batch Scrubber utility to remove most of the noise files, which left us with an estimate of total files recorded. Calls of good quality resulted in classification from Sonobatch with discriminate probability >0.90. We reviewed calls that had a discriminate probability <0.90 as determined by Sonobatch. We manually classified all call files of species that were not previously detected in a particular area. Three myotis species (western small-footed [*M. ciliolabrum*], little brown, and long-legged [*M. volans*]) all have a characteristic frequency near 40 kHz. In situations where we were unable to manually classify calls to the species level for the 3 similar 40 kHz species, we classified calls to the frequency group, "40 kHz bats". We also counted the number of classified files per survey hr as an index of activity and number of species detected for species diversity. All acoustic data are summarized with means (±SE) for each region.

RESULTS

For 2013, we surveyed sites located within the western part of Wyoming, which included the Wyoming Game and Fish Department (Department) Regions of Cody, Green River, Pinedale, and Lander (Fig. 1). A majority of sites were ≤1 km of cliff and canyon habitat. A majority of sites were comprised predominantly by big-sagebrush (*Artemisia tridentata*), and many sites were within shrub-dominated riparian areas. Few sites were within other types of xeric habitat, such as juniper woodland (*Juniperus* spp.), and all other land cover types comprised <10%. Mean (±SE) elevation of sites we surveyed was 1,865 m (±72 m), which was similar to those surveyed in 2012 ($t_{57} = 1.3$, $P = 0.19$).

We primarily netted over open water, including riparian, ephemeral and permanent streams and rivers, reservoirs, and small ponds. We also surveyed roosting sites: caves, rock shelters, and a mine. Sites we surveyed covered as much of western Wyoming (i.e., spatial variation) and as much ecological diversity as possible. For all 33 grids that we mist netted in 2013, we captured 337 bats that represented 10 different species at 28 grids (Table 1, Fig. 2). We used a mean of 37.7 net meters (±4.0 m) per survey with a mean survey length of 2.7 hrs (±0.1 hrs; Table 2). The mean number of individuals captured per survey night was 10.8 (±1.8, range = 0-37; Fig. 2). Morphometric measurements were within the range of historical captures for Wyoming (Table 3). Six bats escaped after we identified them to species; therefore, we counted them as captures but we were unable to report morphometric measurements for these captures. The little brown myotis (35%) was the most commonly captured species, followed by big brown bat (*Eptesicus fuscus*; 19%), long-legged myotis (15%), and the western small-footed myotis (13%). The remaining species each comprised <10% of all captures and included pallid bat (*Antrozous pallidus*), spotted bat (*Euderma maculatum*), Townsend's big-eared bat (*Corynorhinus townsendii*), silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinerus*), and long-eared myotis (*M. evotis*). Figs. 3-13 show locations of captures for each species.

Thirty-six percent of captured bats were female, and nine percent of all captures were identified as juveniles. Approximately 17% of captured bats were reproductive, with all of them being females. Juveniles are difficult to distinguish around the beginning of September, and therefore, juveniles may be underrepresented (Table 4). There was occasional notable wing or tail membrane damage, which most often consisted of pin holes and old scarring. However, 93%

of bats had no notable physical damage. We failed to detect evidence of damage from WNS, and therefore, all bats received a score of 0.

Captures per unit of effort were highest in the Cody region, followed by the Green River, Lander, and Pinedale Regions (Table 2, Fig. 2). The diversity of species captured per survey was highest and nearly equal in the Cody and Pinedale Regions and lowest in the Green River Region (Table 2, Fig. 14). Overall, species diversity was highest in the eastern portion of the Cody region along the western front of the Bighorn Mountains. Captures contributed to seven updates in the Department's Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming (Table 5).

We used acoustic detectors at 32 grids in western Wyoming during the 2013 season (Fig. 1). We placed 1 or 2 detectors within each grid for a total of 59 acoustic survey nights with mean 3.7 hrs (±0.1 hrs) per survey night. The detectors recorded a total 26,570 files, and we classified 3,988 files to species. Detections included 10 resident and 2 peripheral species across all grids. We classified 50 individuals as "40 kHz bats". Additionally, we aurally detected 18 spotted bats, which is the only bat with a frequency low enough for the human ear to detect. We had a total of 4,056 bat acoustic detections in 2013 (Table 1).

The western small-footed myotis (60%) was the most frequently detected species, followed by the big brown bat (18%) and little brown myotis (8%). All other species each comprised <5% of detections. Figs. 3-13 show locations where we detected each species through the use of acoustic equipment. The highest diversity of species was detected in the eastern portion of the Cody Region, consistent with capture data, as well as the south central portion of the Green River Region (Fig. 14). Yuma (*M. yumanensis*) and California myotis (*M. californicus*) were the least detected species.

Activity of bats at sites in the Green River Regions were highest (20.5 ±5.5) followed by the Lander (17.4 ±11.6) and Cody regions (16.8 ±4.5; Table 6, Fig. 15). The number of species detected per survey was highest and equal in the Cody and Green River regions. Acoustic detections contributed to three updates in the Department's Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming (Table 5).

We surveyed 62 sites over the course of the inventory (2012-2013). We used both acoustic equipment and audible methods to capture 683 bats and identify 9,625 bats to species. We detected (i.e., acoustically and by capture) 11 resident species and 2 peripheral species, 9 of which are SGCN. In cliff and canyon habitats in western Wyoming, little brown myotis was the most common species we detected (34%), followed by big brown bat (13%), long-legged myotis (13%), and western small-footed myotis (12%). All other captured species each comprised <10% of remaining captures. For acoustic detections, half of the classifications were identified as western small-footed (50%), followed by big brown bat (15%), and little brown myotis (12%). All other species each account for <10% of classified files. The findings have provided important updates to the Department's Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming for 11 of the 13 species detected during the two years.

DISCUSSION

During this two-year inventory project, we successfully detected all species that were classified as residents (i.e., 11 species) and SGCN (i.e., 9 species) that occur in western Wyoming. By targeting cliff and canyon habitat, we were able to collect information about species that were underrepresented in previous inventory efforts (e.g., Forest Bat Inventory 2008-2011). The cliff and canyon inventory was the single largest survey effort for bats in this habitat type in Wyoming and will be an informative contribution to the conservation and management of bats in Wyoming.

This project targeted habitats and features important for many bats in Wyoming that were not surveyed during the forest bat inventory (Abel and Grenier 2012a, b). Rock crevices, shelters, and caves provide physical structure and microhabitats that are important to many bats classified as SGCN. Cliffs and canyons are widely used by bats as seasonal roosts, foraging areas, and travel corridors. By focusing on these habitats, we detected several cliff and canyon specialists, notably, the pallid bat, spotted bat, and Townsend's big-eared bat, at several sites during our surveys. We were surprised, however, that detection of cliff and canyon specialists were lacking at many sites we surveyed. Our results suggest that either cliff or canyon habitats were not used by specialists or that they were difficult to detect at some sites. At over half of the sites surveyed in 2013, we detected tree-roosting species that are primarily associated with forest habitats: silver-haired bat and hoary bat. For these tree-roosting and generalist species, cliff and canyon habitats may provide a buffer against developed and unsuitable habitats. For example, cliff and canyon habitat may constitute the environment between forest and riparian areas primarily used by tree-roosting species. While these bats do not specialize in cliff and canyon habitat, they may use such habitats to move between preferred areas. Our results, therefore, emphasize the importance of cliff and canyon habitats for a broad suite of species, which includes but is not limited to cliff and canyon specialists.

This two-year survey effort allowed us to sample a wide variety of sites and explore annual differences in the data. Notably, we deployed nearly the same amount of net meters across years (i.e., about 37 m), and we captured nearly equal numbers of bats (i.e., 346 in 2012, 337 in 2013; $t_{57} = 0.69$, $P = 0.5$). However, in 2012, we surveyed seven fewer sites and captured about two more bats per survey hr. Diversity of bat species we detected, however, was not statistically different between years ($t_{57} = 0.14$, $P = 0.9$). The difference in capture rates could be due to the fact that in year one, personnel often selected grids with a higher proportion of cliff and canyon habitats than we did in year two. Differences in personnel, placement of equipment, and environmental factors could all contribute to the annual variation we report.

Comparing the relative differences in species composition of captured individuals can be meaningful for understanding annual variation and for determining the appropriate length of an inventory. We found similar percentages of the most frequently detected species, the little brown myotis (34% in 2012, 35% in 2013) and the western small-footed myotis (12% in 2012, 13% in 2013). The two most striking differences in species composition were our captures of big brown bats (8% in 2012, 19% in 2013) and long-legged myotis (10% in 2012, 15% in 2013), which were higher in 2013. We captured spotted bats in 2013 only, and we captured fringed myotis (*M.*

thysanodes) in 2012 only. Because we sampled different sites each year, some variation in species composition is expected and confirms the importance of sampling multiple sites.

Demographic data, which include sex ratios, reproductive status, and age class, can be informative for characterizing a population of a given site or region. Sex ratios in 2012 were nearly equal in both years, although we captured about half the number of females as males in 2013. Percent of females that were reproductive was higher in 2012 (i.e., 68% versus 46% in 2013) as were reproductive males (i.e., 33% of captured males were reproductive in 2012, 0% in 2013). Recognition of reproductive status is particularly difficult in the early season, because handlers depend on palpating for the embryo of pregnant females, which can be difficult to find. Several factors influence site variation and annual differences in results such as the location of a survey and the time of season. We captured similar percentages of juveniles between the first year (11%) and the second year (9%). Our demographic results depended, in part, on proximity to roosts, which are often dominated by any demographic group: males or females in reproductive or non-reproductive status. Our results represent the highest percentages of juveniles we have captured in all previous survey efforts in Wyoming (Cudworth et al. 2011; Abel and Grenier 2012a). This is not surprising, as previous survey efforts were conducted at higher elevations where we seldom detected bats that were reproductive. Our results are consistent with our hypothesis that reproductive females are selecting and utilizing habitats that are warmer in Wyoming. Also, the timing of our surveys during the season in relation to parturition and weaning may have influenced the number of juveniles we captured and our ability to assess reproductive status correctly. Differences in availability of prey and environmental conditions likely also account for some of the variation across sites and years we experienced.

Using a combination of capture and acoustic survey methods increased our likelihood of detecting all species that were present at a survey site, especially species that were difficult to capture. We found that for a given site, we often detected a species via both methods (i.e., capture and acoustic). However, sometimes we captured species that we had failed to detect acoustically and vice versa. For example, we captured long-legged myotis at 12 sites, but at 7 of those sites we failed to detect this species acoustically. We observed an opposite pattern for Townsend's big-eared bat, pallid bat, and spotted bat, which are reported to be difficult to capture (O'Farrell and Gannon 1999). Our data supported that these bats were present, although we seldom captured them. We suggest that the differences in rates of detections for species using these two survey instruments (i.e., nets and detectors) may be attributed to localized variation when we deployed the instrument. Specifically, because we often separated nets and detectors by several hundred meters or more, our results could be indicative of localized differences at each specific site. We believe that in spite of this drawback, our approach enables us to maximize the detections of species within a survey grid. Meaning, by selecting different characteristics at each local site where we deployed each instrument we were able to maximize our ability to detect most bats that occurred in the grid.

Upon completion of the two-year project, we have made considerable progress toward improving our understanding the status and distributions of bat species associated with cliff and canyon habitat in western Wyoming. This inventory encompassed a large geographic area within a relatively short time period, which should be considered when interpreting results.

Predicting the exact distribution and abundance of bats based on our results is problematic as our detection rates were often low for some species. Replication of surveys is not feasible across such a large study area and for species that are particularly difficult to detect given our objectives. Therefore, count data, relative abundance, and species diversity are the most informative data for a project of this scope. During the next two years, we will focus on cliff and canyon habitats in eastern Wyoming and plan to provide a more complete statewide assessment of bats that use these habitats. As we develop future projects on bats, we will continue to explore alternative approaches that may enhance our ability to detect bats. The results of this and future projects will help inform management decisions and enhance our ability to improve conservation and management of bats and their habitats.

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Table 1. Bat species that occur in Wyoming with number captured during the 2013 survey (May-September). Status of residency for bats are represented by: R = resident (year-round or seasonal); P = peripheral; A = accidental occurrence, as identified by Hester and Grenier (2005). Association with cliff and canyon identifies the ecology of each species in the context of cliff and canyon habitat: S = Specialist of cliff and canyon in Wyoming; G = Generalist, cliffs and canyons are important for this species in addition to other habitats; N = species is not expected to be associated with cliff and canyon habitat (Adams 2003). Native Species Status (NSS) of Species of Greatest Conservation Need for bats are 2, 3, 4, or U, as identified in the State Wildlife Action Plan (WGFD 2010).

Scientific name (common name)	Resident status	Cliff & canyon assoc.	Native Species Status	Captures in 2013	Total captures 2012/13	Acoustic detections in 2013	Total acoustic 2012/13
Antrozous pallidus (Pallid bat)	R	S	NSS3	9	40	62	151
Corynorhinus townsendii (Townsend's big-eared bat)	R	S	NSS2	9	11	32	38
Eptesicus fuscus (Big brown bat)	R	G	NSS4	63	91	709	1525
Euderma maculatum (Spotted bat)	R	S	NSS3	6	6	26	42
Lasionycteris noctivagans (Silver-haired bat)	R	N	-	9	48	138	887
Lasiurus cinereus (Hoary bat)	R	N	-	11	23	32	110
Myotis ciliolabrum (Western small-footed myotis)	R	S	NSS4	42	83	2436	4479
Myotis evotis (Long-eared myotis)	R	G	NSS3	18	51	160	767
Myotis lucifugus (Little brown myotis)	R	G	NSS4	118	233	319	1107
Myotis septentrionalis (Northern myotis)	R	G	NSS3	0	0	0	0
Myotis thysanodes (Fringed myotis)	R	G	NSS3	0	1	0	1
Myotis volans (Long-legged myotis)	R	G	NSS3	49	85	67	120
Lasiurus borealis (Eastern red bat)	P	N	NSSU	0	0	0	0
Myotis californicus (California myotis)	P	G	-	0	0	4	4
Myotis yumanensis (Yuma myotis)	P	G	-	0	0	3	16
Tadarida brasiliensis (Brazilian free-tailed bat)	P	G	-	0	0	0	0
Nyctinomops macrotis (Big free-tailed bat)	A	G	-	0	0	0	0
Pipistrellus subflavus (Eastern pipistrelle)	A	G	-	0	0	0	0

Table 2. Mist-net survey results for each Wyoming Game and Fish Department Region in western Wyoming, May-September, 2013. Net m•hrs is meters of net × hrs of survey per grid. Captures per effort is an index of activity based on number of captures per 100 net m•hrs per grid.

	Cody Region (*n* = 16)		Green River Region (*n* = 7)		Lander Region (*n* = 8)		Pinedale Region (*n* = 2)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
No. captures	12.5	3.0	12.3	3.8	5.1	1.7	6.0	0.0
Net m•hrs	77.0	16.0	125.7	22.6	109.7	20.7	153.5	18.5
Captures per effort	19.4	5.6	11.9	3.7	8.0	3.5	4.0	0.5
No. species captured	3.2	0.6	1.6	0.3	1.9	0.4	3.0	0.0

Table 3. Mean and standard error (SE) of measurements taken from individual bats captured in western Wyoming, May-September 2013. Data are summarized by species.

Species	Forearm length (mm)			Ear length (mm)			Weight (g)		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
Antrozous pallidus	56.25	0.76	8	27.50	0.37	7	21.81	1.11	8
Corynorhinus townsendii	42.16	0.36	9	32.17	0.32	9	9.11	0.51	9
Eptesicus fuscus	46.12	0.23	63	14.04	0.13	63	17.75	0.42	63
Euderma maculata	50.13	0.47	6	38.00	0.68	6	18.00	2.21	6
Lasiurus cinereus	53.69	0.70	11	15.27	0.46	11	26.64	1.11	11
Lasionycteris noctivagans	40.59	0.43	9	13.06	0.38	9	10.22	0.36	9
Myotis ciliolabrum	32.20	0.21	37	12.11	0.36	39	5.42	0.34	41
Myotis evotis	38.93	0.28	18	20.06	0.21	18	6.67	0.32	18
Myotis lucifugus	37.79	0.11	117	12.64	0.11	117	7.36	0.11	117
Myotis volans	39.40	0.16	48	12.03	0.17	48	8.24	0.22	48

Table 4. Population parameters for bats captured in western Wyoming, May-September 2013. Data are summarized by species. Undetermined (Und.) age, sex, and reproductive status indicate that the individual was released early or escaped the handler before measurements could be taken. Reproductive status is represented by the following abbreviations: N = Non-reproductive; R = Reproductive.

Species	Sex			Age			Reproductive status		
	F	M	Und.	A	J	Und.	N	R	Und.
Antrozous pallidus	4	4	1	8	0	1	2	4	3
Corynorhinus townsendii	4	5	0	6	3	0	7	2	0
Eptesicus fuscus	28	35	0	62	1	0	37	16	10
Euderma maculatum	1	5	0	6	0	0	5	0	1
Lasiurus cinereus	4	7	0	10	0	1	8	2	1
Lasionycteris noctivagans	0	9	0	9	0	0	9	0	0
Myotis ciliolabrum	14	29	0	42	0	0	28	9	6
Myotis evotis	6	12	0	16	2	1	15	1	2
Myotis lucifugus	39	80	0	97	20	0	100	7	12
Myotis volans	22	28	0	44	5	0	32	15	3
Total 2013	122	214	1	300	31	2	243	56	38

Table 5. Updates to the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012) from surveys in western Wyoming, May–September 2013. Updates are presented by latilong, based on individuals captured and summarized by species. B = Breeding, including dependent young, juvenile animals, lactating or post-lactating females, or males in breeding condition observed; O = Observed but due to mobility of the species and lack of factors listed under "B", breeding cannot be assumed; b = Animals were observed and, due to limited mobility, breeding is assumed; a = The species was detected with acoustic equipment and additional verification is warranted; _ = No verified records.

Species	Latilong degree block	Current status	Updated status
Antrozous pallidus	11, 3	O	B
	9	_	a
Corynorhinus townsendii	9	_	O
Lasiurus cinereus	3	O	B
	9	_	O
Myotis californicus	24	_	a
Myotis ciliolabrum	3	b	B
	4, 11	O	B
Myotis evotis	4	O	B
Myotis lucifugus	22	O	B
	24	_	a
Myotis volans	17, 24	O	B

Table 6. Details of acoustic surveys conducted in western Wyoming, May-September, 2013. Data are summarized by Wyoming Game and Fish Department Region. Total files recorded = number of files recorded at each survey grid after removing noise files. Classified files included both manual and Sonobatch classified files. Classified files per hr = an index of activity based on classified files and survey length. Species detected is a measure of species diversity.

	Cody Region (*n* = 16)		Green River Region (*n* = 7)		Lander Region (*n* = 7)		Pinedale Region (*n* = 2)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total files recorded	794.7	192.9	1,128.4	165.0	673.1	325.8	622.0	94.0
No. classified files	124.7	35.0	159.1	44.0	120.6	81.2	42.5	9.5
Survey hrs per grid	7.5	0.3	8.0	0.4	6.8	0.5	8.0	0.0
No. classified files per hr	16.8	4.5	20.5	5.5	17.4	11.6	5.3	1.2
No. species detected	6.0	0.6	6.4	0.7	5.7	0.8	5.0	1.0

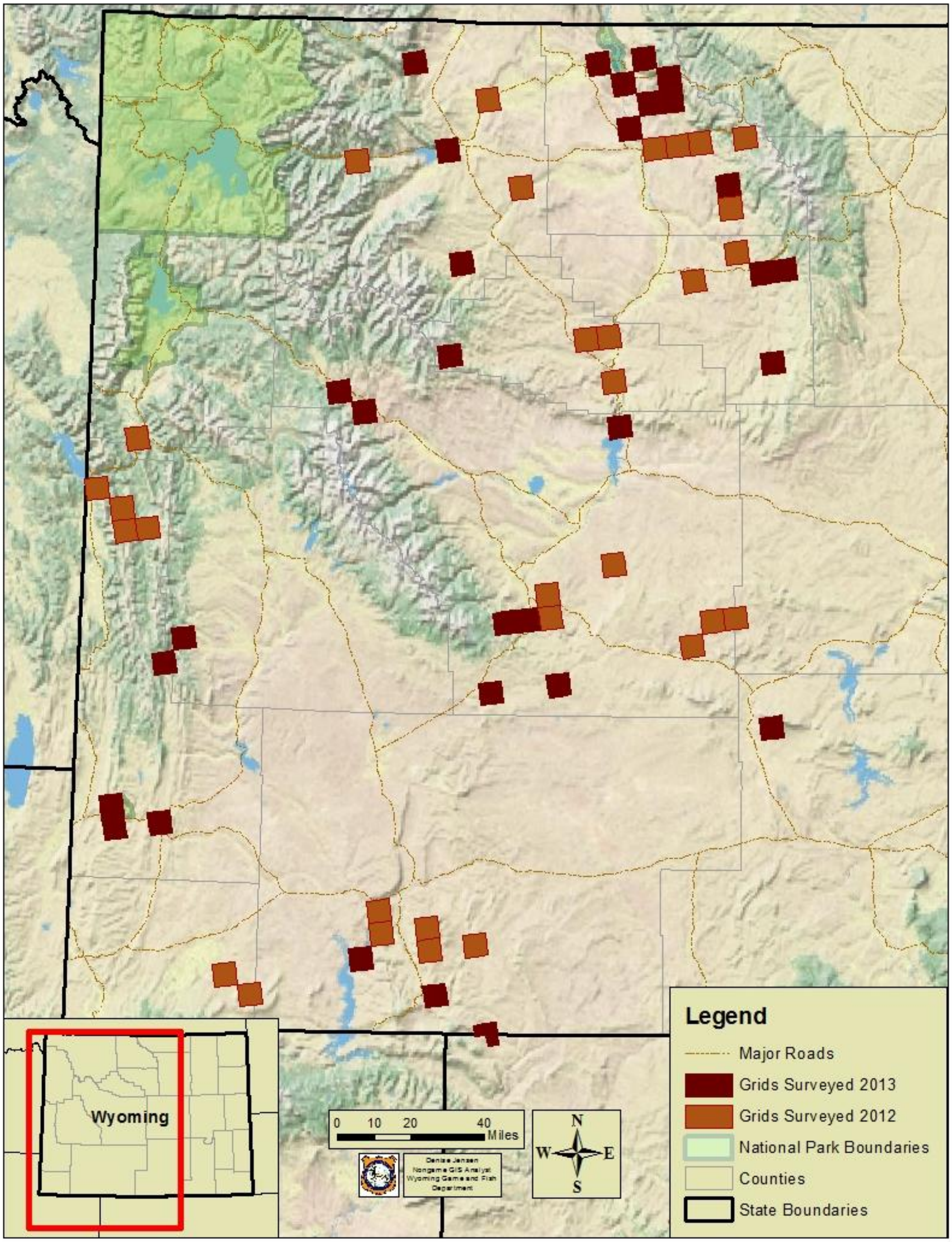

Figure 1. Study area and location of grids surveyed for bats associated with cliff and canyon habitats in western Wyoming, May-September, 2012 and 2013.

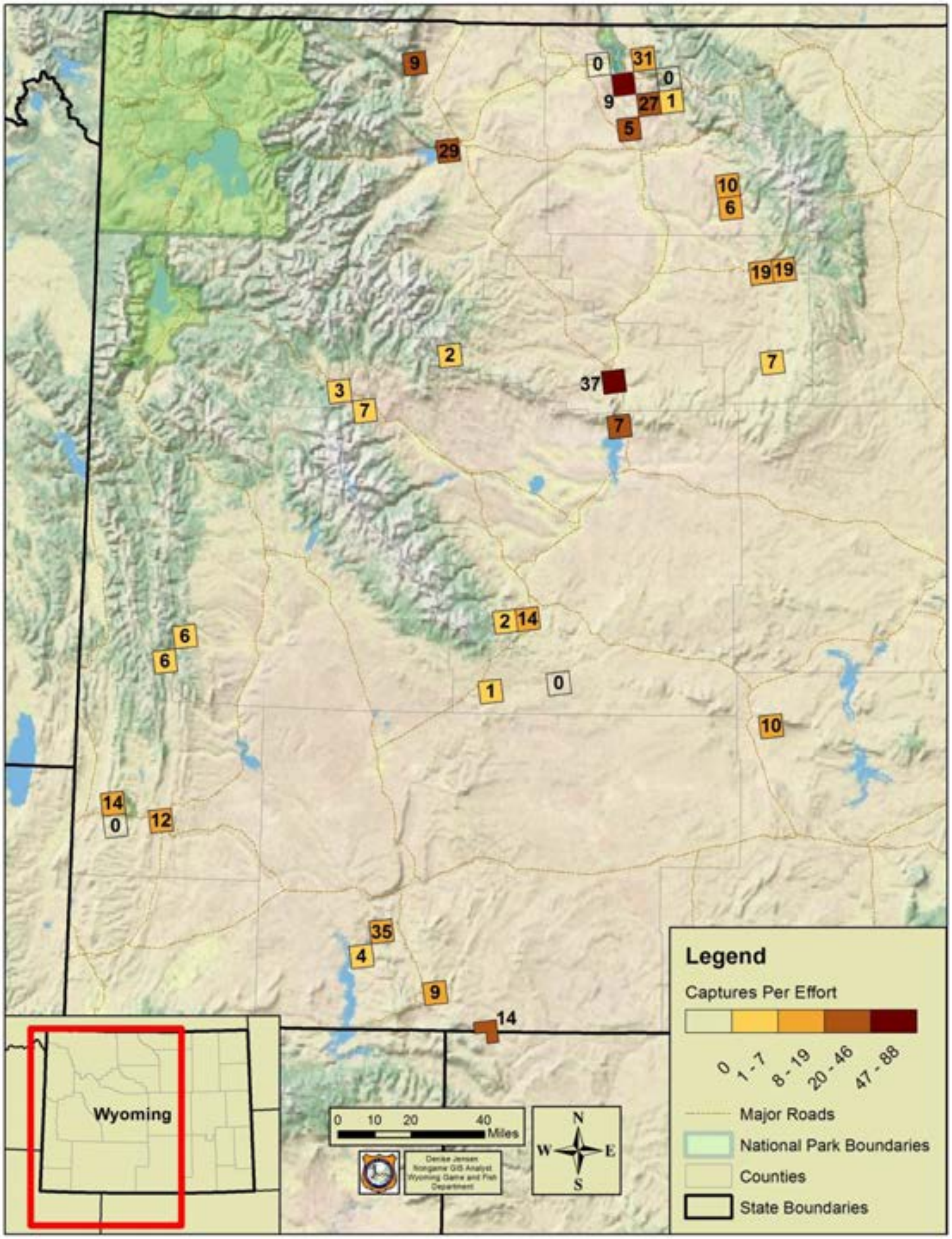

Figure 2. Location of grids surveyed throughout western Wyoming, May-September, 2013. We present both captures per unit effort and individuals captured. Colors correspond to captures per unit effort. Labels show the number of individuals captured per grid.

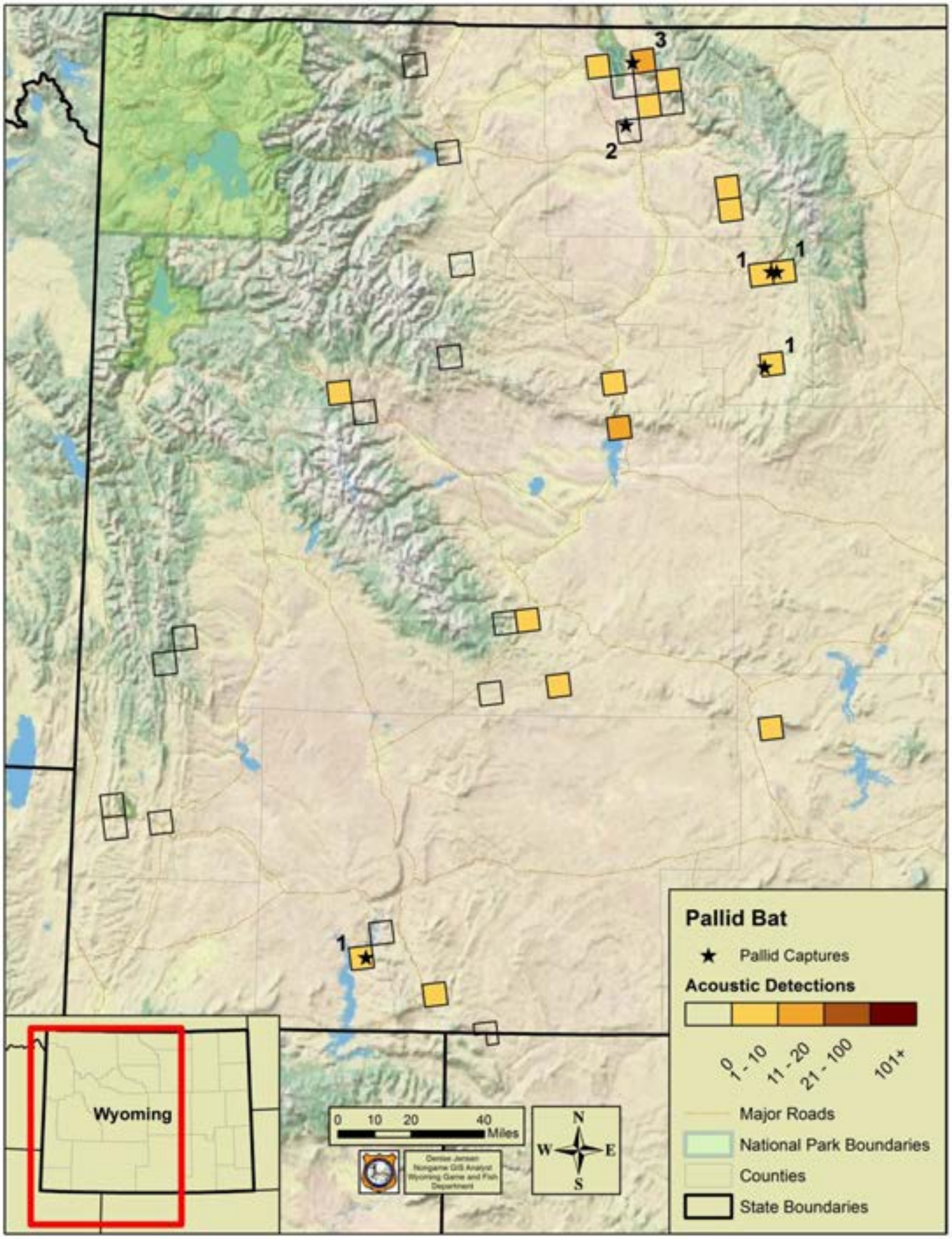

Figure 3. Locations where we captured and detected pallid bats (*Antrozous pallidus*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

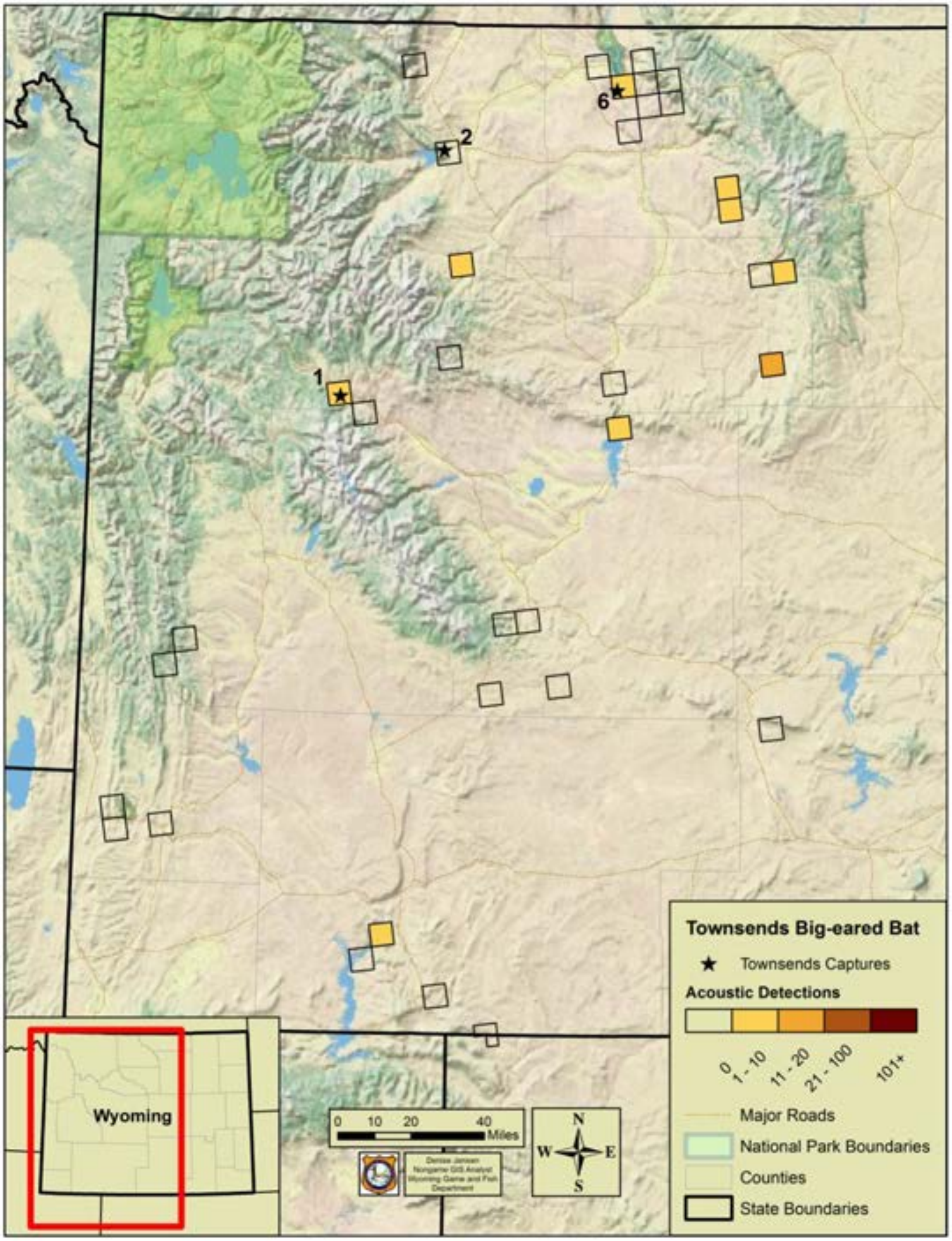

Figure 4. Locations where we captured and detected Townsend's big-eared bat (*Corynorhinus townsendii*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

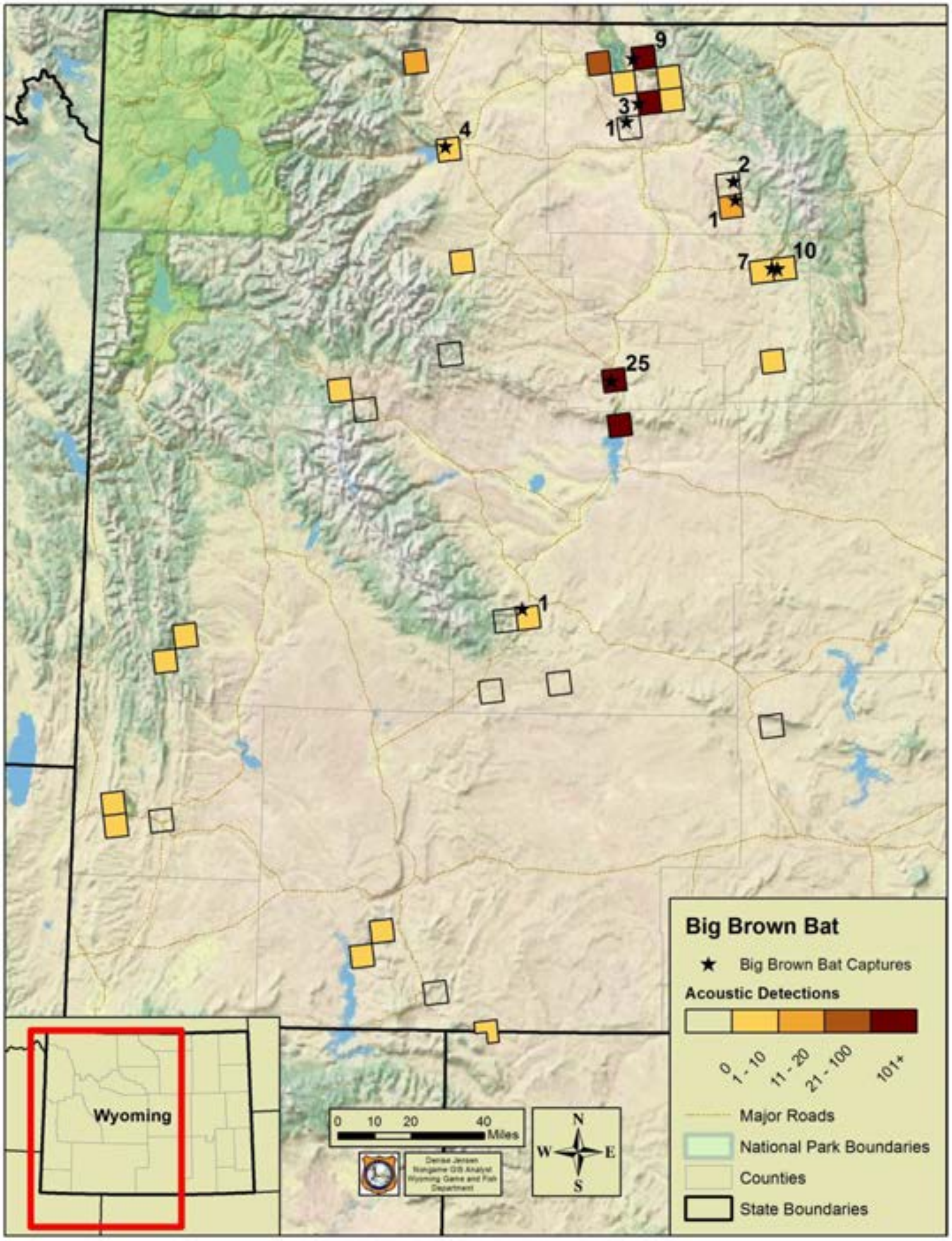

Figure 5. Locations where we captured and detected big brown bats (*Eptesicus fuscus*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

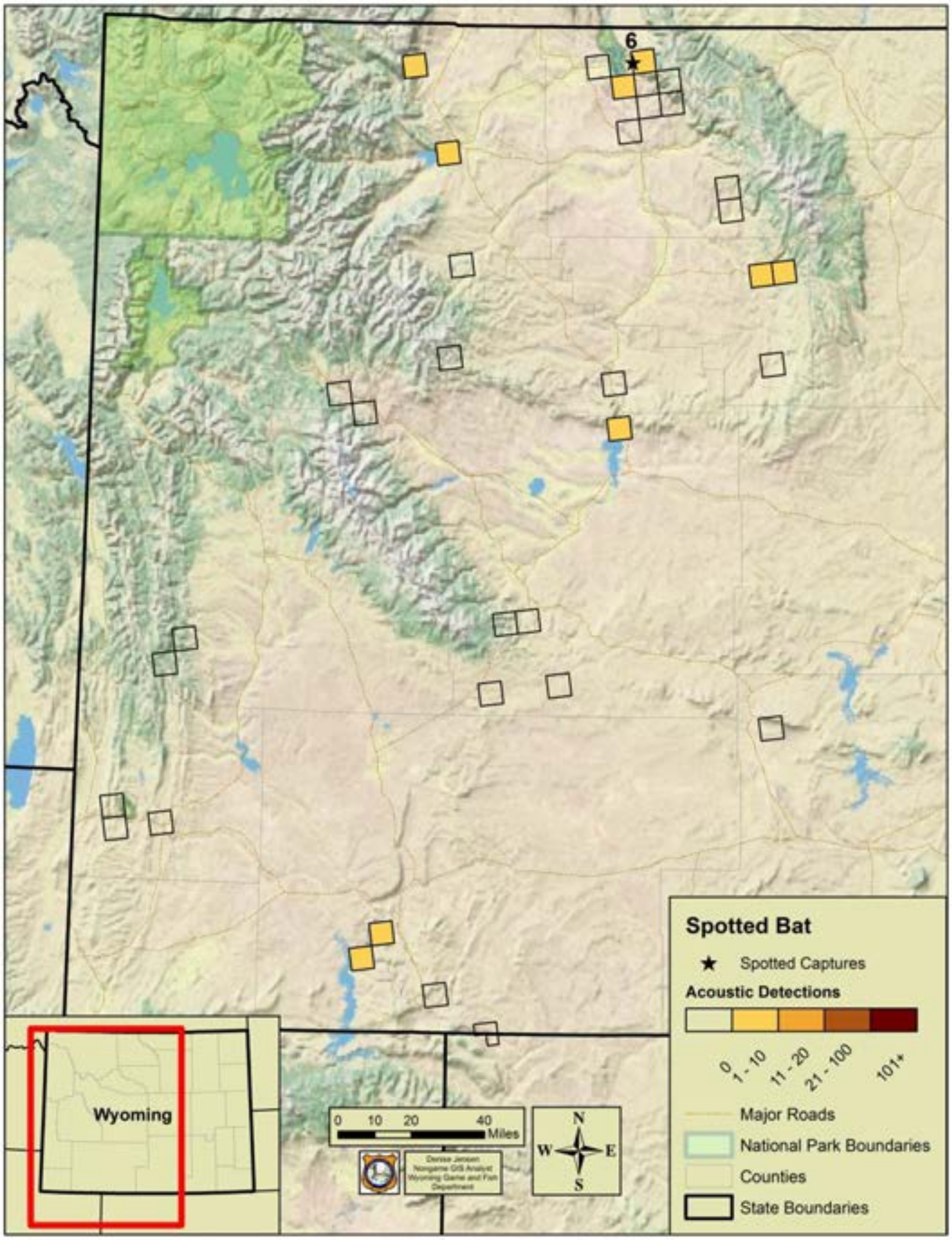

Figure 6. Locations where we captured and detected spotted bats (*Euderma maculatum*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of acoustic detections including classified call files and aural detections.

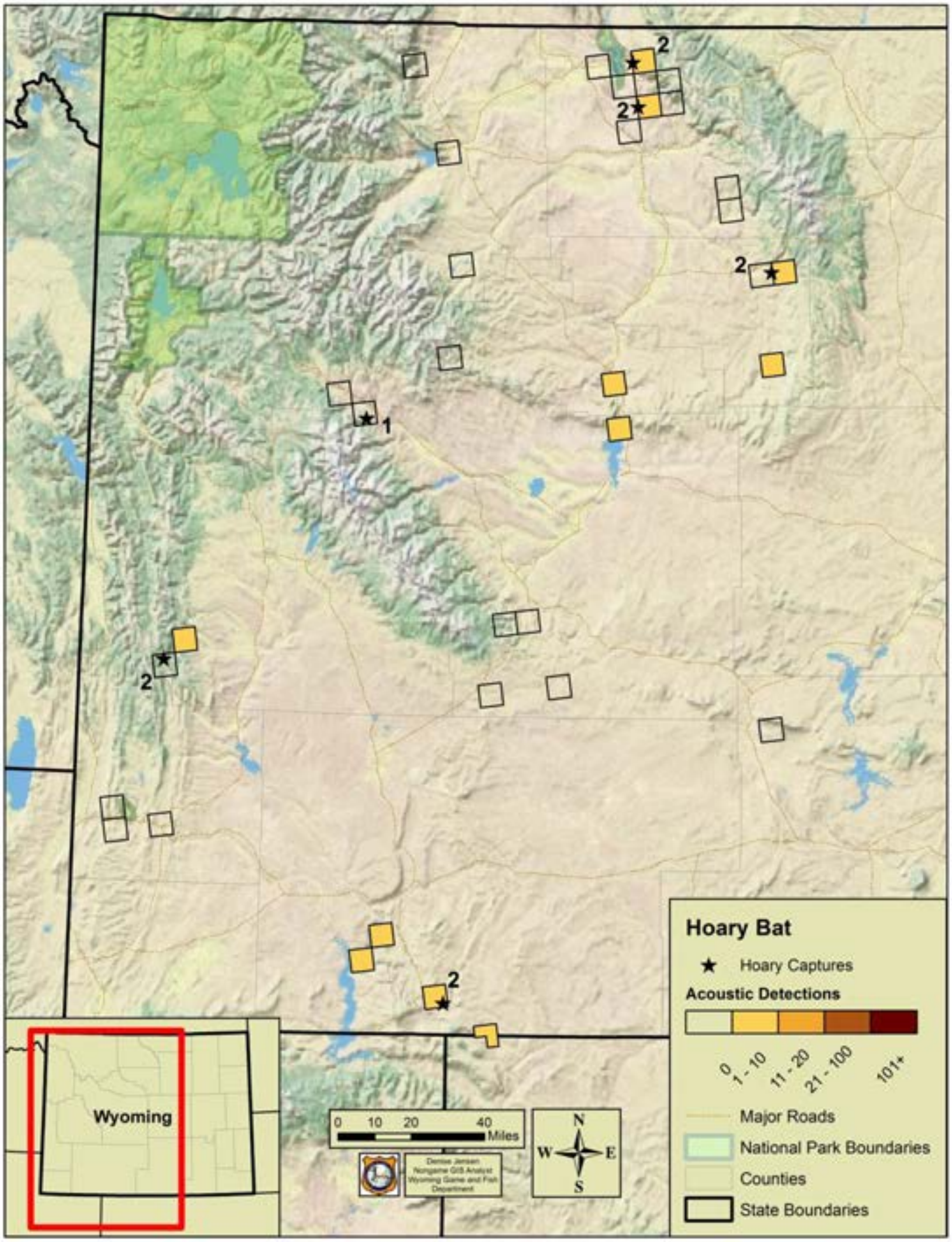

Figure 7. Locations where we captured and detected hoary bats (*Lasiurus cinereus*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

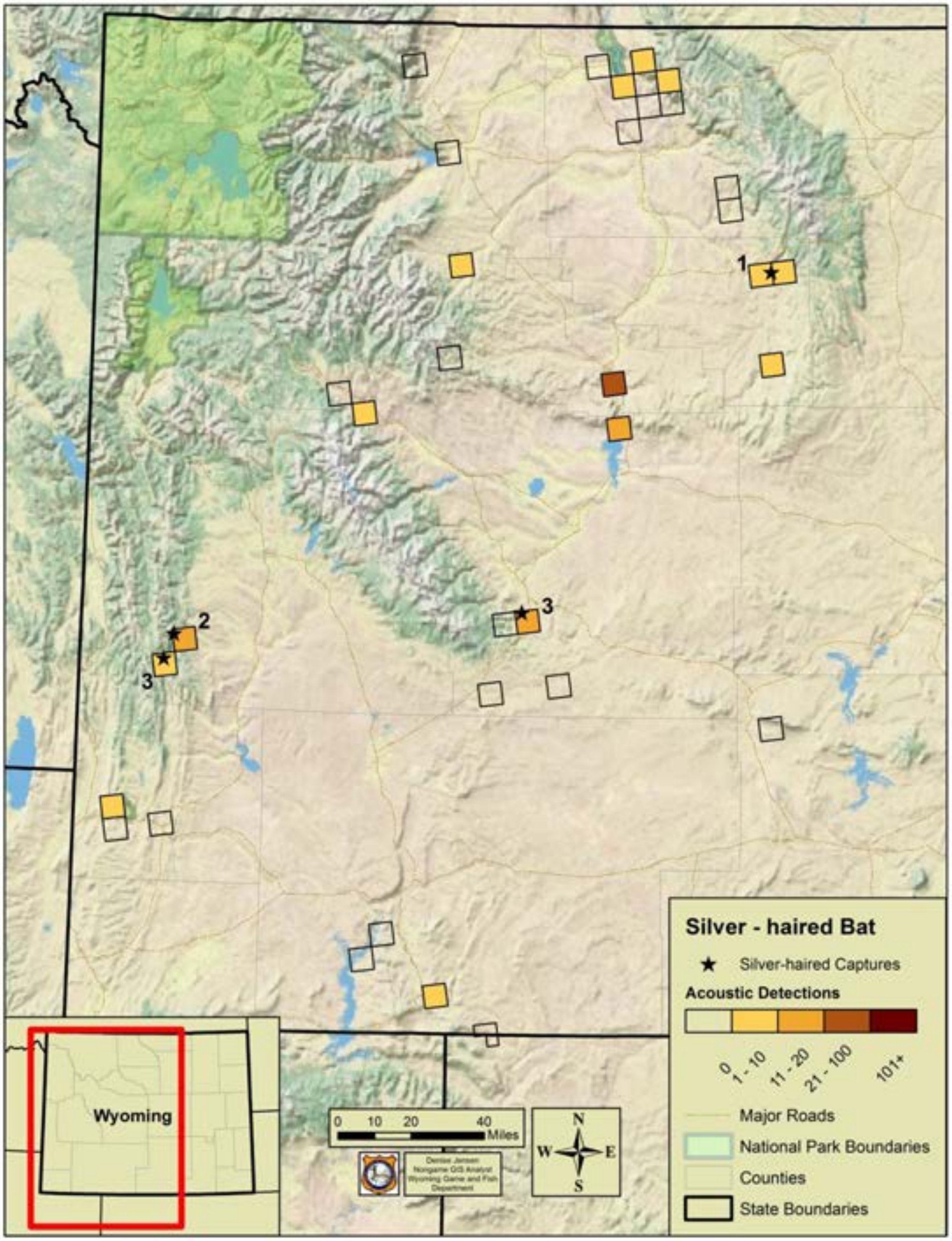

Figure 8. Locations where we captured and detected silver-haired bats (*Lasionycteris noctivagans*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

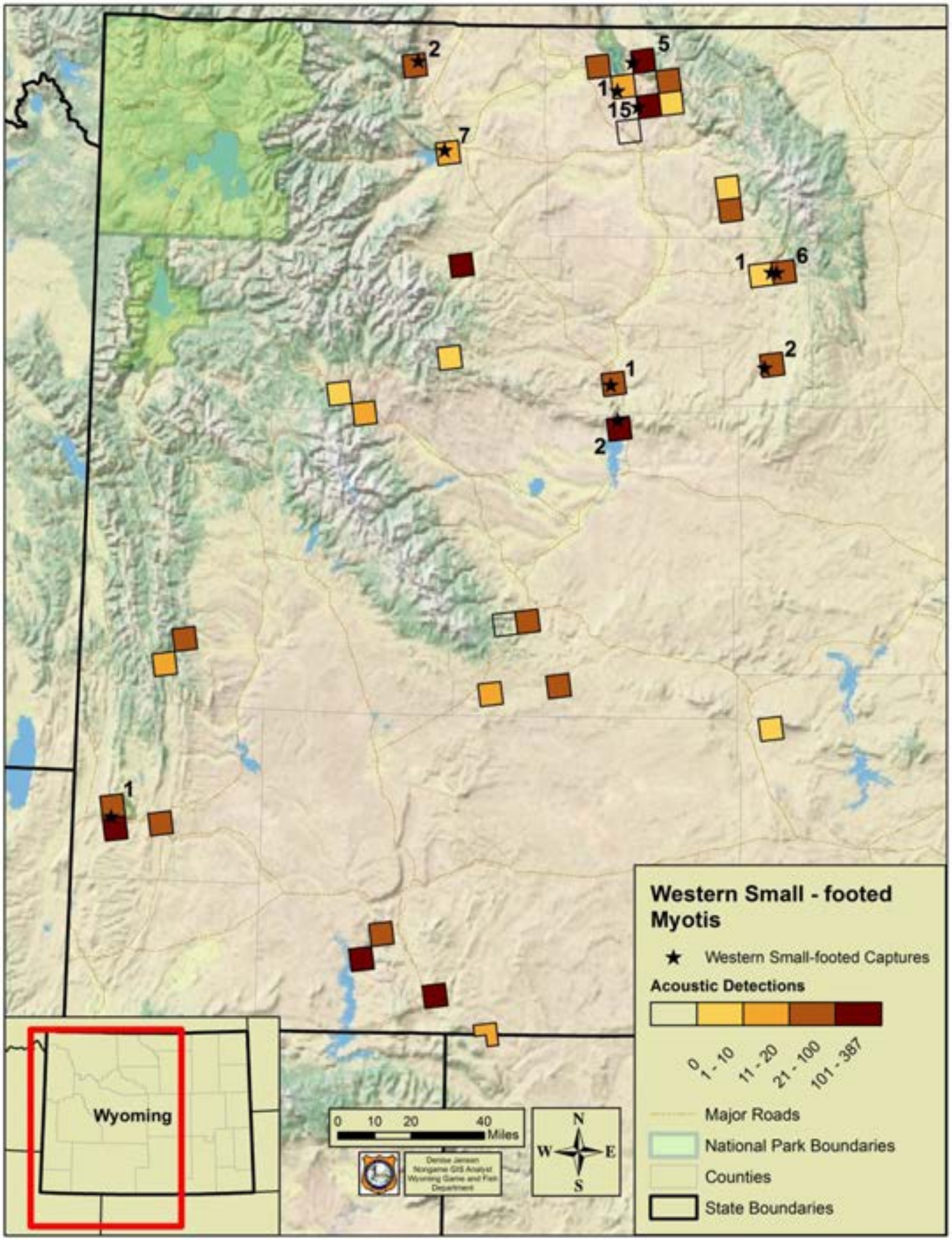

Figure 9. Locations where we captured and detected western small-footed myotis (*Myotis ciliolabrum*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

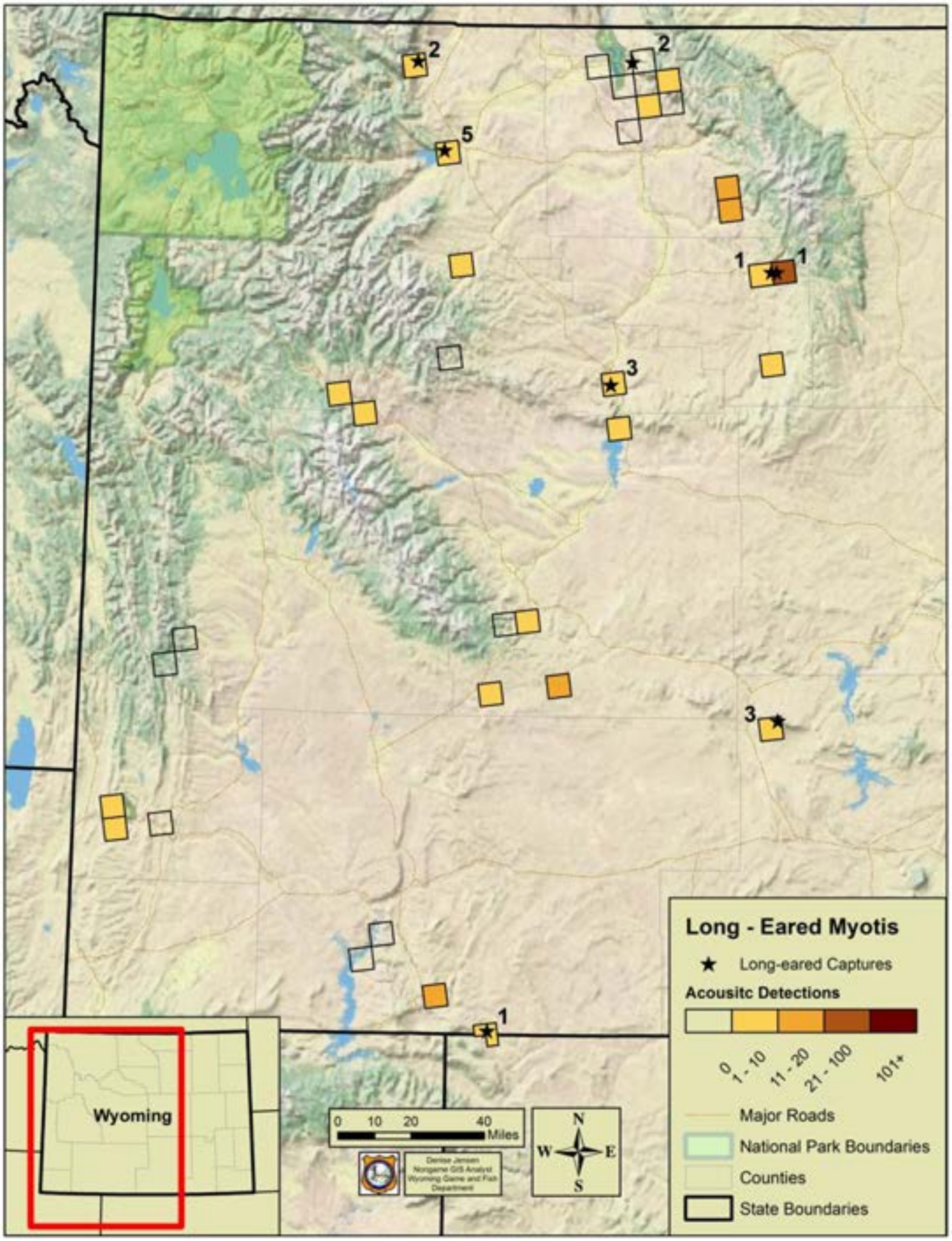

Figure 10. Locations where we captured and detected long-eared myotis (*Myotis evotis*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

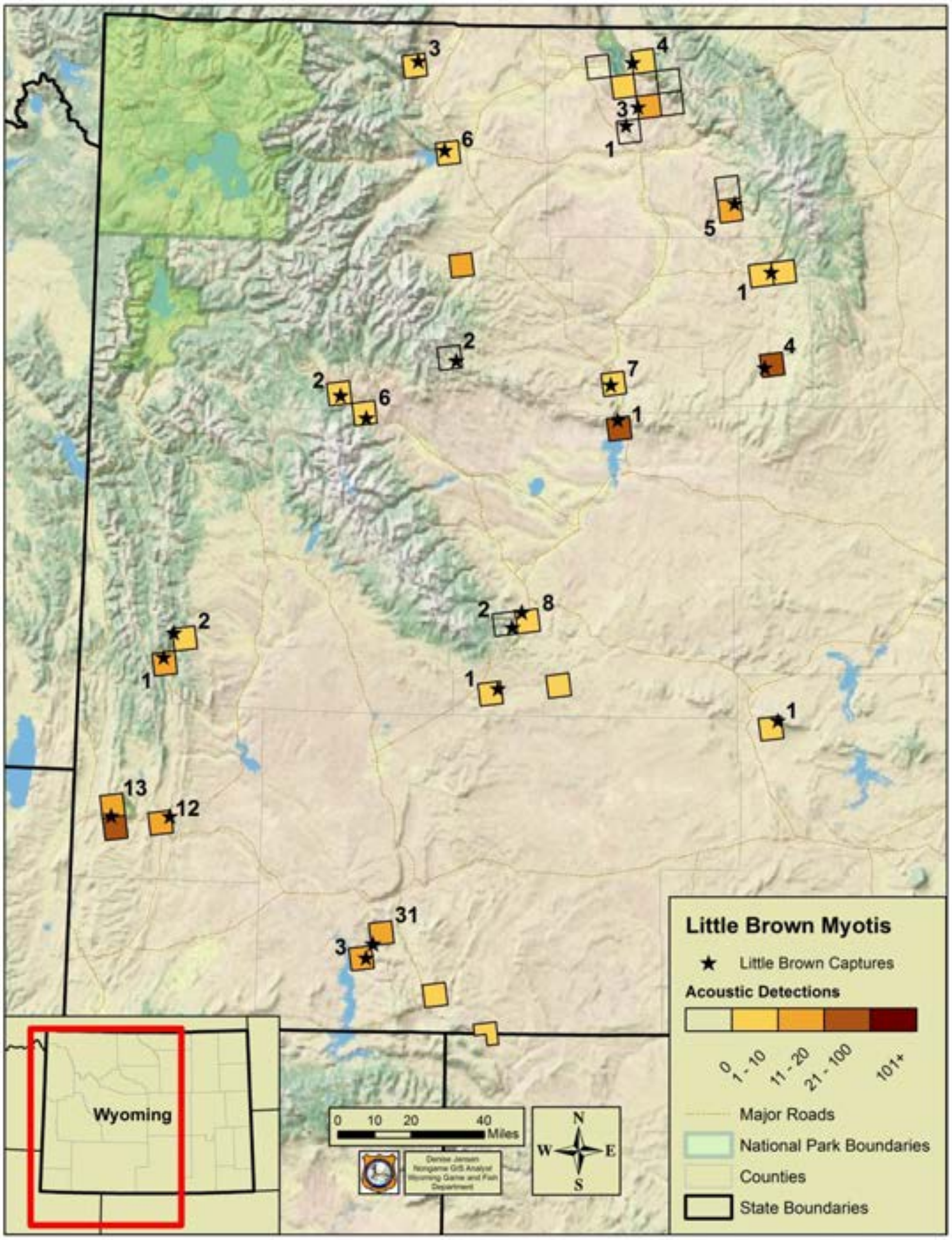

Figure 11. Locations where we captured and detected little brown myotis (*Myotis lucifugus*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

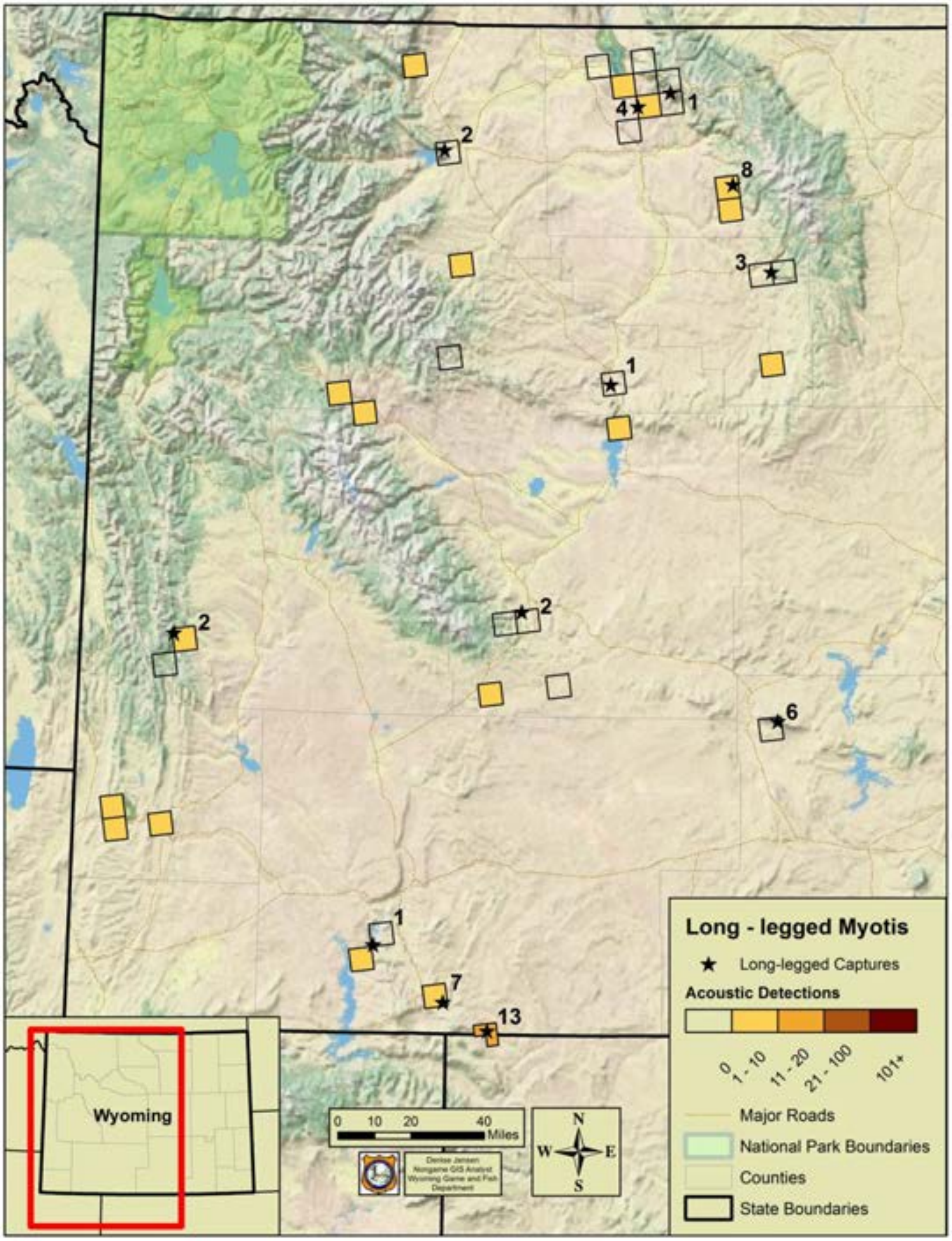

Figure 12. Locations where we captured and detected long-legged myotis (*Myotis volans*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

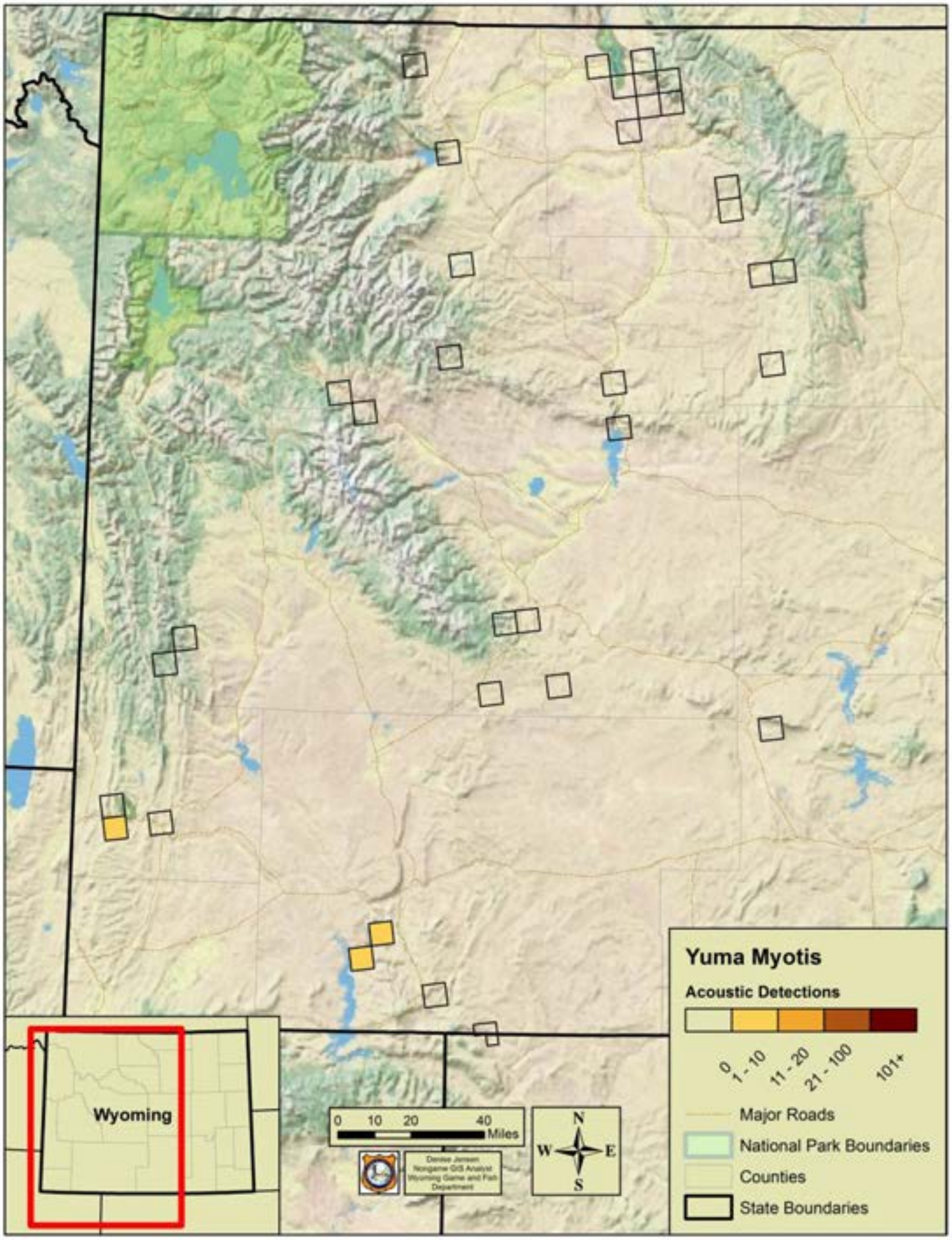

Figure 13. Locations where we captured and detected Yuma myotis (*Myotis yumanensis*) for each survey grid in western Wyoming, May-September, 2013. Stars within each grid represent netting locations, and corresponding labels refer to the number of captured individuals. Color of each grid corresponds to the number of classified call files.

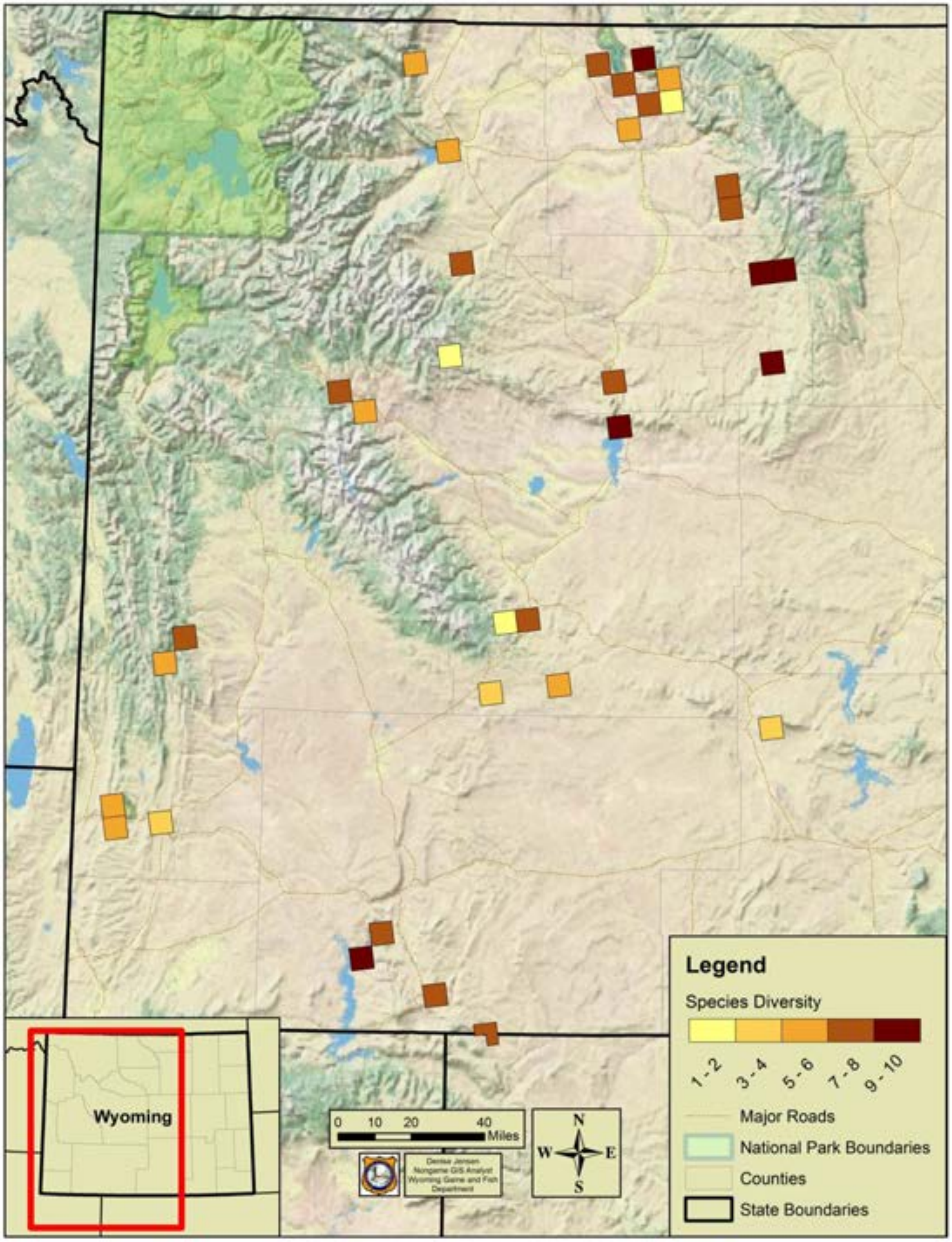

Figure 14. Location of grids surveyed throughout western Wyoming, May-September, 2013. Colors correspond to the number of species of bats detected (acoustic and captures) within each grid that surveyed.

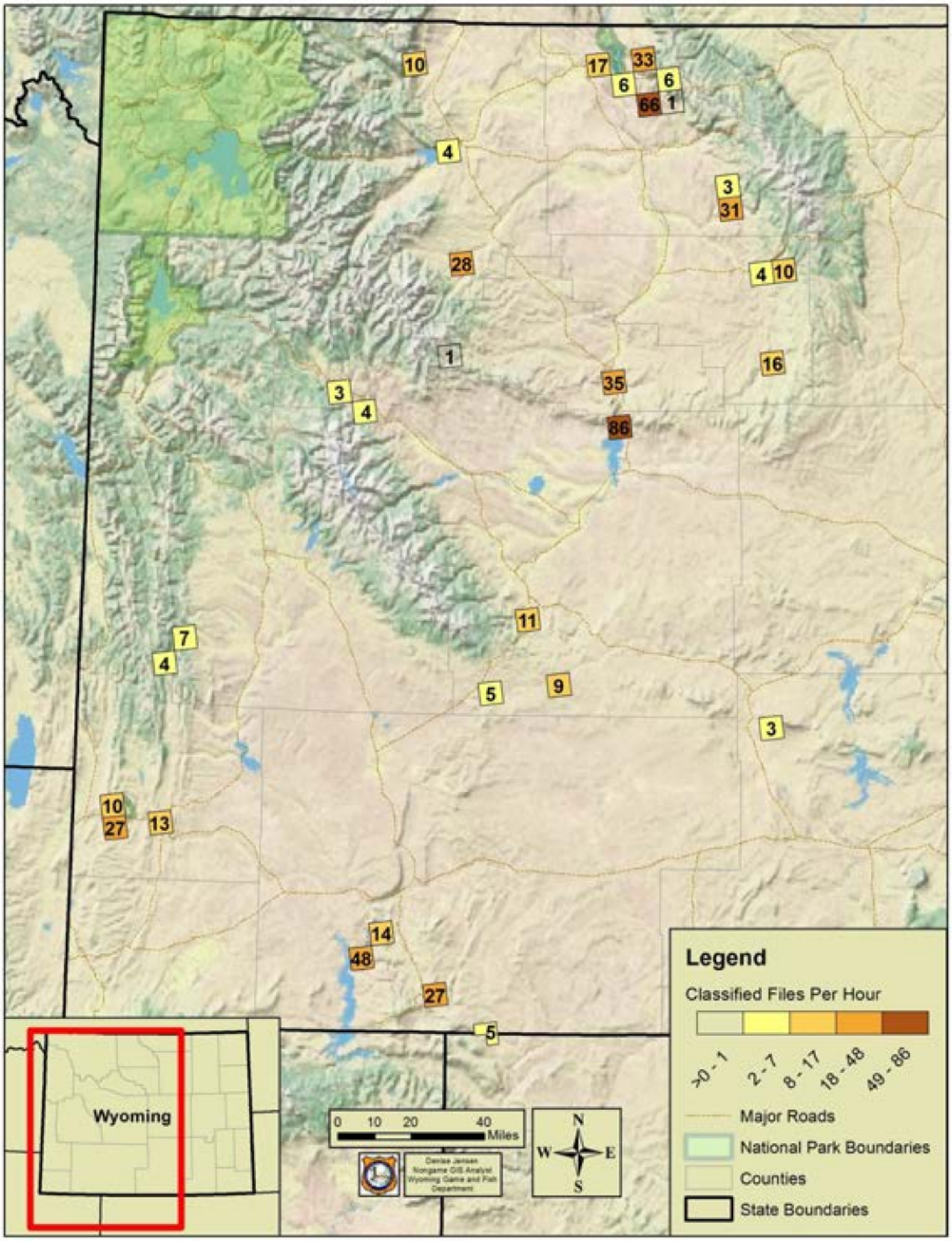

Figure 15. Location of grids surveyed throughout western Wyoming, May-September, 2013. Colors and labels correspond to classified calls per hr for each grid.

REGIONAL ACOUSTIC SURVEYS FOR BATS: RECOMMENDATIONS FOR LONG-TERM SURVEILLANCE EFFORTS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: Wyoming Governor's Big Game License Coalition
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Leah Yandow, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Bats (Order: Chiroptera) make up nearly 25% of the mammalian Species of Greatest Conservation Need as recognized by the Wyoming Game and Fish Department. They are an important suite of species because of their sensitivity to disturbances and ecological roles. Our understanding of habitat associations and current distributions within specific regions of the Wyoming Game and Fish Department are limited. Bats are perceived as being difficult to survey because they are nocturnal, volant, and often cryptic. We used an acoustic detector to gain information about bats that were present in the Lander Region. Personnel in the Lander region deployed acoustic detectors at 22 sites throughout the region. Twelve of these sites recorded bat calls that we classified to species. Little brown myotis (*Myotis lucifugus*) was the most commonly detected species followed by the long-eared myotis (*M. evotis*) and the western small-footed myotis (*M. ciliolabrum*). Generally, personnel were enthusiastic about participating and assisting with the surveys. We encountered several issues that will need to be resolved for future surveys, including damaged equipment and a longer power source for the detectors. We propose to modify the approach by providing further training and purchasing additional equipment as needed to improve the success of the surveys in the future.

INTRODUCTION

Wyoming hosts 12 resident species of bats (Order: Chiroptera), 10 of which are recognized as Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (Department). All Wyoming bats are insectivorous and provide ecosystem services via the consumption of herbivorous insects and redistribution of nutrients across the landscape

(Duchamp et al. 2010, Boyles et al. 2011). As important contributors to the health and function of Wyoming's ecosystems, bats are particularly vulnerable to large-scale disturbance (Racey and Entwistle 2000, Jones et al. 2009). Disease, climate change, development of wind farms, roost disturbance, and timber harvest practices are currently recognized as threats to bats (Patriquin and Barclay 2003, Arnett et al. 2008, Tuttle and Stevenson 2011, Sherwin et al. 2013). As disturbances continue to affect the abundance and distribution of bats, development of long-term surveillance of bats in Wyoming will be important for conserving and managing these species.

Bats are often considered difficult to detect because of their small body size as well as their volant, nocturnal, and cryptic behaviors. However, over the last decade, advances in technology have made using acoustic detectors more affordable and practical. Consequently this approach makes it easier to detect bats. With this project, we make use of acoustic detectors and utilize regional personnel to conduct the surveys. The advantage of this approach is that it allows these detectors to be deployed by personnel who are already in the field, resulting in additional opportunities to collect data on bats in the region. Collaborating with regional personnel allows us to overcome some of the logistical challenges encountered by our statewide personnel who survey for bats. For example, we are often limited by the number of personnel, which in turn limits our ability to survey multiple sites during a single night.

Our objectives for the pilot year of this project were twofold: 1) determine if our approach is logistically feasible and would be supported by regional personnel and 2) evaluate and improve the study design for future surveys. A systematic approach to data collection at the regional scale will enhance our understanding of bat species distribution, diversity, and habitat associations within regions and will provide enhanced resolution of our understanding. Our goal is to use this approach to supplement our statewide surveys. This project addresses objectives outlined in the State Wildlife Action Plan by collecting data on several SGCN across a diverse suite of habitats. Results from the project will contribute to the annual update of the Department's Atlas of Birds, Mammals, Amphibians and Reptiles in Wyoming, the Wildlife Observation System (WOS), and WISDOM.

METHODS

Personnel in the Nongame Program generated a 100-km^2 Bat Grid system (P. Ormsbee, pers. comm.) that overlaid the Lander Region. The grid system was used to incorporate and evaluate spatial variation of surveys across the Region. In the field, regional personnel selected survey sites based on accessibility and proximity to habitat characteristics and resources that would increase the likelihood of having high bat activity (i.e., water, potential roosts, and flyways). We instructed personnel to include spatial, temporal, and geographic variation in selecting survey sites, whenever possible. We programmed an acoustic detector (Song Meter SM2BAT+, Wildlife Acoustics, Inc., Concord, MA) to turn on each day at ½ hr before sunset and record data for four consecutive hrs throughout June-September 2013. At each site, personnel used a tripod to deploy the acoustic detector and positioned the unit approximately 2 m above the ground with the microphone pointing skyward at about 65°. Regional personnel used a GPS (GPSMap 72, Garmin International, Inc. Olathe, KS, USA) to record location and elevation and a portable weather tracker (Kestrel 4500 series, Optimum Energy Products, Calgary, Alberta, Canada) to record current weather conditions as well as site characteristics (e.g., habitat type).

Personnel in the Nongame Program performed acoustic analyses. We used Sonobat Batch Scrubber utility to filter out noise files and classify the remaining files. Calls of good quality had a discriminate probability >0.90. We reviewed calls that had a discriminate probability <0.90 as determined by Sonobatch. We also counted the number of classified files per survey hr as an index of activity and number of species detected during each survey.

RESULTS

Regional personnel deployed the detector at 22 sites across 12 grids within the Lander Region from 17 June-18 September 2013. We recorded data at 15 of these sites for a total of 2,376 call files (Fig. 1). At the other seven sites, the detector failed to record data due to equipment malfunction. For sites where we recoded data, mean elevation was 2,467 m (±111 m). Across 12 of the sites, we classified 238 files to species level and detected 7 resident species, 5 of which are SGCN (Table 1). Little brown myotis (*Myotis lucifugus*; 55%) was the most frequently detected species followed by long-eared myotis (*M. evotis*; 20%) and western small-footed myotis (*M. ciliolabrum*; 13%). All other species each comprised <5% of the detections (Table 1).

The maximum number of species of bats we detected at any site was five (Table 2). This occurred 3 times, once at a site approximately 6 km north of Rawlins, and twice at sites near Green Mountain. We detected a similar pattern for bat activity in these areas. Green Mountain had the highest index of activity with an average of 18.0 (±5.38) calls per hr between the two sites, and the Rawlins site had 15.3 calls per hr (Table 3). Bat activity was also high (i.e., 13 and 14 calls per hr) at two sites 10-20 km southwest of Dubois, although nearby sites had very low activity (i.e., 0 and 1.2 calls per hr) showing inconsistent bat activity for that area (Fig. 2).

DISCUSSION

During this pilot project, we detected 7 species at 15 new survey sites throughout the region. Generally, regional personnel were enthusiastic and supportive of participating in the surveys. Similarly we got broad support from the Lander Regional Leadership Team. Though success of this initial endeavor was limited, we suggest that this approach to conducting bat surveys has potential for the future. The surveys were conducted in an opportunistic manner (e.g., personnel were not assigned survey grids) in 2013. In order to eventually survey the entire region, we may need to consider changing this approach. However, this could result in additional burdens or resource needs for regional personnel. Success of this project will be contingent upon frequent and regular feedback between the Nongame Program and regional personnel.

One of the primary challenges during this pilot project was the small number of sites sampled. There were two reasons this occurred. First, the detector required repairs during the season after it fell over in a wind storm. This unfortunately removed it from operation for several weeks. Second, we had issues with power for the unit. There were seven nights that personnel deployed the detector but the detector failed to record. We hypothesize this was due to dead batteries in the detector and a lack of familiarity with the survey equipment by regional personnel. To address these technical issues for future efforts, we will modify the set-up by adding an external power source that is expected to last longer and conserve battery power when the unit is not deployed. We will also supply a guy line and stake to secure the tripod with the detector to the ground. This should enable the unit to withstand high winds and prevent similar damage in the future. In addition to the technical modifications, we will provide more instruction on placement of the detector and its operation. These changes should improve the ability of personnel to select high quality sites, thereby increasing spatial variation across the region and minimizing noise files. We will also require personnel to record additional data on habitat and characteristics of the site, such as distance to nearest water source, rock feature, and trees. Finally, we will provide more specific instruction for regional personnel including how to check that the detector is working properly. We plan to incorporate these changes in 2014 and propose to broaden the effort to include both the Lander and Casper Regions if and additional detector can be purchased.

The Nongame Program has the unique and important challenge of conserving and managing >500 wildlife species for which the Department is responsible. This project represents an example of how we can collaborate with regional personnel to expand our survey capacity and ultimately our understanding of nongame species that occur within each region. Although this was a pilot project, we hope to build on this endeavor in future years by exploring opportunities to expand surveys. First, we plan to transition to a systematic survey approach whereby an entire region will eventually be surveyed to establish a baseline for distribution of species. Second, we have applied for additional funds via grants to purchase additional survey equipment that would enable us to expand survey efforts to other regions. Finally, we aim to conduct these surveys over the long-term. By working interdependently, regional and nongame personnel have the potential to accomplish objectives that were not feasible otherwise. This pilot project, although limited, could become an important model for demonstrating how we can increase capacity of the Nongame Program for surveys by increasing interest and involvement of regional personnel.

ACKNOWLEDGEMENTS

Survey equipment was purchased using the funds from the Wyoming Governor's Big Game License Coalition. We would like to thank personnel in the Lander region who contributed to this project, including G. Anderson, B. Baker, R. Beattie, B. Brinegar, B. Frude, P. Gerrity, S. Harter, B. Hovinga, J. Hunter, and B. Sherwood. Also would like to thank the Lander Regional Leadership Team, specifically J. Hunter, K. Johnson, and D. Lutz, for their support and for encouraging their personnel to participate in the surveys.

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Table 1. Resident bat species expected to occur in Lander Region, Wyoming with number of detections for surveys conducted from June-September 2013 (Hester and Grenier 2005). Native Species Status of Species of Greatest Conservation Need for bats are 2, 3, 4, or U, as identified in the species accounts of the State Wildlife Action Plan (WGFD 2010).

Scientific name	Native Species Status	No. of detections
Antrozous pallidus	NSS3	0
Corynorhinus townsendii	NSS2	0
Eptesicus fuscus	NSS4	4
Euderma maculatum	NSS3	0
Lasionycteris noctivagans	-	12
Lasiurus cinereus	-	6
Myotis ciliolabrum	NSS4	37
Myotis evotis	NSS3	58
Myotis lucifugus	NSS4	155
Myotis thysanodes	NSS3	0
Myotis volans	NSS3	11

Table 2. Species diversity of bats detected at each site in the Lander Region, Wyoming during surveys conducted from June-September 2013. Species codes represent *Antrozous pallidus* (ANPA), *Corynorhinus townsendii* (COTO), *Eptesicus fuscus* (EPFU), *Euderma maculatum* (EUMA), *Lasionycteris noctivagans* (LANO), *Lasiurus cinereus* (LACI), *Myotis ciliolabrum* (MYCI), *Myotis evotis* (MYEV), *Myotis lucifugus* (MYLU), *Myotis thysanodes* (MYTH), and *Myotis volans* (MYVO).

Site no.	No. of species detected	Species detected
901	3	EPFU, LANO, MYEV
902	5	EPFU, LANO, MYCI, MYEV, MYLU
903	5	LACI, LANO, MYCI, MYEV, MYLU
904	5	LANO, MYCI, MYEV, MYLU, MYVO
905	3	LACI, LANO, MYLU
906	2	MYEV, MYLU
907	1	LACI
913	1	MYEV
914	3	MYCI, MYEV, MYLU
915	4	LACI, MYCI, MYEV, MYLU
916	1	LACI
917	2	MYEV, MYLU

Table 3. Means and standard errors (SE) for acoustic surveys conducted throughout the Lander Region, Wyoming, June-September 2013 (*n* = 15). Total files recorded are the number of files recorded at each survey site after removing noise files. Classified files included both manual and Sonobatch classified files. Classified files per hr is an index of activity based on classified files and survey length. Species detected is a measure of species diversity.

	Mean	SE
Total files recorded	158.4	82.1
Classified files	20.3	6.6
Survey hrs per grid	3.0	0.14
Classified per hr	5.9	1.9
Species detected	2.3	0.5

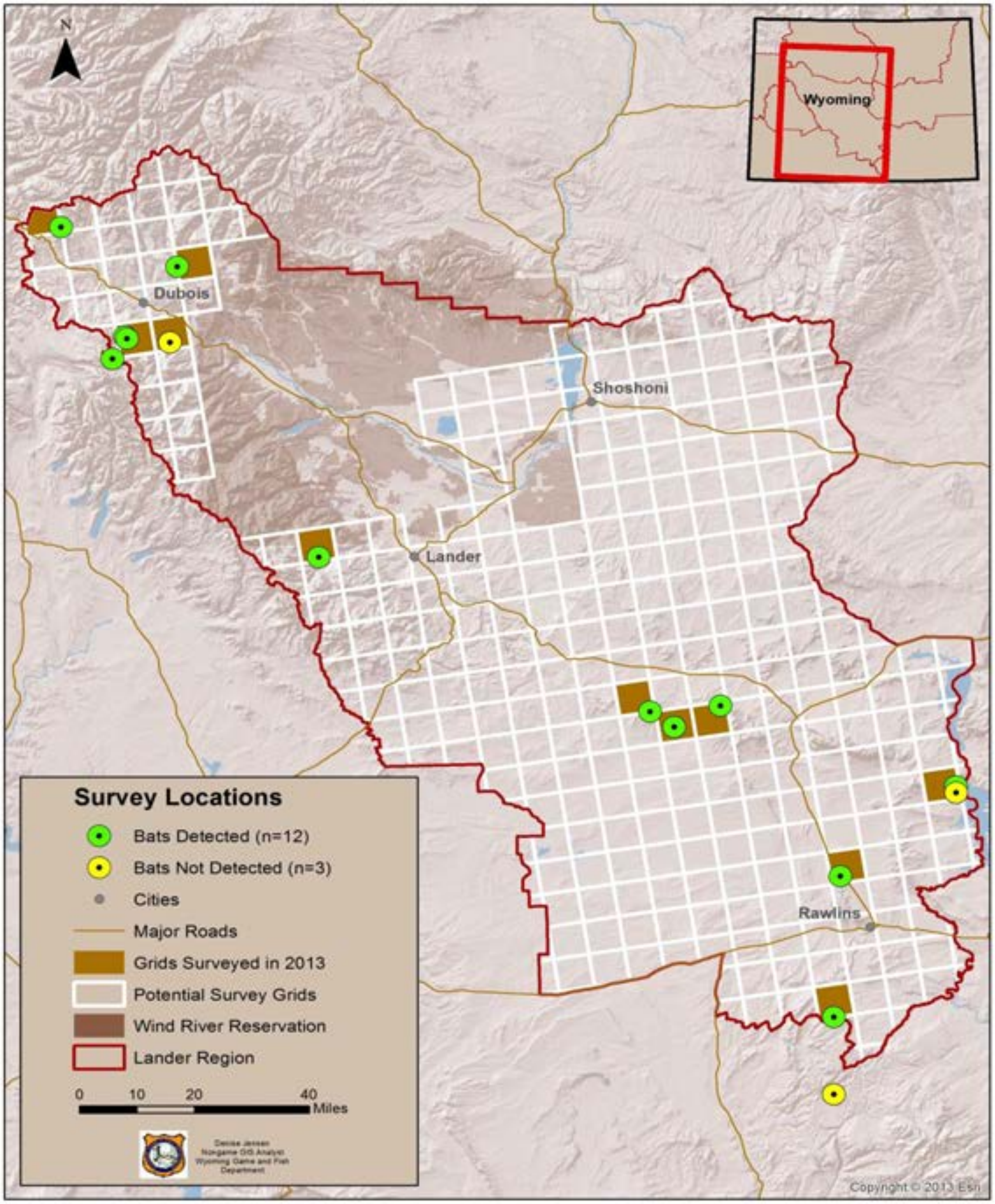

Figure 1. Study area and location of acoustic surveys for bats in the Lander Region, Wyoming, June-September 2013. Green circles represent survey locations where we detected bats. Sites where we deployed equipment and failed to detect any bats are depicted in yellow.

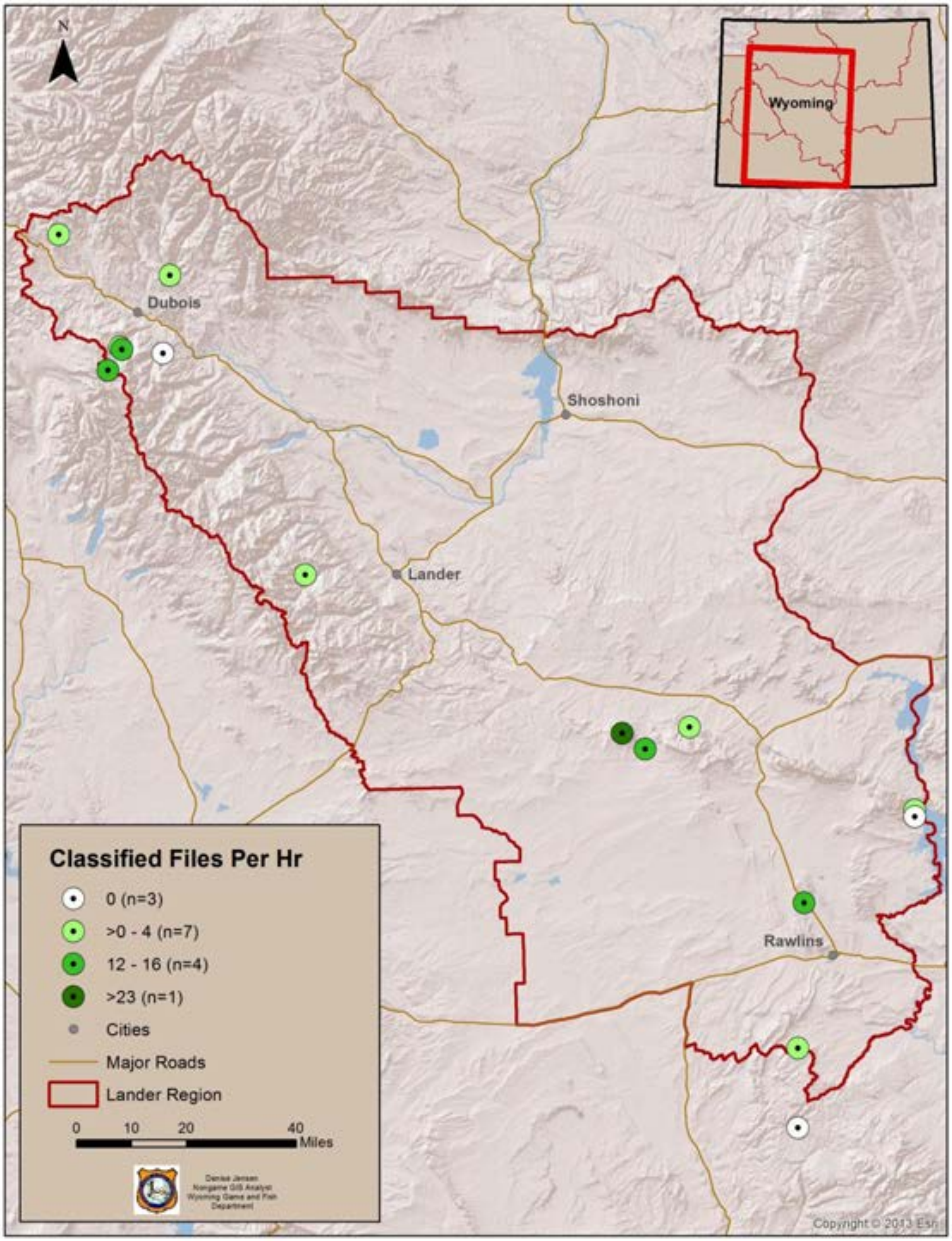

Figure 2. Number of classified files per hr of bats detected at each survey site in the Lander Region, Wyoming, June-September 2013. Color of each circle corresponds with the number of call files per hr for that location.

PYGMY RABBIT (*BRACHYLAGUS IDAHOENSIS*) DISTRIBUTION AND OCCUPANCY IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Pygmy Rabbit

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Nichole Cudworth, Nongame Biologist
Meghann Karsch, Nongame Technician
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Pygmy rabbits (*Brachylagus idahoensis*) are dependent on sagebrush (*Artemisia* spp.) for food, habitat, protection from predators, and thermal cover. Consequently, they are susceptible to a number of land management practices that reduce or alter sagebrush ecosystems. Because they are especially susceptible to habitat loss and lack basic data on population distribution and trends, the Wyoming Game and Fish Department classifies pygmy rabbits as a Species of Greatest Conservation Need. In 2013, the Department initiated a survey to document distribution, evaluate the impact of a number of variables on occupancy of pygmy rabbits, and develop a baseline occupancy estimate with which to monitor trends. We detected pygmy rabbits on 21 of 50 grids throughout the predicted distribution in southwestern Wyoming. Detection probability was high overall ($\geq$0.97), and occupancy was 48%. Occupancy was negatively associated with the presence of predators and habitat disturbance but positively associated with the presence of cottontails (*Sylvilagus* spp.). The power to detect a decrease in the occupancy of pygmy rabbits was low, potentially suggesting the need for increased survey effort. However, observers were able to consistently and accurately detect pygmy rabbits, suggesting our methods can be easily implemented in subsequent years.

INTRODUCTION

Sagebrush (*Aretemisia* spp.) shrublands represent a major ecosystem in the western United States, and Wyoming contains a higher proportion of this ecosystem than any other state (WGFD 2010). At least eight wildlife species in Wyoming are considered sagebrush-obligates, and sagebrush shrublands provide crucial winter range and habitat for numerous other species (Paige and Ritter 1999, WGFD 2010). Despite the unique contribution of sagebrush to Wyoming's landscape and its importance as wildlife habitat, this ecosystem faces a number of threats, including invasive plants, incompatible energy development and mining practices, and rural subdivision (Vale 1974, Miller et al. 1994, WGFD 2010). A variety of habitat treatments have been proposed to enhance and manage sagebrush systems, but their impacts on wildlife vary (Wyoming Interagency Vegetation Committee 2002, Baker 2006, Wilson et al. 2011).

The pygmy rabbit (*Brachylagus idahoensis*) is a sagebrush-obligate that depends on sagebrush for food and cover. Pygmy rabbits are most commonly associated with areas of dense, tall sagebrush with deep, friable soils, as the species is unique in its ability to build and maintain extensive burrow systems, the entrances of which are typically located at the base of sagebrush (Green and Flinders 1980a, b; Weiss and Verts 1984; Katzner and Parker 1997; Gabler et al. 2001; Larrucea and Brussard 2008a). Although diet varies throughout the year, sagebrush is a dominant food source in all seasons and may comprise ≤ 99% of the diet in winter (Green and Flinders 1980b). Pygmy rabbits are also prey for a variety of avian and mammalian predators, and their burrow systems are often used by other species, including other rabbits (Green and Flinders 1980a). Consequently, pygmy rabbits may be considered a keystone species in sagebrush habitats.

Pygmy rabbits are susceptible to habitat loss due to manipulation and degradation of sagebrush systems, which contributed to their classification as a Species of Greatest Conservation Need in Wyoming's State Wildlife Action Plan (SWAP; Thimmayya 2010, WGFD 2010, Wilson et al. 2011). In addition, the pygmy rabbit was previously petitioned for listing under the Endangered Species Act, although the US Fish and Wildlife Service subsequently found that listing was not warranted except for the distinct population segment of the Columbia Basin pygmy rabbit, which remains listed as Endangered where it occurs in Washington (USFWS 2003, 2010). Pygmy rabbits are further impacted by edge effects, likely due to competition with cottontails (*Sylvilagus* spp.) and jackrabbits (*Lepus* spp.) as well as predation, which is a major cause of pygmy rabbit mortality (Estes-Zumph and Rachlow 2009, Crawford et al. 2010, Price et al. 2010, Pierce et al. 2011). The relatively large home ranges and long dispersal distances utilized by pygmy rabbits further emphasize the need for contiguous sagebrush habitat connected by dispersal corridors (Sanchez and Rachlow 2008, Estes-Zumph and Rachlow 2009). However, the lack of data on population densities and trends of pygmy rabbits in Wyoming make assessing population status and potential impacts of habitat manipulations or reductions difficult (WGFD 2010).

Our objectives for this project were three-fold. First, we implemented a range-wide survey of pygmy rabbits in Wyoming to address conservation objectives outlined in the SWAP, including the need for adequate survey protocol and a better understanding of presence and distribution (WGFD 2010). Second, we evaluated the influence of a number of factors on occupancy of pygmy rabbits, including habitat manipulation, competitors, and predators. Finally, we developed a baseline occupancy estimate with which to monitor trends over time.

METHODS

We overlaid the southwestern corner of Wyoming with 400 m × 400 m grids and classified grids as available to survey if they overlapped the predicted distribution of pygmy rabbits (WGFD 2010). The predicted distribution was developed by using a maximum entropy model incorporating historical records of pygmy rabbits as well as metrics for elevation and habitat. The model was then validated on the ground in order to further refine the predicted distribution (D. Keinath, personal communication). We divided the distribution of pygmy rabbits into three sections of roughly equal area to ensure grids were allocated evenly throughout the distribution. We randomly selected 50 grids from throughout the study area and allocated in proportion to the amount of area available in each section (Fig. 1). Once a grid was selected, we determined land ownership and attempted to contact all private landowners for access. We randomly selected a replacement grid within the same section if ownership could not be determined or if landowners could not be reached or declined to participate in the survey. We divided each grid into 8, 50-m wide transects to facilitate surveys and ensure grids were surveyed thoroughly and consistently.

We developed our survey approach using methods developed by H. Ulmschneider (BLM) and modified by S. Germain (US Geological Survey) and D. Woolwine (BLM; S. Germain, personal communication). We conducted all surveys between 14 January and 27 March 2013 in order to maximize detections during ideal snow conditions and minimize overlap with juvenile cottontails. Although vegetative characteristics varied among grids, dominant cover was always sagebrush, and grids often contained ephemeral or, occasionally, perennial streams. The majority of grids had at least partial snow cover during our surveys. Average monthly temperature across our study area was 3°C, and average monthly precipitation was 0.45 cm, nearly all of which was snowfall (Weather Underground 2013).

We used a double-observer approach to survey for pygmy rabbits in order to evaluate detection probability and maintain independence between visits. We trained observers to identify pygmy rabbit habitat and sign before beginning field surveys. Observers surveyed grids concurrently, with one observer starting at the southwest corner and the other starting at the northeast corner of the grid. Observers walked down the center of each transect and thoroughly searched all habitat for evidence of pygmy rabbits, including observations of individuals, fresh pellets, occupied burrows with evidence of recent use, and fresh tracks in the snow. When a pygmy rabbit was detected, observers recorded location and type of detection and documented data with photographs. Detections were considered independent if they were ≥30 m apart. Observers searched each grid completely before moving to the next.

We used data from both observers to develop an encounter history for each grid and used program PRESENCE (Hines 2010) to develop occupancy models. Models included the probability of occupancy (Ψ) and two detection probabilities (p), one for each observer. Three additional occupancy covariates included the presence of cottontails, predators [i.e., coyotes (*Canis latrans*), weasels (*Mustela* spp.), and raptors], and habitat disturbance (i.e., oil/gas development, two-track and larger roads, reclamation, and pipelines) in the grid. Detection probability covariates included observer modeled as a time covariate and the presence of current snow cover. We developed additive models including all possible combinations of covariates for a total of 32 models. We used AIC for model selection (Burnham and Anderson 1998) and model averaging for all models with ΔAIC < 2. Once top models were selected, we performed a MacKenzie-Bailey goodness of fit test (MacKenzie and Bailey 2004) for each model to test for overdispersion. We used G*Power Version 3.1.5 (Faul et al. 2007) to conduct a power analysis to test our ability to detect a change in the probability of occupancy of 0.10, 0.15, and 0.20; we calculated effect size from the standard deviation calculated from this survey. We used the matched pairs t-test option with $\alpha = 0.05$ and sample size of 50. We report detection probabilities and average occupancy (± *SE*) from model averaged results.

RESULTS

Of the 50 grids we surveyed for pygmy rabbits, 21 (42%) contained tracks, pellets, active burrows, or individuals; most occupied grids resulted in multiple detections. The majority of grids containing pygmy rabbits were located in the northern and western sections of the distribution (Fig. 1). We identified 4 models with ΔAIC < 2 (Table 1). Probability of occupancy was influenced by the presence of cottontails and predators in all models, and by the presence of habitat disturbance in the top two models. Detection probability varied between observers, but models containing the observer covariate consistently ranked below models with a constant detection probability (Table 1). Observers obtained similar results on all grids except one, which the second observer classified as occupied and the first observer documented scat but was unable to positively identify current presence. When models were averaged, detection probabilities were similar between observers, with detection rates of 0.97 (± 0.03) and 0.99 (± 0.01), respectively.

Probability of occupancy was 21.32% (± 0.01%) higher on grids containing cottontails ($t_{48} = 4.22$, $P < 0.001$; Fig. 2a), 38.42% (± 0.01%) lower on grids containing predators ($t_{48} = -10.67$, $P < 0.001$; Fig. 2b), and tended to be 12.33% (± 0.01%) lower on grids containing habitat disturbance ($t_{48} = -1.96$, $P = 0.068$; Fig. 2c). Across all grids, probability of occupancy averaged 0.48 (± 0.09), suggesting that 24 (± 4.5) grids were occupied. With 50 survey grids, the power to detect a change in the probability of occupancy of 0.10 (i.e., a reduction from 0.48 to 0.38) was only 30.1%. However, the power to detect a change of 0.15 was 51.7%, and the power to detect a change of 0.20 was 72.6%.

Several other species of wildlife were also detected during surveys, including Greater Sage-Grouse (*Centrocercus urophasianus*), Bald Eagle (*Haliaeetus leucocephalus*), pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), moose (*Alces alces*), cattle (*Bos primigenius*), feral horse (*Equus ferus*), coyote, ermine (*Mustela erminea*), cottontail, jackrabbit, and several unidentified small mammal species, likely from the Order Rodentia.

DISCUSSION

We designed our survey technique to maximize the potential of detecting pygmy rabbits while minimizing confusion with similar species (i.e., false positives). Surveys were typically conducted in <2 hrs and resulted in high detection probability for both observers (≥0.97). Because detection probabilities vary depending on type of detection (i.e., tracks, pellets, individuals, or active burrows; Larrucea and Brussard 2008b), our survey included any sign of occupancy in order to maximize detection. In fact, observers documented >1 detection on the majority of occupied grids, many of which included multiple detection types. We also conducted our surveys during winter, since fresh tracks, pellets, and active burrows and runways are more easily observed on snow cover than bare ground (A. Thimmayya, personal communication). This timing also reduced the chance of misidentifying juvenile cottontail pellets as pygmy rabbit pellets or misidentifying pregnant pygmy rabbit pellets as cottontail pellets (Larrucea and Brussard 2008b). Interestingly, snow cover had no impact on our ability to detect pygmy rabbits. However, the majority of our grids had at least some snow at the time of survey, which may have limited our ability to fully evaluate the effects of snow cover on detection probability.

Although we found pygmy rabbits throughout the predicted distribution in Wyoming, detections were most common in the western and northern sections, closer to the core of the geographic range. Because Wyoming is at the eastern edge of the pygmy rabbit range, we would expect lower abundance, and therefore lower density, as we move closer to the range boundary (Brown 1984). Overall, occupancy was < 50% despite all grids being located within the predicted distribution of pygmy rabbits. However, current sagebrush models for Wyoming are not at a fine enough scale to discern height or density, and the state lacks a soil model, both of which limit our ability to accurately predict habitat at a fine-scale resolution. Even when pygmy rabbit habitat can be mapped precisely, pygmy rabbits may still be difficult to locate because they are not found in all areas that appear to be suitable habitat (Larrucea and Brussard 2008a), and populations are susceptible to rapid declines that could easily lead to local extirpation (Weiss and Verts 1984). Our surveys support these observations, as we encountered several grids that looked like pygmy rabbit habitat but where none were detected, emphasizing the need for on-the-ground validation of distribution models.

Both the presence of predators and disturbance of sagebrush habitat were negatively associated with occupancy of pygmy rabbits. Predators constitute a major source of mortality for pygmy rabbits, and observations of pygmy rabbits have been shown to decrease with increasing predator observations, especially along habitat edges (Crawford et al. 2010, Pierce et al. 2011). Habitat disturbance may also lead to increased predation risk, as sagebrush habitat that has been disturbed has shorter, sparser stands of sagebrush to provide protection from predators or for use as corridors (Weiss and Verts 1984, Katzner and Parker 1997). Because pygmy rabbits are dependent upon sagebrush for protection, thermal cover, and food, maintaining undisturbed habitat is vital for presence and survival (Green and Flinders 1980b, Gabler et al. 2001, Larrucea and Brussard 2008a, Thimmayya 2010, Wilson et al. 2011). Interestingly, however, occupancy of pygmy rabbits was positively associated with the presence of cottontails, despite potential negative effects due to competition reported in other studies (Larrucea and Brussard 2008a, Pierce et al. 2011). It is unclear whether pygmy rabbits are benefitting from the presence of cottontails or if both species are simply associated with a common habitat variable, but the apparent lack of inter-species competition in Wyoming likely warrants further investigation.

Overall occupancy of pygmy rabbits throughout their distribution in Wyoming was 48%. This estimate can be used as a baseline with which to monitor trends in occupancy of pygmy rabbits over time (MacKenzie et al. 2006). Although our ability to detect pygmy rabbits was high, our ability to detect a change in occupancy was quite low, only 30% for a reduction from 48% to 38% occupancy. Two variables that determine power and are under control of the managers include variance and sample size. By conducting repeated surveys of the same sites, we were able to utilize a paired t-test, thus reducing variance between surveys. Detection probability was also high, minimizing variance caused by imperfect detection. It may be possible to further reduce variance among grids by more accurately predicting habitat, but this reduction is likely to be minimal. Instead, increasing sample size is likely to have the largest impact on power, and future endeavors should evaluate the trade-off between increasing power and increasing survey effort. They may also benefit by including on-the-ground habitat measurements at both occupied and unoccupied sites. Not only can these measurements be used to refine predictive models and increase our knowledge of the ecology of pygmy rabbits in Wyoming, but they will also allow baseline habitat information with which to monitor changes that may result in associated changes in occupancy.

Pygmy rabbits were first reported in southwestern Wyoming in 1981 (Campbell et al. 1982). Since that time, reports of pygmy rabbits have continued to increase, in part due to a heightened awareness and increased survey effort for the species. However, pygmy rabbits are still classified as rare in Wyoming (WGFD 2010) despite the large amount of sagebrush available in the state, emphasizing the need to accurately predict distribution and monitor trends. Currently, the availability of GIS layers that capture the extreme variation in sagebrush vegetation, including species, height, density, or underlying soil composition, are lacking. Consequently, despite focusing on the predicted distribution for pygmy rabbits in Wyoming, we still encountered grids that did not contain suitable sagebrush habitat. These observations highlight the need for refined sagebrush and soil layers in order to better predict pygmy rabbit distribution (e.g., Gabler et al. 2001, Rachlow and Svancara 2006). These changes would increase our potential to locate appropriate habitat, increase detections of pygmy rabbits and other sagebrush-dependent species of interest, and gain a better understanding of this important ecosystem overall.

ACKNOWLEDGEMENTS

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Table 1. Models, AIC scores, AIC weights, X^2 goodness of fit, and *P*-value for models with ΔAIC < 2 developed to evaluate occupancy of pygmy rabbits (*Brachylagus idahoensis*) throughout southwestern Wyoming from January-March 2013.

Model	AIC	AIC wt.	X^2	*P*
psi(cottontails+disturbance+predators),p(.)	74.99	0.377	1.27	0.74
psi(cottontails+disturbance+predators),p(observer)	75.61	0.276	0.55	0.91
psi(cottontails+predators),p(.)	76.25	0.201	2.66	0.45
psi(cottontails+predators),p(observer)	76.88	0.146	2.01	0.57

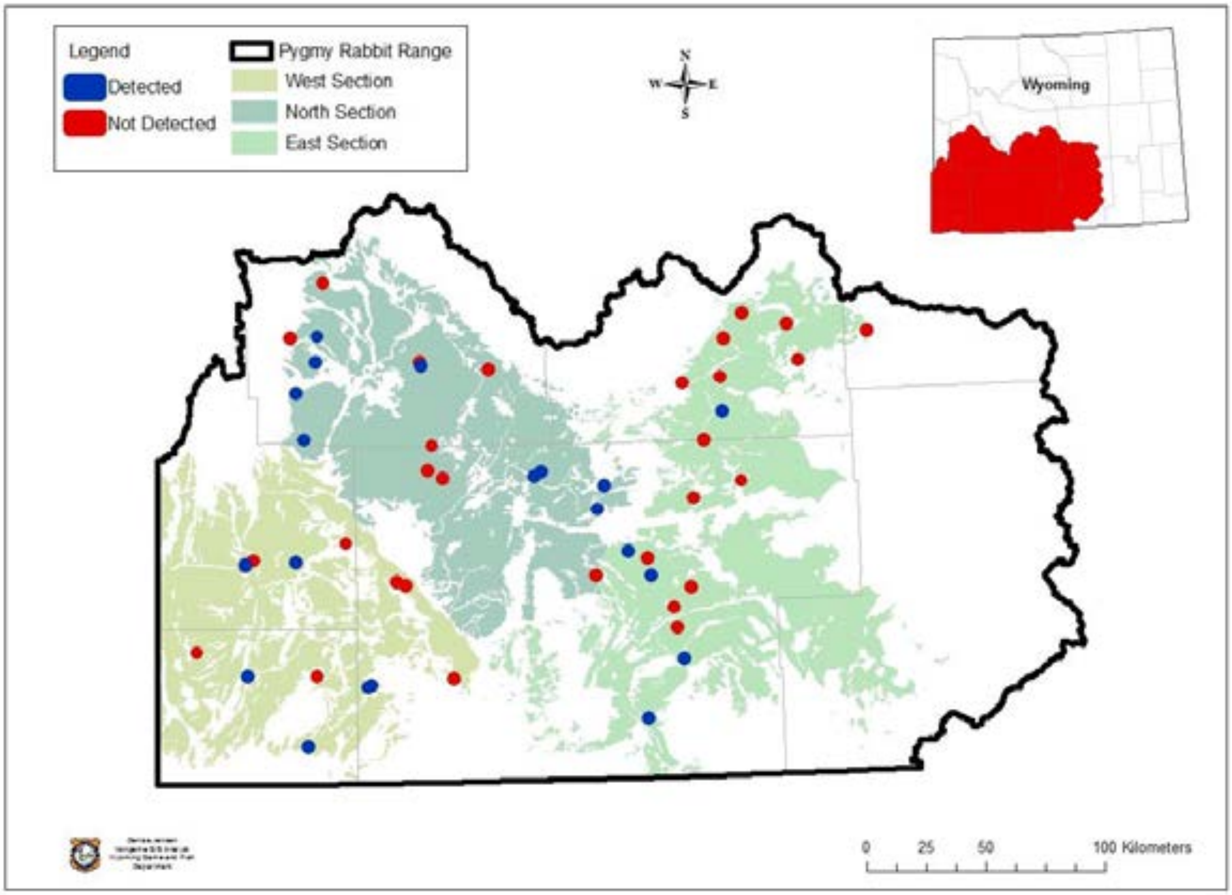

Figure 1. Locations of grids surveyed for pygmy rabbits (*Brachylagus idahoensis*) in southwestern Wyoming, January-March 2013. Grids where pygmy rabbits were detected are shown in blue; grids where pygmy rabbits were not detected are shown in red. Detections included observation of fresh tracks and pellets, active burrows, and individuals. The predicted distribution is shown with the three survey sections for reference.

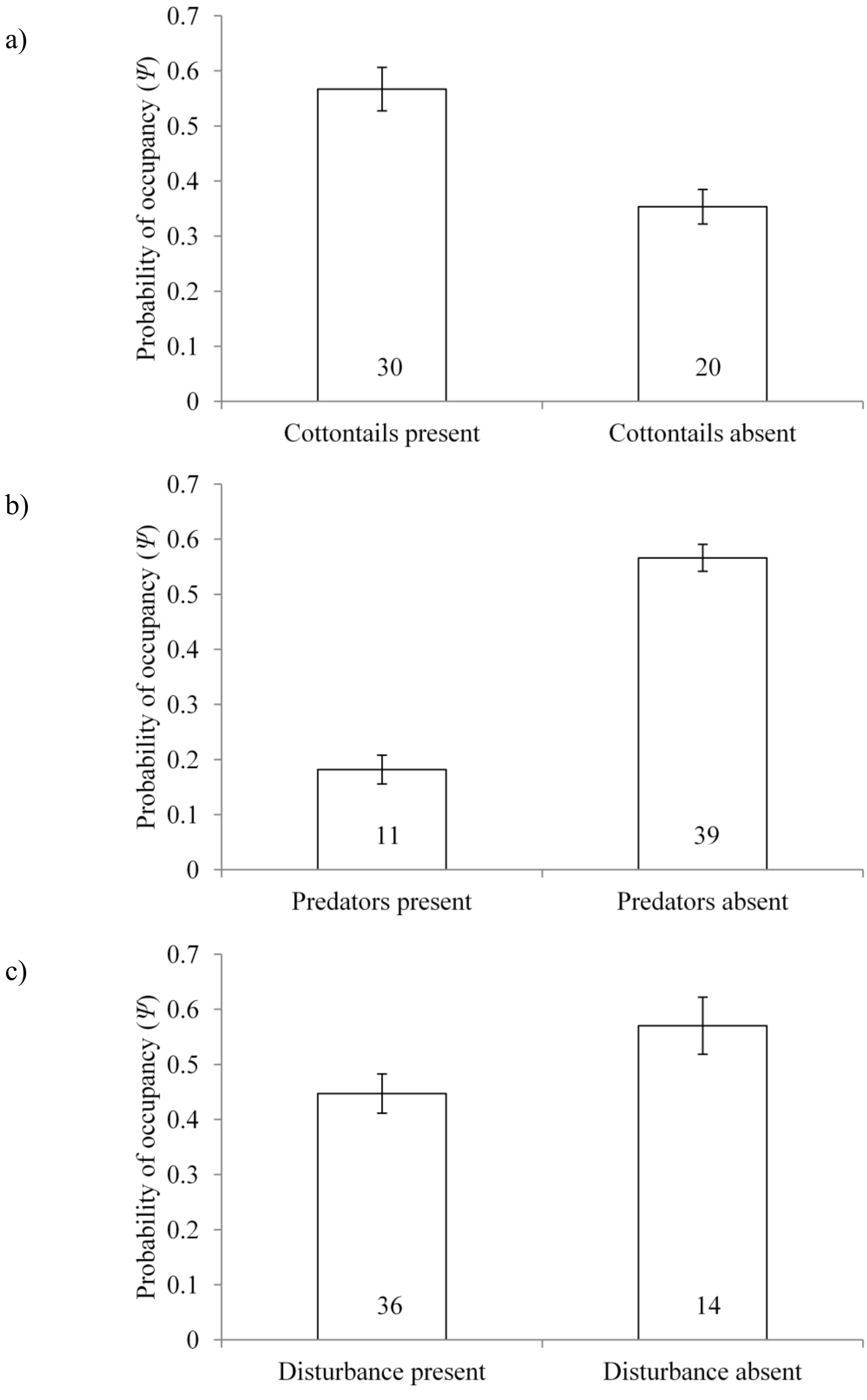

Figure 2. Average probability of occupancy (*Ψ*; ± *SE*) of pygmy rabbits (*Brachylagus idahoensis*) for grids that did and did not contain a) cottontails (*Sylvilagus* spp.), b) predators, and c) habitat disturbance from January-March 2013 in southwestern Wyoming. Sample size is shown at the base of each bar.

TRENDS AND DISTRIBUTION OF THE NORTHERN FLYING SQUIRREL (*GLAUCOMYS SABRINUS*) IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Northern Flying Squirrel

FUNDING SOURCE: United States Fish and Wildlife Service Cooperative Agreement
Wyoming Governor's Big Game License Coalition
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 September 2013

PERIOD COVERED: 15 April 2012 – 14 April 2014

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ABSTRACT

The northern flying squirrel (*Glaucomys sabrinus*) is a secretive and nocturnal mammal that can be difficult to detect. The Wyoming Game and Fish Department classifies the northern flying squirrel as a Species of Greatest Conservation Need because statewide population trends are unknown and the species is at risk from habitat loss due to natural and anthropogenic disturbances. Between August-October 2012 and May-August 2013, we used remote infrared cameras and enclosed bait tubes at 48 plots to estimate occupancy and update the current distribution of northern flying squirrels in the Wyoming Range. Additionally, we evaluated important components of habitat that could be used to predict presence of flying squirrels. We recorded 239 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 33 plots. Plots occupied by flying squirrels were characterized by live trees with larger diameter at breast height ($Z = 3.59$; $P < 0.001$) and lower basal area when compared to unoccupied sites. The mean diameter at breast height of snags in class 1 was also greater ($Z = 1.85$; $P = 0.032$) in occupied plots. Ground cover varied among sites, with grasses being significantly more abundant ($\bar{X} = 16.10 \pm 3.85\%$; $Z = 2.58$, $P = 0.005$) in occupied sites, while we detected fewer forbs ($\bar{X} = 18.06 \pm 3.25\%$; $Z = -1.83$, $P = 0.034$). Probability of occupancy was influenced by mean tree diameter at breast height, while detection probability was influenced by time and was highest in late summer and fall (AIC = 269.21, $\chi^2 = 25.92$, $P = 0.44$). Across all grids, probability of occupancy averaged 0.80 (±0.09). We recommend that future monitoring should employ cameras and enclosed bait tubes and be conducted in the late summer and fall seasons to optimize detections of flying squirrels. We also recommend that future survey efforts focus on

incorporating additional habitat components in the data collection and eliminating those that were found to not be significant during our analyses.

INTRODUCTION

The northern flying squirrel (*Glaucomys sabrinus;* flying squirrel) is an important small mammal species in coniferous and old growth forests. Not only does the species serve as a prey base for nocturnal raptors and mammalian carnivores, it is also important to ecosystem processes since flying squirrels consume and transport fungal spores (Wells-Gosling and Heaney 1984, Gabel et al. 2010). Consequently, because of their dependence on and importance to forest ecosystems, flying squirrels can serve as excellent indicators of forest health (Carey 2000). In Wyoming, flying squirrels are primarily restricted to the western mountains, although isolated populations occur in the Black Hills (WGFD 2010). Because their habitat is naturally patchy and susceptible to natural and anthropogenic disturbances, the flying squirrel is classified as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department (Department; NSS 4, Tier 2; WGFD 2010).

In 2011, the Department conducted a pilot project to test and develop a cost effective and non-invasive technique to document presence of flying squirrels (Van Fleet and Grenier 2012). As a result, in 2012 we implemented a 2-year project utilizing enclosed bait tubes (EBTs) and remote cameras (cameras) in the Wyoming Range (Van Fleet and Grenier 2012, Cudworth et al. 2013). Cameras have been used effectively with baits to detect nocturnal and secretive mammals (Heilbrun et al. 2006, Campbell et al. 2008, Pettorelli et al. 2010). EBTs provide a directional delivery system for baits that can improve a surveyor's opportunity to correctly identify a species at the point of detection (Zielinski et al. 2006, Campbell et al. 2008, Pauli et al. 2008). EBTs have been successfully used to detect and identify many forest carnivores (Kucera et al. 1995, Peterson and Thomas 1998). When combined with cameras, EBTs have been successful in detecting flying squirrels (Van Fleet and Grenier 2012).

Our objectives were to utilize cameras and EBTs to develop a baseline occupancy model for flying squirrels in the Wyoming Range, revise known distribution, and record new observations. Additionally we evaluated important components of habitat that can be used to predict presence of flying squirrels as outlined in the State Wildlife Action Plan (WGFD 2010).

METHODS

Our study area was located in the Wyoming Range, Bridger Teton National Forest in western Wyoming (Fig. 1). Dominate forest trees included Douglas fir (*Pseudotsuga menziezii)*, Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), and sub-alpine fir (*Abies lasiocarpa*), with elevation ranging from approximately 1760 m to 2620 m. Specifically, we conducted our surveys within the Grey's River, Ham's Fork, Horse Creek, and La Barge Creek drainages. During the summer of 2012, a fire consumed >26,000 ha within the Bridger Teton National Forest on the eastern side of the Wyoming Range (Teton Interagency Dispatch

Center 2012). This large area south of Cottonwood Creek and north of La Barge Creek was excluded from our survey.

We used 10.2-cm diameter (0.3 cm thick) Polyvinyl Chloride (PVC) pipe to construct EBTs (Fig. 2). We cut 30.5-cm lengths of PVC pipe and removed a 7.0 cm wide × 30.5 cm long section from each pipe. This allowed the EBT to lay flush against the tree and enabled flying squirrels to cling to the tree while entering and exiting the EBT. We drilled a 1 cm hole on each side of the EBT approximately 7.0 cm from the removed section and 15.0 cm from the end. We used these holes to secure the EBT vertically to a tree with re-bar wire. We used a sheet of flat stock PVC (0.3 cm thick) to construct a cap for the EBT. We cut a 61.0 cm wide × 122.0 cm long sheet of PVC flat stock (Grainger Industrial Supplies, Casper, WY) with a band saw to replicate the shape of the EBT. We glued the flat stock to a 10.2 cm diameter × 2.5 cm long piece of PVC pipe to make the cap. Both the bait cap and EBT were spray painted in a camouflaged color to blend in with trees and reduce visibility to humans. We used duct tape to secure the bait cap to the bottom of the EBT. The cost of materials for constructing 50 EBTs was approximately $3.75 per EBT. When assembled in bulk, construction time was approximately 20 min per EBT. Each EBT with cap weighed 451.0 g, approximately one half the weight of each camera. One person with an internal frame pack was capable of hiking with 8 EBTs and 8 cameras.

We completed surveys between 22 August and 15 October 2012 and 30 May and 17 August 2013. We used camera-trapping protocols established by Van Fleet and Grenier (2012) and Cudworth et al. (2013) to conduct surveys. We used GIS (ArcGIS 10.1, ESRI, Redlands, CA) to randomly select 4-ha survey plots from suitable habitat (i.e., spruce-fir and lodgepole-pine forests). If survey locations were not accessible in a pre-selected plot, we selected a suitable replacement site within the same drainage. Each plot contained 16 survey stations (i.e., 1 EBT and 1 camera) set in a 4 × 4 array with 50 m between stations and a 50 m buffer zone between the outer perimeter of the plot and survey stations. This distance accounted for home range overlap between flying squirrels and maximized detection opportunities (Hough and Dieter 2009).

At each survey station, we affixed a camera (PC800 Reconyx, Holmen, WI) to a tree with a bungee cord approximately 1.5 m above ground (Fig. 3). We attached each EBT to a tree ≤ 2 m from the camera and baited them to lure flying squirrels within camera range. Using a mixture of oatmeal, peanut butter, and bacon grease, we baited EBTs at each station in the late afternoon for five consecutive days. We programmed cameras to take pictures from 1800 to 0600 and 3 photos every 10 sec each time the camera was triggered. At each station we recorded the UTM location, species of tree, diameter at breast height (DBH), and approximate height of each bait tree. At the end of the fifth night, we retrieved the EBTs and cameras, downloaded pictures to a laptop, and erased each memory card. We identified flying squirrels from red squirrels (*Tamiasciurus hudsonicus*) and chipmunks (*Neotamias* spp.) in the photographs by the presence of a patagium, large eyes, and a square, flat tail. We recorded all locations for flying squirrels and non-target species that were detected.

In conjunction with the camera surveys, we randomly selected 3 survey stations within each 4-ha survey plot and collected data for several habitat variables. We used concentric circular plots at each random location with the bait tree as our center point. In each cardinal direction, we placed one transect, 7 m in length, and recorded ground cover, canopy cover, and coarse woody debris (CWD; Rosenberg and Anthony 1992). At the 7 m and 4 m points of each transect, we used 1 m^2 plots to record visual estimates of percent ground cover (Daubenmire 1959). Additionally, we used a convex densiometer (Forestry Suppliers Spherical Crown Densiometer, Forestry Suppliers Inc., Jackson, MS) to record percent canopy cover at 7 m from the bait tree. When a transect intersected CWD or stumps, we recorded diameter (≥20 cm), decay class, and species of tree when possible (Ganey and Vojta 2010). We used a wedge prism (BAF 10; Jim Gem® Prisms, Forestry Suppliers Inc., Jackson, MS) to determine the basal area factor (BAF) of trees within 360° of the bait tree. Additionally, all dead standing trees were assigned to a snag class (Ganey and Vojka 2007). We also measured slope, aspect, and elevation at each bait tree. We summarized all data we collected for each plot. We averaged the results to provide an estimate for each plot. We only report results for live tree DBH, basal area, snags, and ground cover as other results were not informative.

To evaluate occupancy, we combined data from each of the 16 camera stations to develop an encounter history for each plot and used program PRESENCE (Hines 2010) to develop models. Models included the probability of occupancy (Ψ) and five detection probabilities (p) for the five camera nights. We averaged data for habitat from each of the stations to provide covariates for each habitat variable per survey plot. Occupancy covariates included slope, total DBH, snag DBH, canopy cover, and number of CWD per habitat station; we standardized covariates before inclusion in the model (Franklin 2001). Because we combined data from 2012 and 2013, we also included a year covariate to account for potential differences in occupancy. Detection probability covariates included time, to allow for systematic changes in detection at each plot throughout the survey, as well as season (i.e., spring: May-June, summer: July-August, and fall: September-October). We developed additive models including all possible combinations of covariates, with the exception of models including both DBH covariates, for a total of 192 models. We used AIC for model selection (Burnham and Anderson 1998). Once top models were selected, we performed a MacKenzie-Bailey goodness of fit test with 1000 bootstraps (MacKenzie and Bailey 2004) to test for overdispersion. We used G*Power Version 3.1.7 (Faul et al. 2007) to conduct a power analysis to test our ability to detect a change in the probability of occupancy of 0.10, 0.15, and 0.20; we calculated effect size from the standard deviation calculated from this survey and assumed correlation between surveys would be relatively high (i.e., $r = 0.7$). We used the matched pairs t-test option with $\alpha = 0.05$ and sample size of 48. We report detection probabilities and average occupancy (± *SE*) from model results.

RESULTS

We surveyed 48 plots (18 in 2012, 30 in 2013) for a total of 3,840 camera nights (Fig. 1). We recorded 239 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 33 plots. Detections of flying squirrels were greater in the northern portion of the Wyoming Range (Fig. 1). Plots occupied by flying squirrels had a predominantly south or southwest mean aspect of 192°, while unoccupied plots had a mean eastern aspect of 98°. All observations of flying squirrels and non-target species were entered into the Department’s Wildlife Observation System (WOS).

Our EBTs and cameras were easily deployed and each plot required about 4 person•hrs to set up and ≤2 person•hrs to remove. Re-baiting of 16 stations required approximately 0.75 person•hrs per plot. We did not observe any mortality during our survey. None of our EBTs were damaged or destroyed during the survey. Remarkably, black bears visited three grids on several occasions, and, although they successfully loosened the bait cap or pulled the EBT to the ground at several stations, the EBTs remained intact.

We sampled 1,595 live trees and 312 snags at 151 stations within 48 plots. Plots occupied by flying squirrels were characterized by live trees with larger DBH and lower basal area when compared to unoccupied sites (Table 1). Although we analyzed and compared DBH for five dominate tree species, results were only significant when we pooled our data for DBH of all live trees ($Z = 3.59$; $P < 0.001$). The mean DBH of snags in class 1 (i.e., dead trees that retained needles, twigs, and intact limbs) was also greater ($Z = 1.85$; $P = 0.032$) in occupied plots when compared to unoccupied sites (Table 2). We found no difference between occupied and unoccupied plots for other snag classes. Ground cover varied among sites, although grasses were found most frequently in occupied plots ($\bar{X} = 16.10 \pm 3.85\%$) and less frequently in unoccupied plots ($\bar{X} = 7.22 \pm 3.19\%$; $Z = 2.58$; $P = 0.005$). Conversely, we detected a greater amount of forbs in unoccupied sites ($\bar{X} = 18.06 \pm 3.25\%$) than in occupied sites ($\bar{X} = 12.45 \pm 2.85\%$; $Z = -1.83$, $P = 0.034$). Other ground cover (e.g., litter, bare soil, and shrubs) and habitat (e.g., CWD, slope, canopy cover, etc.) components failed to predict occupancy of flying squirrels, likely due to high variance.

We identified 5 models with ΔAIC < 2.0. In the top model, probability of occupancy was influenced by average tree DBH, and detection probability was influenced by time and season (AIC = 269.21, $\chi^2 = 25.92$, $P = 0.44$). The additional models were similar to the top model, but probability of occupancy included both tree DBH and one additional covariate in each model: canopy cover, year, CWD, and slope. However, these additional covariates were only marginally to non-significant based upon β-values that overlapped zero, and, instead of adding to the explanatory value of the top model, detract from the importance of tree DBH to explaining occupancy of flying squirrels. Therefore, we only considered the top model in all further analyses.

Detection probabilities were positively correlated with both time and season (Fig. 4). Probability of occupancy was positively correlated with average DBH of trees in the plot (Fig. 5) and ranged from 0.22 (±0.21) on a plot with an average DBH of 18.2 cm to 0.99 (±0.01) on a plot with an average DBH of 40.0 cm. Across all grids, probability of occupancy averaged 0.80 (±0.09), suggesting that 38.4 (±4.3) plots were occupied, as opposed to the 33 plots on which we detected flying squirrels. With 48 survey plots, the power to detect a change in the probability of occupancy of 0.10 (i.e., a reduction from 0.80 to 0.70) was only 40.2%. However, the power to detect a change of 0.15 was 68.7%, and the power to detect a change of 0.20 was 88.5%.

DISCUSSION

Our survey stations were easily assembled, deployed, maintained, and removed by one person. The EBTs prevented diurnal non-target species (e.g., birds) from consuming the bait, and shielded the bait from environmental elements (e.g., rain and direct sunlight), thus increasing opportunities for flying squirrels to be attracted to the survey stations. Notably, flying squirrels detected during our surveys had no aversion to entering the EBTs on multiple occasions. We also observed several squirrels perching on top of the EBT while consuming the bait, thus increasing our opportunity for proper identification. Our survey method proved highly successful at detecting flying squirrels. We recommend that this non-invasive, non-lethal, and cost-effective method be implemented for future surveys of flying squirrels in Wyoming.

Interestingly we observed lower detection rates for flying squirrels during late-spring and early-summer compared to late-summer and early-fall surveys. For example, in the southern Wyoming Range we detected flying squirrels at 4 of 6 plots during late-August and early September of 2012, while we only detected flying squirrels at 4 of 12 plots during late-spring and early summer of 2013 (Fig. 1). Krueger (2004) and Vernes (2004) reported low capture success in May and June with greater success occurring in summer and fall months. Additionally, Wells-Gosling (1985) reported that females with young will forage less often and typically only leave the nest for short intervals during this season. Conversely, our detection rates increased in late-summer and early fall, which are reported to coincide with peaks in juvenile dispersal (Kurta 1995). This may explain the differences in our ability to detect flying squirrels between seasons. Therefore, we recommend that future monitoring should be conducted in the late summer and fall seasons to optimize detections of flying squirrels.

Our results of characteristics of stands that were occupied by flying squirrels were comparable to those of Waters and Zabel (1995), who compared old-growth (i.e., 200-400 years old) and mature stands (i.e., even-aged after logging; 80-100 years old). We often found flying squirrels associated with stands that had a lower basal area of live trees, lower percent canopy cover, and larger DBH of live trees and snags. These results suggest that flying squirrels were selecting mature stands that were dominated by larger trees and snags, which often provide suitable cavities, greater thermal insulation, reduced predation risk, and greater biomass of lichen (Meyer et al. 2005, Smith 2007). In addition, these mature stands are often characterized by a lack of mid-story structure (e.g., saplings and interlocking branches). The lack of structure is reported to facilitate movement of flying squirrels by allowing them to launch from the upper canopy and glide to a nearby tree (Hackett and Pagels 2003). Flying squirrels often descend to the ground from trees they have glided to in order to forage.

We failed to detect a significant difference in most ground cover components between sites that were occupied by flying squirrels and those that were not. Interestingly, in our study plots that were occupied by flying squirrels contained significantly more grasses and fewer forbs. Why we detected this difference is unclear. Grasses and other materials (e.g., dried bark, sticks, mosses, and lichen) have frequently been reported to be used by flying squirrels to build external nests in live trees (Hayward and Rosentreter 1994). This suggests that grasses in Wyoming may be important for thermoregulation in the nest. Conversely, we detected significantly fewer forbs on occupied sites. Our results for forbs are potentially contradicted by the literature. Several investigators suggest that flying squirrels utilize ground cover with a higher density of forbs to avoid predators or to feed on other food items (e.g., insects, buds, and seeds–Pyare and Longland 2002, Smith 2007). However, others reported that understory cover was not an important factor in predicting flying squirrel occupancy and density (Payne et al. 1989, Waters and Zabel 1995).

During our study, grasses were often found in mature stands that contained some open canopy. While opinions differ on the composition of understory needed for flying squirrels, the diversity and abundance of mycorrhizal fungi and lichen may be a limiting factor and may explain the lack of agreement on ground cover. Perhaps instead of selecting areas based on specific ground cover components, flying squirrels are selecting for cool micro-habitats within the forest floor that promote organic soils, important for fungal growth (Gomez et al. 2005, Meyer et al. 2005, Weigl 2007).

During our assessment of habitat, we collected a great deal of data; however, our methods overemphasized forest structure and overlooked other components that may have been important to flying squirrels. For example, we classified CWD into three stages of above-ground decay following recommendations of Ganey and Vojta (2010) to characterize structure of the stand. However we failed to detect a difference in occupancy rates of flying squirrels. Conversely, due to time constraints and limited personnel, we were unable to quantify availability of mycorrhizal fungi or lichen, important food items, within each plot. Gomez et al. (2005) found a direct correlation between flying squirrel density and abundance of mycorrhizal fungi. The authors concluded that flying squirrels were responding to a food item rather than forest structure. Similarly, lichen has been reported to be not only an important winter food item but may also be used as cavity nest material (Maser et al. 1985, Maser et al. 1986, Hayward and Rosentreter 1994). We recommend that future surveys consider characterizing availability of mycorrhizal fungi or lichen as well as other non-structural components that could affect occupancy of flying squirrels.

Prior to 2012, very few records of flying squirrel existed in the WOS. During this project, we were able to contribute 180 additional records to the WOS for flying squirrel within the Wyoming Range. Although the flying squirrel appears to be more common than previously believed (WGFD 2010), it is still vulnerable to population declines due to fire, logging, and pine beetle kill that removes mature trees. Our results suggest that the persistence of flying squirrels may be more complex than previously believed. For example, improved understanding of relationships among habitat use, micro-habitat structure, and preferred foods could improve guidance for forest management. We recommend that future survey efforts focus on incorporating additional habitat components in the data collection and eliminating those that were found to not be significant during our analyses.

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Table 1. Species of live trees measured for all a) occupied plots and b) unoccupied plots from August-October 2012 (n = 18) and May-September 2013 (n = 30) in western Wyoming. We present mean number of live trees, diameter at breast height (DBH; cm), basal area factor (BAF), and standard error (SE) per species for plots surveyed for northern flying squirrels (*Glaucomys sabrinus*). Mean DBH of all live trees were significantly different for occupied sites and those where we failed to detect flying squirrels ($P < 0.001$).

a)

Tree species	n	DBH (cm)	SE	BAF	SE
Subalpine fir (*Abies lasiocarpa*)	13.58	24.81	3.63	121.52	11.11
Lodgepole pine (*Pinus contora*)	9.88	21.63	3.81	82.73	8.96
Englemanmn's Spruce (*Pinus engelmanii*)	1.79	6.80	4.16	13.64	6.40
Aspen (*Populus tremuloides*)	0.70	4.18	3.28	6.67	4.65
Douglas fir (*Psuedotsuga menziesii*)	3.09	20.16	4.87	28.18	6.27
All live trees	30.67	30.53	2.36	265.61	9.26

b)

Tree species	n	DBH (cm)	SE	BAF	SE
Subalpine fir (*Abies lasiocarpa*)	14.67	21.10	3.48	119.00	11.13
Lodgepole pine (*Pinus contora*)	1.64	19.42	3.34	146.33	13.44
Englemanmn's Spruce (*Pinus engelmanii*)	1.40	12.67	4.44	12.67	4.60
Aspen (*Populus tremuloides*)	2.07	1.02	1.99	19.33	8.65
Douglas fir (*Psuedotsuga menziesii*)	1.53	7.04	3.86	14.33	5.67
All live trees	38.87	25.14	2.11	347.67	11.73

Table 2. Snags classified for all a) occupied plots and b) unoccupied plots surveyed in the Wyoming Range, August-October 2012 (n = 18) and May-September 2013 (n = 30). We present mean number of snags by class, diameter at breast height (DBH; cm), basal area factor (BAF), and standard error (SE) per snag class where we surveyed for northern flying squirrels (*Glaucomys sabrinus*). Mean DBH of snags in class 1 were significantly different for occupied sites than those where we failed to detect flying squirrels (P = 0.032).

a)

Snag Class	n	DBH (cm)	SE	BAF	SE
Class 1	1.97	17.48	3.81	16.21	4.30
Class 2	2.39	22.91	4.01	23.79	5.46
Class ≥3	1.00	11.84	3.87	6.67	3.48

b)

Snag class	n	DBH (cm)	SE	BAF	SE
Class 1	2.00	9.73	3.59	18.00	5.58
Class 2	5.27	26.65	3.52	48.00	6.78
Class ≥3	2.33	19.89	4.00	20.33	5.79

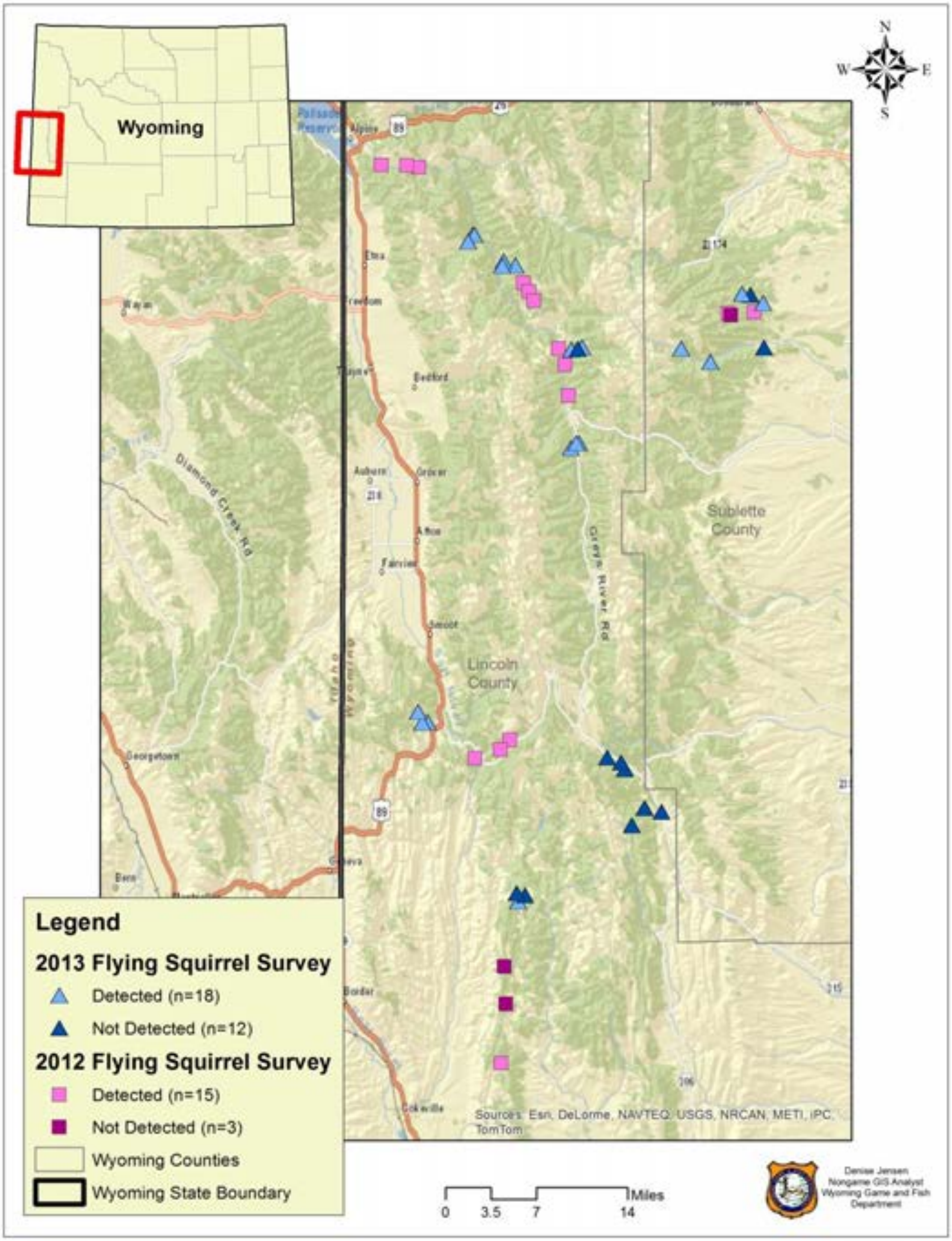

Figure 1. Study area, locations of survey plots, and detections of northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from 22 August-15 October 2012 (*n* = 18) and 30 May-17 August 2013 (*n* = 30) in the Wyoming Range, Bridger-Teton National Forest.

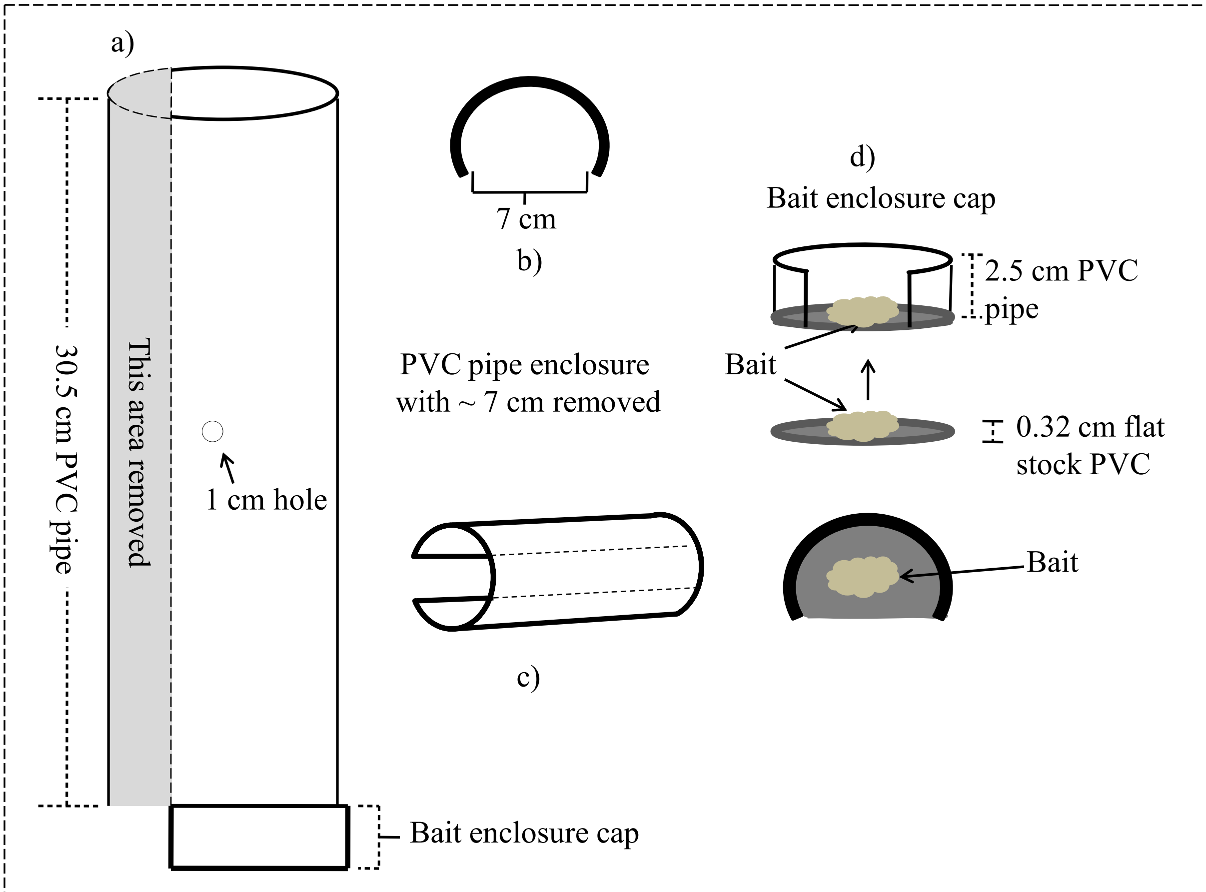

Figure 2. Schematic of enclosed bait tube construction, including pipe enclosure (a, b, and c) and bait enclosure cap (d) for detecting northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from August-October 2012 and May-September 2013 in the Wyoming Range, Bridger-Teton National Forest.

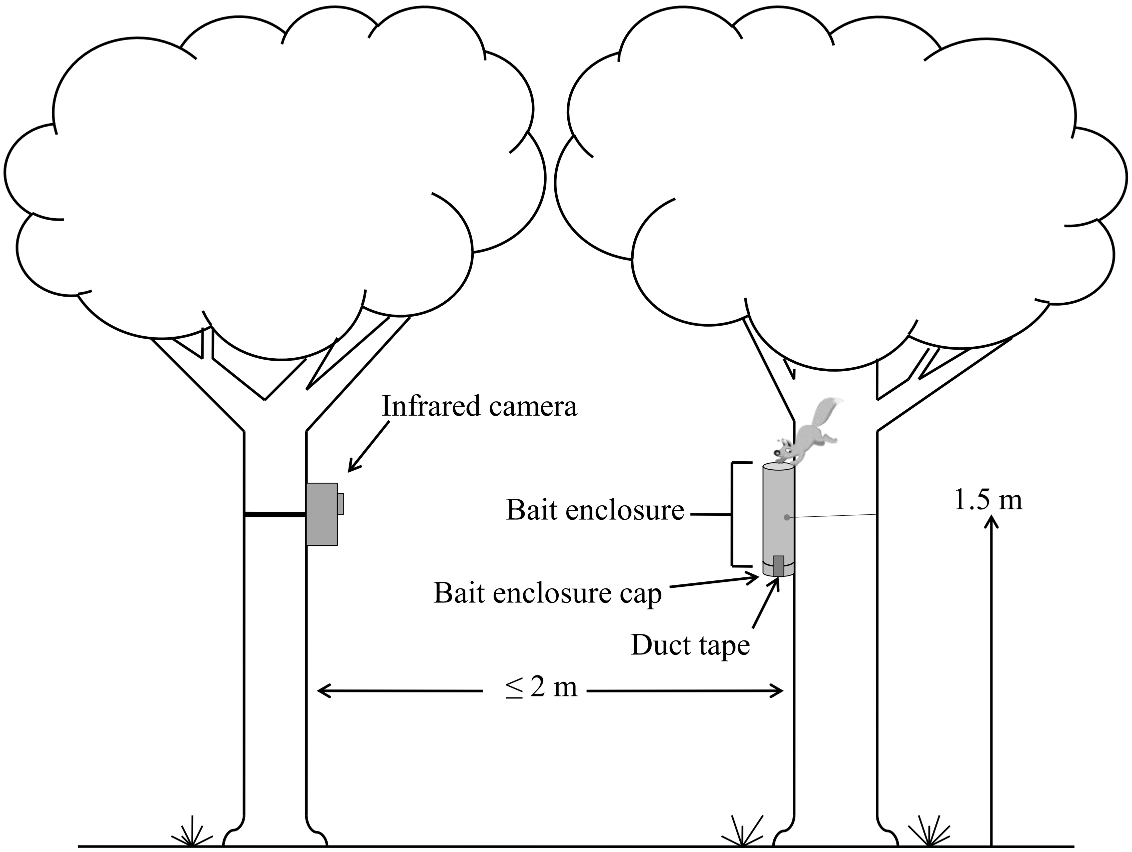

Figure 3. Schematic of infrared camera and bait enclosure tube for detecting northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from August-October 2012 and May-September 2013 in the Wyoming Range, Bridger-Teton National Forest.

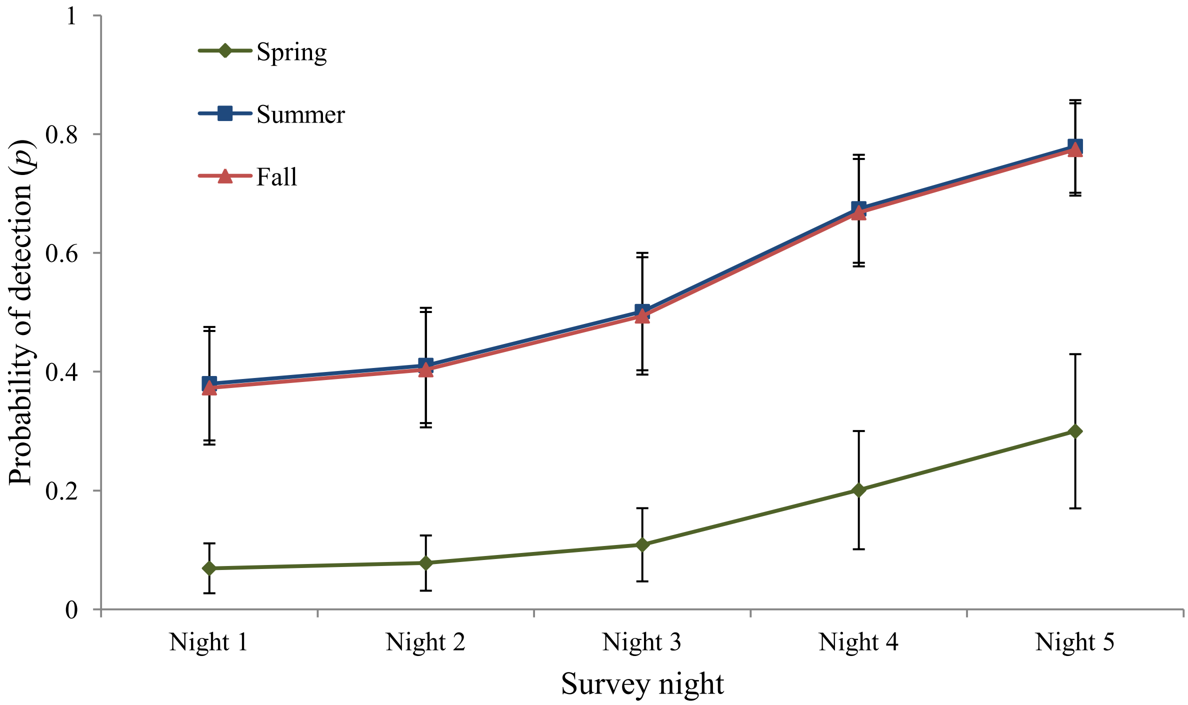

Figure 4. Average probability of detection (p ± SE) of northern flying squirrels (*Glaucomys sabrinus*) for all plots from August-October 2012 (n = 18) and May-August 2013 (n = 30) in western Wyoming. Seasons are as follows: spring, May-June; summer, July-August; and fall, September-October.

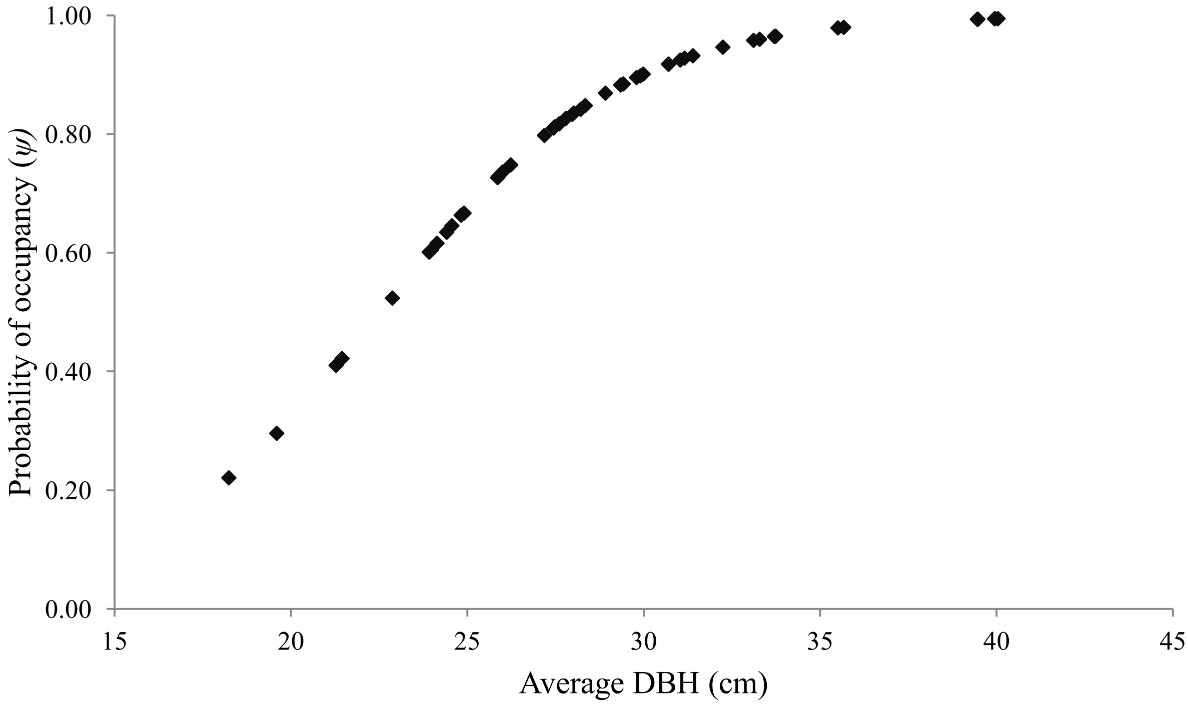

Figure 5. Probability of occupancy (*ψ*) of northern flying squirrels (*Glaucomys sabrinus*) for all plots as a function of mean diameter at breast height (DBH; cm) of all trees observed per plot from August-October 2012 (*n* = 18) and May-August 2013 (*n* = 30) in western Wyoming.

TRENDS IN OCCUPANCY OF SWIFT FOX (*VULPES VELOX*) IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Swift Fox

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Laurie Van Fleet, Nongame Biologist
Nichole Cudworth, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

The swift fox (*Vulpes velox*) is a small canid whose abundance and distribution declined greatly in the late 19th and 20th centuries due to loss of native prairie habitat and widespread predator control. The Wyoming Game and Fish Department classifies the swift fox as a Species of Greatest Conservation Need with Native Species Status of 4. From September through November 2013, we used remote cameras and scent stations to survey 48 grids previously surveyed in 2010 as part of a long-term monitoring program. Additionally, we evaluated the influence of predators and energy development on local extinction rates of grids to investigate the dynamic processes that may underlie changes in occupancy. The probability of occupancy decreased from 0.43 in 2010 to 0.39 in 2013. Although the number of grids with coyotes (*Canis latrans*) increased between surveys, the relationship between predators and probability of extinction was not clear. Probability of extinction was 0.31 when models were averaged and was positively related to the number of years with observed energy development. Given the increase in probability of local extinction of grids with length of time exposed to energy development, it is important to continue to evaluate this and other potential variables to elucidate causes of changes in occupancy for swift fox Wyoming.

INTRODUCTION

The swift fox (*Vulpes velox*) is the smallest of the North American foxes and historically occupied the short- and mixed-grass prairie from northern Texas to southern Canada (Scott-Brown et al. 1987). Historically, swift fox covered 12 states, including areas east of the Continental Divide in Wyoming, but densities and distribution declined greatly in the late 19th and 20th centuries due to loss of native prairie habitat and predator control (Scott-Brown et al. 1987). The swift fox was petitioned for listing as Endangered under the Endangered Species Act (ESA) in 1992, and the U.S. Fish and Wildlife Service issued a "warranted but precluded" finding in 1995. Due in large part to efforts from the Swift Fox Conservation Team and the collection of new data, the swift fox was removed from the ESA Candidate List in 2002. However, the swift fox remains classified as a Species of Greatest Conservation Need with a Native Species Status of 4 (NSS4) by the Wyoming Game and Fish Department (Department; WGFD 2010). Although the distribution of swift fox is secure and the species is widely distributed, data on status and trends of populations for the majority of the state are lacking (WGFD 2010).

In 2010, we developed a baseline occupancy model with which to monitor trends for swift fox in eastern Wyoming as part of a long-term monitoring program (Cudworth et al. 2011). In addition to reevaluating occupancy of swift fox in Wyoming, we were also interested in variables that could influence changes in occupancy rates. Coyotes (*Canis latrans*) are known predators of swift fox and can be a major cause of mortality (Sovada et al. 1998, Kitchen et al. 1999, Olson and Lindzey 2002). In addition, swift fox remain susceptible to habitat loss and degradation from factors such as energy development; although the impacts of these threats are still unknown (WGFD 2010). Therefore, our objectives in 2013 were two-fold. First, we revisited 48 survey grids within the predicted distribution of swift fox to compare occupancy results to 2010. Secondly, we evaluated the influence of predators and energy development on local extinction rates of grids to investigate the dynamic processes that may underlie changes in occupancy.

METHODS

Following protocols outlined in Cudworth et al. (2011), we surveyed 48 grids previously selected in 2010, all of which fell within the predicted distribution for swift fox in eastern Wyoming (WGFD 2010). We randomly selected a replacement grid to survey if landowners could not be reached or declined to participate for a second time ($n = 6$ grids). We contacted landowners twice, once to obtain initial permission to access or set up cameras on their property and again a week prior to conducting the survey. All surveys were completed between 9 September and 13 November 2013 to coincide with juvenile dispersal in an attempt to maximize detection probabilities (Finley et al. 2005).

We combined data from each of the five cameras to develop an encounter history for each grid and used program PRESENCE (Hines 2010) to develop occupancy models. We were specifically interested in the impact of habitat disturbance, namely energy development, and coyotes on occupancy and extinction rates. However, previous analyses suggested the percentage of the grid composed of grassland and suitable slope were also important (Cudworth et al. 2011); therefore, these covariates were included where appropriate. Models included the probability of occupancy (Ψ) for each survey, probability of extinction (ε), and 10 detection probabilities (p) for each the five trapping nights per year. Additional occupancy covariates included the percentage of the grid composed of suitable slope (< 10%), number of years with observed energy development, and number of years with detected coyotes. Extinction probability covariates also included number of years with energy development and number of years with coyotes, and detection probability covariates included number of years with coyotes and percentage of grid composed of grassland and was allowed to vary between years. We standardized covariates before inclusion in the model (Franklin 2001) and developed 64 additive models. We used AIC for model selection (Burnham and Anderson 1998) and model averaging for all models with ΔAIC < 2.0. We report detection probabilities and average occupancy and extinction rates (± SE) from model averaged results.

RESULTS

We surveyed 48 grids, 42 of which were previously surveyed in 2010, for a total of 1,195 camera nights. We recorded 73 unique detections (i.e., photographs of swift fox > 1 hr apart) on 15 grids (Fig. 1). Mesocarnivore communities were similar between surveys, with the exception of coyotes, for which detections increased substantially in 2013 (Table 1). Because we had 12 grids that were surveyed only 1 year (6 each in 2010 and 2013), we only used grids that were surveyed both years for occupancy analyses (n = 42). We identified four top models with ΔAIC < 2.0 (Table 2).

In the top model, ψ was influenced by slope ($\beta = 0.65 \pm 0.34$), ε was influenced by energy development ($\beta = 0.65 \pm 0.48$), and p was influenced by the amount of grassland ($\beta = 0.39 \pm 0.20$). As in previous analyses, ψ was positively correlated with the percentage of the grid composed of suitable slope. When we averaged models, ψ differed between years ($t_{82} = 1.50$, $P < 0.001$), decreasing from 0.43 (± 0.02) in 2010 to 0.39 (± 0.02) in 2013. Our ε was 0.31 (± 0.01) for models we averaged and was positively related to the number of years with observed energy development and slightly negatively related to the presence of coyotes (Fig. 2). As in 2010, p was positively correlated with the percentage of the grid composed of grassland and differed between years ($t_{82} = 1.31$, $P < 0.001$). When models were averaged, detection probability decreased from an average of 0.47 (± 0.01) in 2010 to an average of 0.44 (± 0.01) in 2013.

DISCUSSION

As in previous studies, percentage of the grid composed of suitable slope influenced ψ and percentage of the grid composed of grassland was important to p (Cudworth et al. 2011). However, we did see a slight decrease in both ψ and p from 2010 to 2013. With only two years of data, it is difficult to discern if this decrease is a result of normal fluctuations or is indicative of a decline in swift fox. Therefore, it is critical to continue to evaluate long-term trends of swift fox in Wyoming. Because of conservation concerns surrounding swift fox, it is especially important to investigate the dynamic processes underlying changes in ψ.

Both predation and habitat loss have been identified as important factors contributing to mortality and declines of swift fox (Scott-Brown et al. 1987, Sovada et al. 1998). Contrary to our expectations, we actually found support for decreased ε with increasing number of surveys where we detected coyotes. However, this relationship was not straightforward and did not consistently appear within models. Because coyotes are known predators of swift fox and can be major causes of mortality (Sovada et al. 1998, Kitchen et al. 1999, Olson and Lindzey 2002), it is unlikely that the presence of coyotes results in more favorable habitat for swift fox. Instead, coyotes and swift fox may both be responding to a common habitat variable or environmental condition we did not measure in this study. Interestingly, mesocarnivore detections increased overall between surveys. This suite of species includes not only predators of swift fox, such as coyotes, but also niche competitors, such as red fox (*V. velox*) and striped skunks (*Mephitis mephitis*—Clark and Stromberg 1987). Further work is needed to evaluate the impact of these species on ψ and ε of swift fox, particularly in response to changing habitat conditions.

The demand for energy has been and is predicted to continue increasing, and Wyoming is likely to maintain its role as a major player in the energy industry (Copeland et al. 2010). As expected, ε was positively correlated with the number of surveys where we observed energy development. The impact of energy development on wildlife is complex, and populations may be negatively impacted in many ways, such as through decreased food availability, loss of habitat, anthropogenic disturbance, or direct mortality due to collisions with vehicles (Carbyn et al. 1994, Cypher et al. 2003, Sawyer et al. 2006). For this project, we classified grids as containing or not containing energy development and made no attempt to quantify the level of development or disturbance. For example, some grids contained obviously older infrastructure where we did not detect any current activity, while other grids contained new activities such as construction of wells or roads. We expect these levels of impacts and activity to affect swift fox differently (Sawyer et al. 2009, Gilbert and Chalfoun 2011). Additionally, we only evaluated disturbances caused by energy development and did not investigate the effects of other types of development, such as housing, roads, or agriculture, or changes in land cover. Given the increase in ε with length of time exposed to energy development, it is important to continue to evaluate this and other potential variables to elucidate causes of changes in ψ for swift fox in Wyoming.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming Governor's Endangered Species Account Funds and the Wyoming State Legislature General Fund Appropriations, for which the Department is extremely grateful. We also extend a special thanks to Department biologist D. Thiele for his assistance in our efforts to contact private landowners. We are especially thankful to the many private landowners who graciously provided access to their lands to assist this project. Department Nongame GIS analyst D. Jensen provided invaluable assistance selecting survey grids and developing maps for the survey.

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Table 1. Number of grids and type of mesocarnivores detected during swift fox (*Vulpes velox*) surveys throughout eastern Wyoming in fall 2010 and 2013. Only grids that were surveyed in both years (n = 42) are included.

Mesocarnivore species	No. of grids with detections	
	2010	2013
Canis latrans	4	19
Vulpes vulpes	2	2
Procyon lotor	5	1
Taxidea taxus	9	10
Mephitis mephitis	11	17
Felis rufus	1	2
No. of grids with ≥1 detection	24	30

Table 2. Models and AIC scores and weights for models with ΔAIC < 2 developed to evaluate changes in occupancy of swift fox (*Vulpes velox*) throughout eastern Wyoming in fall 2010 and 2013. "Slope" indicates the percentage of the grid composed of suitable slope (<10%), "grass" indicates the percentage of the grid composed of grassland, "energy" indicates the number of years with energy development, and "coyote" indicates the number of years with coyote (*Canis latrans*) detections.

Model	AIC	AIC weight
ψ(slope),ε(energy),p(grass)	323.48	0.336
ψ(slope),ε(.),p(grass)	323.53	0.328
ψ(slope),ε(.),p(grass+year)	324.63	0.189
ψ(slope),ε(energy+coyote),p(grass+year)	325.13	0.147

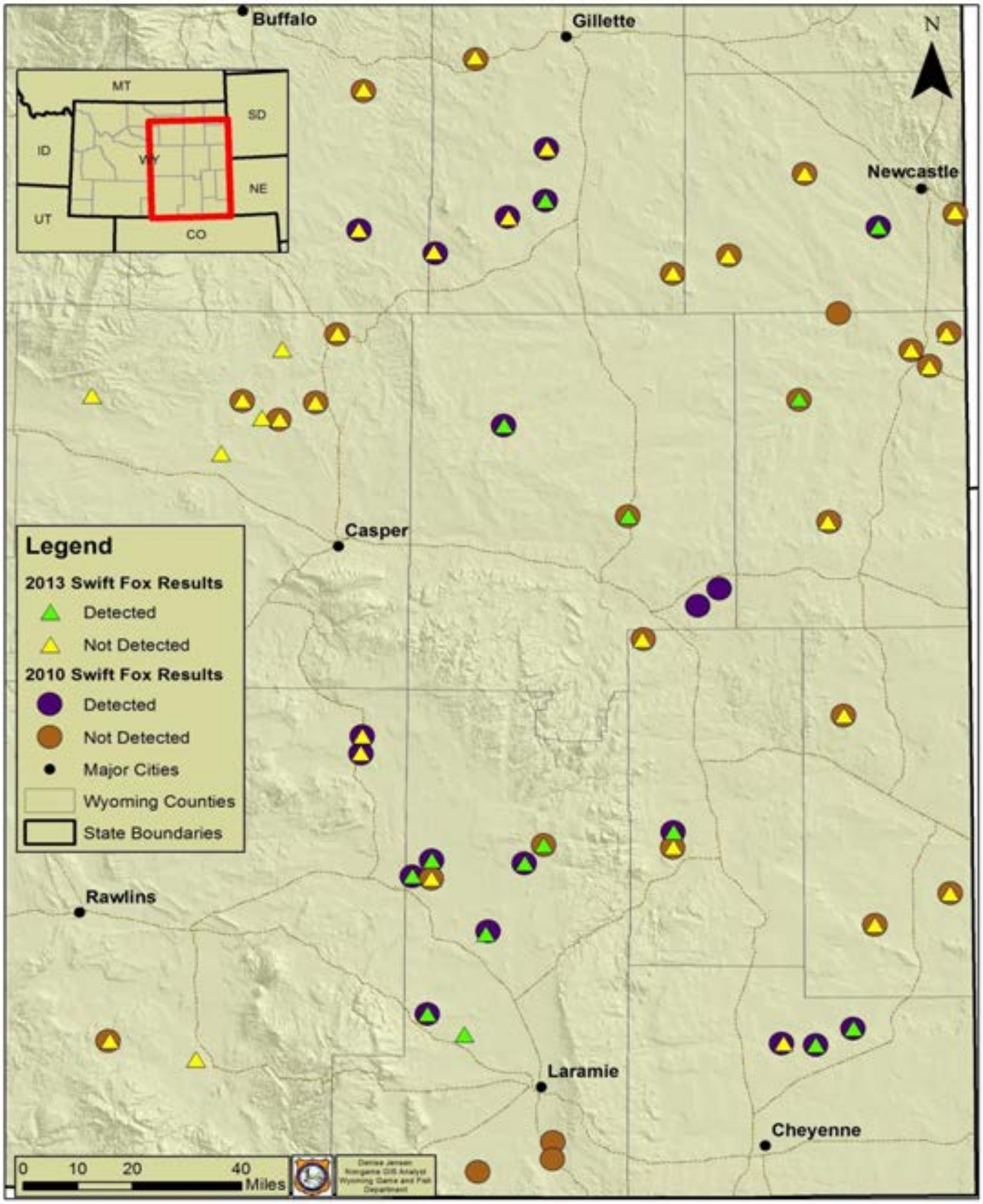

Figure 1. Locations of grids surveyed for swift fox (*Vulpes velox*) in eastern Wyoming, fall 2010 and 2013. Grids where swift fox were detected in 2013 are designated by green triangles and those with no detections are represented by yellow triangles. Grids where we detected swift fox in 2010 are shown in dark blue and while light brown circles represent locations where we had no detections.

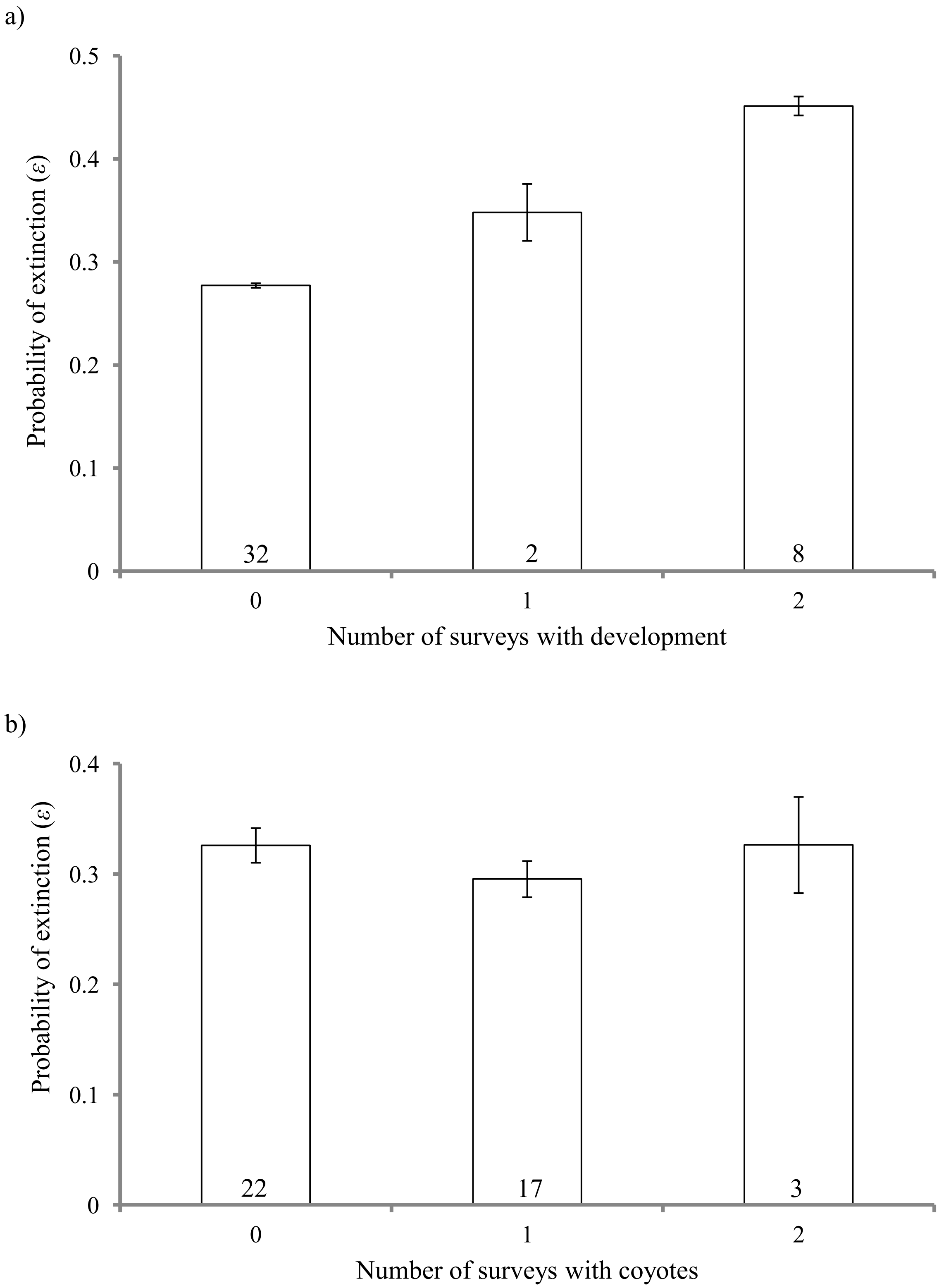

Figure 2. Average probability of extinction (ε; ± *SE*) of swift fox (*Vulpes velox*) for grids that contained a) energy development and b) coyotes (*Canis latrans*) in 0, 1, or 2 surveys in fall 2010 and 2013 in eastern Wyoming. Sample size is shown at the base of each bar.

EVALUATING THE STATUS OF FISHER (*MARTES PENNANTI*) IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Fisher

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grants
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Jesse Boulerice, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

SUMMARY

The fisher (*Martes pennanti*) is a medium-sized mustelid that historically occurred in the northern forests of the Rocky, Appalachian, and Pacific Coast mountain ranges (Powell 1981). Today, the distribution of the fisher is a patchwork of the former range as overharvest and habitat loss have led to population declines across North America (Gibilisco 1994). Considered a candidate species for listing by the US Fish and Wildlife Service under the Endangered Species Act, listing of the West Coast Distinct Population Segment (DPS) as been found to be warranted but precluded, while a recent petition to list the DPS within the Rocky Mountains is currently under reviewed as of January 2014 (USFWS 2004). In Wyoming, the fisher is thought to be rare within a distribution predicted to extend only into the forested regions of the northwestern portion of the state (WGFD 2010). With only a handful of verified fisher sightings reported in Wyoming (WGFD 2010), the species is currently considered to be a Species of Greatest Conservation Need (SGCN) with a Native Species Status Unknown (NSSU, Tier III; WGFD 2010). However, no formal effort has been made to quantify populations of this forest carnivore within Wyoming in several decades. This paucity of information has impeded the ability of the Wyoming Game and Fish Department (Department) to update conservation status and determine current needs of the species within the state (WGFD 2010). In addition, given the ongoing concerns over the status of the Rocky Mountain DPS, an updated assessment on populations of fisher within Wyoming could hold important implications for listing.

In December 2012, the Department began a two-year project to evaluate the status of fisher within northwestern Wyoming. We established a survey grid across the predicted range of fisher in the state, excluding National Parks. Each cell within the grid was 41.4 km^2, approximately the expected home-range size of a female fisher for the Rocky Mountains (Heinemeyer 1993). Given the species' well-documented selection towards dense contiguous

forest, we then selected cells that contained ≥20.7 total km^2 of >40% canopy cover for survey (Ruggiero et al. 1994). We placed one baited camera station in each 10.4 km^2 quadrant of cells we surveyed. We programmed cameras to record a series of 3 photos each time it was triggered for a period of ≥550 consecutive hrs (23 days). After retrieving cameras, we reviewed photos to generate capture histories for all species detected during surveys.

From January through March 2013, 8 cells were surveyed (32 camera stations total) in the Beartooth Pass and Sunlight Basin regions of Wyoming (Fig. 1). We did not detect any fishers during these surveys. However, out of 11,023 photos of wildlife, we detected two SGCN (WGFD 2010): American marten (*Martes americana*; NSS4, Tier II) at eight cells (100%), and moose (*Alces alces*; NSS4, Tier II) at four cells (50%). A detailed list of all detected species is provided in Table 1. We provide locations of observed martens in Fig. 1. Although no fishers were detected, unanticipated logistical difficulties reduced the number of cells we were able to survey, and only a small portion of the predicted range was sampled during the 2012-2013 season.

At the completion of the 2013-2014 season of this project, we expect to have surveyed a significant portion of the predicted range of fisher in Wyoming. At that time, we will conduct a full report containing an assessment of the status of fisher and an evaluation of the current classification for the species in Wyoming. Additionally, we plan to measure and report on selection of habitat by species for which we observed sufficient rates of detection.

ACKNOWLEDGEMENTS

Funding for this project was provided by US Fish and Wildlife Service State Wildlife Grants and the Wyoming State Legislature General Fund Appropriations, for which the Department is very grateful. Nongame GIS Analyst B. Webber created survey maps, and Nongame Biologist B. Abel and Nongame Technician L. Tafelmeyer provided invaluable assistance in the field.

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Table 1. Summary of detections recorded from camera surveys in northwestern Wyoming from December 2012-March 2013. Each cell consisted of four camera sites. Sites contained one camera and were positioned in each quadrant of a cell. We calculated a naïve occupancy rate of a cell for each species we detected.

	Scientific name	Common name	Cells (n = 8)	Sites (n = 32)	Photos (n = 11,023)	Naïve occupancy
Mammals	*Martes pennanti*	Fisher	0	0	0	0
	Martes americana	American marten	8	17	4,064	1
	Vulpes vulpes	Red fox	6	13	2,505	0.75
	Canis latrans	Coyote	2	7	247	0.25
	Lynx rufus	Bobcat	2	2	10	0.25
	Puma concolor	Mountain lion	2	2	10	0.25
	Cervus canadensis	Elk	1	1	1,058	0.125
	Alces alces	Moose	4	5	184	0.5
	Odocoileus spp.	Deer	5	5	469	0.625
	Lepus americanus	Showshoe hare	6	7	199	0.75
	Tamiasciurus hudsonicus	Red squirrel	5	8	55	0.625
Birds	*Nucifraga columbiana*	Clark's Nutcracker	6	9	79	0.75
	Perisoreus canadensis	Gray Jay	3	4	1,990	0.375
	Pica hudsonia	Black-billed Magpie	2	2	16	0.25
	Cyanocitta stelleri	Stellar's Jay	5	5	137	0.625

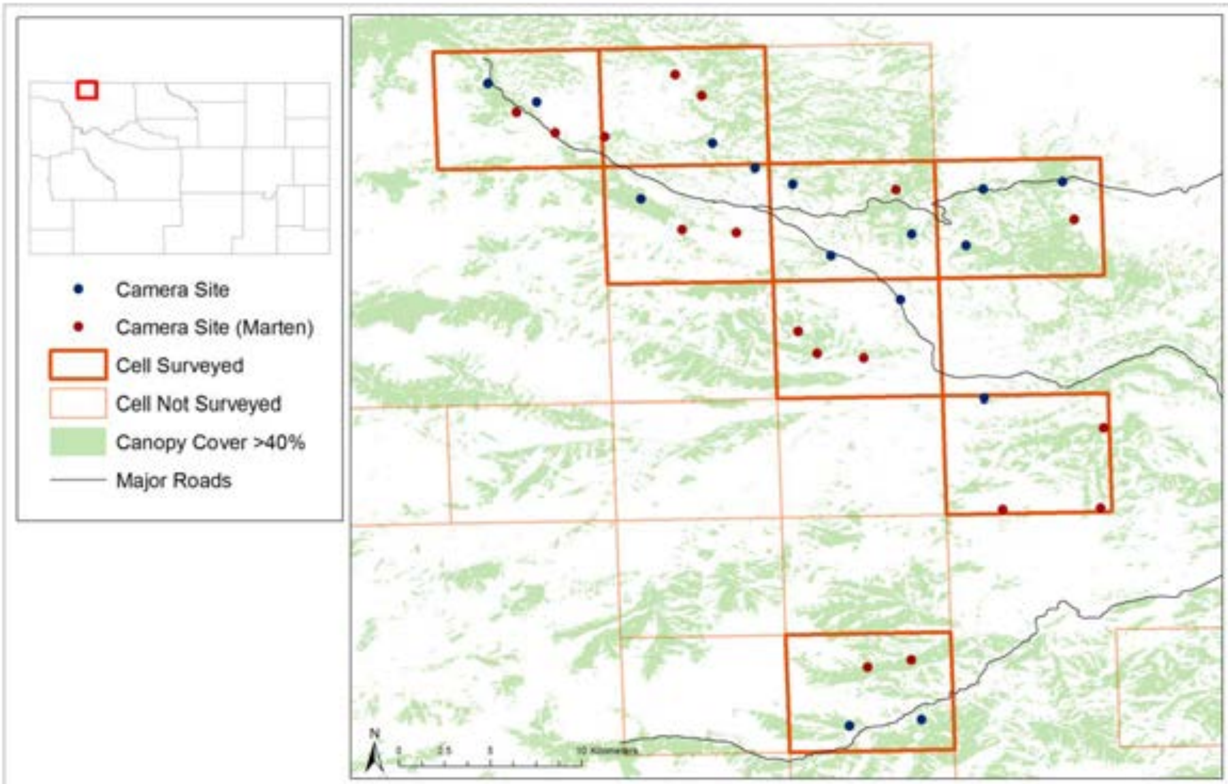

Figure 1. Location of camera sites as part of surveys for fisher (*Martes pennanti*) in northwestern Wyoming. Eight cells were surveyed in 2013, consisting of 32 baited camera stations. No fishers were detected. American marten (*Martes americana)*, a Species of Greatest Conservation Need, was detected at 17 sites. Locations of observed martens are designated by red dots.

HARVEST REPORTS

HARVEST OF RAPTORS FOR FALCONRY

STATE OF WYOMING

NONGAME BIRDS: Raptors

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2013 – 31 December 2013

PREPARED BY: Courtney Rudd, Nongame Biologist
Nick Roberts, Game Warden

SUMMARY

In 2013, the Wyoming Game and Fish Department issued 33 falconry capture licenses. The number of licenses issued represented a decrease from 2012 (41 licenses), but is similar to the number issued in 2011 and 2007 (30 each year). Licenses were issued for 23 residents and 10 nonresidents. Similar to 2011, capture success was greater for nonresidents (80%) than residents (8.69%). Residents filled 2 of 23 licenses; nonresidents filled 8 of 10 licenses. Ferruginous Hawk (*Buteo regalis*) was the most commonly captured species, with all seven captures (five females, two males) taken by non-residents. Two Red-tailed Hawks (*Buteo jamaicensis*) were captured, one (female) by a resident and the remaining bird (sex unknown) by a non-resident. A lone male American Kestrel (*Falco sparverius*) was captured by a resident. Although Northern Goshawk (*Accipiter gentilis*) was one of the two most commonly captured species in 2012, no individuals were captured during 2013 (Table 1). The total number of birds captured in 2013 (n = 10) was significantly less than the mean (±SE) number of captures from 1981-2012 (22.8 ± 1.49 birds). Additionally, capture success for 2013 (30%) was less than the mean (±SE) capture success from 1981-2012 (47% ± 2.24%; Table 2).

Table 1. Species and number of raptors captured by residents and nonresidents for falconry in Wyoming, 2013.

Species captured	Number of resident captures	Number of nonresident captures	Total captures
Cooper's Hawk	0	0	0
Northern Goshawk	0	0	0
Red-tailed Hawk	1	1	2
Ferruginous Hawk	0	7	7
American Kestrel	1	0	1
Merlin	0	0	0
Prairie Falcon	0	0	0
Great Horned Owl	0	0	0
Total	2	8	10

Table 2. Number of individuals captured and yearly capture success rate (%) for raptors taken for falconry in Wyoming, 1981-2013.

Year	Number of raptors captured	Capture success rate (%)
1981	27	37
1982	40	52
1983	18	18
1984	25	33
1985	39	53
1986	33	35
1987	19	36
1988	28	51
1989	26	55
1990	32	68
1991	29	66
1992	22	53
1993	13	37
1994	21	33
1995	12	30
1996	25	47
1997	19	61
1998	31	63
1999	27	55
2000	24	57
2001	21	45
2002	29	58
2003	21	49
2004	33	48
2005	13	31
2006	14	40
2007	15	45
2008	27	69
2009	8	53
2010	5	26
2011	15	50
2012	20	49
2013	10	30

OTHER NONGAME – BIRDS

2013 RAPTOR NEST SURVEY FOR THE BUREAU OF LAND MANAGEMENT CASPER FIELD OFFICE

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Raptors

FUNDING SOURCE: Bureau of Land Management Cooperative Agreement
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 April 2013 – 31 May 2013

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

ABSTRACT

In 2013, we conducted aerial surveys using a fixed-wing aircraft to provide baseline data on nesting raptors associated with lands administered by the Bureau of Land Management Casper Field Office. We followed similar study parameters detailed in previous years' raptor nest survey reports; however, we modified the transect interval from 800 m to 600 m for compatibility with other on-going raptor surveys in Wyoming. Surveys coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles. All nests we located were georeferenced, and we noted nesting activity, physical condition of the nest, and primary habitat in which each nest occurred. We expended nearly 29 hours of flight time, and surveyed approximately 2,300 km^2 of habitat. We located a total of 70 raptor nests representing 4 species: Bald Eagle (*Haliaeetus leucocephalus;* total n = 1, occupied n = 1), Golden Eagle (*Aquila chrysaetos;* total n = 15, occupied n = 4), Ferruginous Hawk (*Buteo regalis;* total n = 27, occupied n = 4), and Red-tailed Hawk (*Buteo jamaicensis;* total n = 27, occupied n = 5). We also detected Swainson's Hawk (*Buteo swainsoni*), American Kestrel (*Falco sparverius*), and Burrowing Owl (*Athene cunicularia*), but did not observe nesting activity. The unusually wet spring weather in 2013 may have contributed to the limited raptor nesting activity we observed overall. Thus, the absence of records for raptor species known to occupy habitats in eastern Wyoming should not be considered documentation that they do not occur in the areas surveyed.

INTRODUCTION

The purpose of this study was to provide baseline data on raptor nesting activity associated with lands administered by the Bureau of Land Management (BLM) Casper Field Office.

A cooperative agreement to survey for nesting raptors was initiated in 1996 between the BLM and Wyoming Game and Fish Department (Department) and has continued periodically since, excluding 2003, 2007, and 2011. In 1997-2002, 2004-2006, 2008-2010, and 2013 (in lieu of 2012 surveys that we could not conduct due to early leaf-out), priority survey areas included specific portions of lands administered by the BLM Newcastle and/or Casper Field Offices that had not been previously surveyed, including lands proposed for and undergoing oil, gas, coal, and/or coalbed methane extraction. Surveys in 2013 focused on two priority areas within the Casper Field Office area that were identified by BLM Wildlife Biologist, Jim Wright (Fig. 1).

Funding for this cooperative effort was provided by the BLM. The Department conducted all aerial surveys and prepared the final report.

METHODS

In 2013, we followed similar study parameters detailed in previous years' raptor nest survey reports. We established survey transects at 600 m intervals in a north-south direction within each priority area. An 800 m interval between transects was used during previous survey years; however, we selected 600 m for compatibility with other on-going raptor surveys in Wyoming. Transects were flown in a fixed-wing aircraft on 22, 24, and 25 May in the Casper area (Husky N302MX; Laird Flying Service; Bob Laird, pilot). The Department's Nongame Bird Biologist, Andrea Orabona, conducted all aerial surveys. No ground surveys or follow-up aerial surveys were conducted by the Department in this area in 2013.

We used a handheld Global Positioning System (GPS) unit (Garmin GPS map 76S) to georeference nest locations during survey flights using Universal Transverse Mercator (UTM) coordinates, NAD 83 datum. We used an on-board GPS unit to maintain accurate flight patterns on survey transects and as a back-up, if needed. We studied each located nest for evidence of nesting activity and the presence of adult birds, young birds, or eggs. We also noted the physical condition of each observed nest, the substrate on which the nest was constructed, and the primary habitat in which the nest occurred. All raptor nests encountered were recorded, regardless of occupancy status or condition.

RESULTS

We expended nearly 29 hours of flight time to search for, locate, and observe raptor nests during the 2013 survey. We surveyed approximately 2,300 km^2, but were only able to complete inventories in Priority Area 1 because we expended all available project funds.

We summarized results of the nesting survey in Table 1. Nest codes we used during the survey are presented in Table 2, and substrate codes are presented in Table 3.

We located a total of 70 raptor nests within the BLM's Casper Field Office Priority Area 1 (Table 1; Fig. 2). Total nests we detected included Bald Eagle (*Haliaeetus leucocephalus; n* = 1), Golden Eagle (*Aquila chrysaetos; n* = 15), Ferruginous Hawk (*Buteo regalis; n* = 27), and Red-tailed Hawk (*Buteo jamaicensis; n* = 27). From these totals, occupied nests included Bald Eagle (*n* = 1), Golden Eagle (*n* = 4), Ferruginous Hawk (*n* = 4), and Red-tailed Hawk (*n* = 5). Other raptors we detected included Swainson's Hawk (*Buteo swainsoni*) and American Kestrel (*Falco sparverius*), although nests were not observed. We observed one Burrowing Owl (*Athene cunicularia*) flying to and escaping down a prairie dog (*Cynomys* spp.) burrow.

DISCUSSION

We conducted the 1996-1998 surveys to coincide with the timing of the incubation, hatching, and pre-fledging stages for Ferruginous Hawks and the nestling stage (post-hatching and pre-fledging) for Golden Eagles. The surveys we conducted in 1999-2013 (excluding years we did not survey) were initiated 2-3 weeks earlier than previous years due to modified project objectives and to avoid observation problems with early leaf-out that we have encountered during some years. Therefore, surveys during most years have coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles.

We have noted a few biases during past surveys that should receive consideration during future efforts or evaluations of results. Swainson's Hawk nests often deteriorate during the winter, and their delayed spring arrival compared to other raptors means that this species may be missed during surveys in late April or early May. Although we conducted the 2013 surveys later in May, the unusually wet spring weather prior to the survey timeframe may have contributed to the low number of Swainson's Hawks we detected, as well as the limited raptor nesting activity we observed overall. In addition, although falcons may occasionally be observed during surveys in fixed-wing aircraft, they require helicopter or ground surveys to adequately detect nesting, neither of which we conducted in 2013. Furthermore, Priority Area 1 contained very little nesting habitat for Prairie Falcons (*Falco mexicanus*). Due to these biases, the absence of records for raptor species known to occupy habitats in eastern Wyoming should not be considered documentation that they do not occur in the areas surveyed.

A continuation of this cooperative effort between the Department and BLM would give us an opportunity to inventory nesting raptors in additional portions of the state for which data are limited or lacking, and allow us to compare raptor nest density within the BLM's priority areas.

Table 1. A summary of the 2013 raptor nest survey we conducted for the Bureau of Land Management Casper Field Office Priority Area 1.

Species	OCAC	UNAL	UNOC	UNDI	UNDE	Total nests
Bald Eagle	1					1
Golden Eagle	4		7	4		15
Ferruginous Hawk	4	1	6	6	10	27
Red-tailed Hawk	5		13	8	1	27
Total	14	1	26	18	11	70

Table 2. Nest code abbreviations we used during the 2013 raptor nest survey.

Nest code	Definition
OCCU	An occupied nest with two adults present at or near the nest and/or fresh lining material in the nest.
OCAC	An occupied nest in which a breeding attempt was made, indicated by a recent and well-used perch near the nest, two adults at or near the nest, fresh lining material in the nest, an incubating or brooding adult, eggs or young in the nest, or fledged young near the nest.
OCFA	An occupied nest that failed to fledge any young.
UNOC	An unoccupied nest that is in good condition but with no apparent recent use or adult presence at the time of the observation.
UNAL	An unoccupied nest within a territory that contains an occupied nest.
UNDI	An unoccupied, dilapidated nest in a state of ruin due to weather, natural aging, and/or neglect.
UNDE	An unoccupied nest showing no sign of raptor activity and that is destroyed to the point that it is no longer useable without major reconstruction. These nests, for all practical purposes, have disappeared.
GONE	A nest that was located during a previous study but has been completely destroyed with no sign of nest material during the current study.
?	A nest whose status was undetermined during subsequent surveys in the same nesting season.

Table 3. Substrate code abbreviations we used during the 2013 raptor nest survey.

Substrate code	Definition
ANS	Artificial nest structure
CKB	Creek bank
CLF	Cliff
CTD	Cottonwood (dead)
CTL	Cottonwood (live)
ELL	Elm (live)
GHS	Ground or hillside
MMS	Manmade structure
POD	Ponderosa pine (dead)
POL	Ponderosa pine (live)
ROC	Rock outcrop
RUS	Russian olive
WIL	Willow (live)

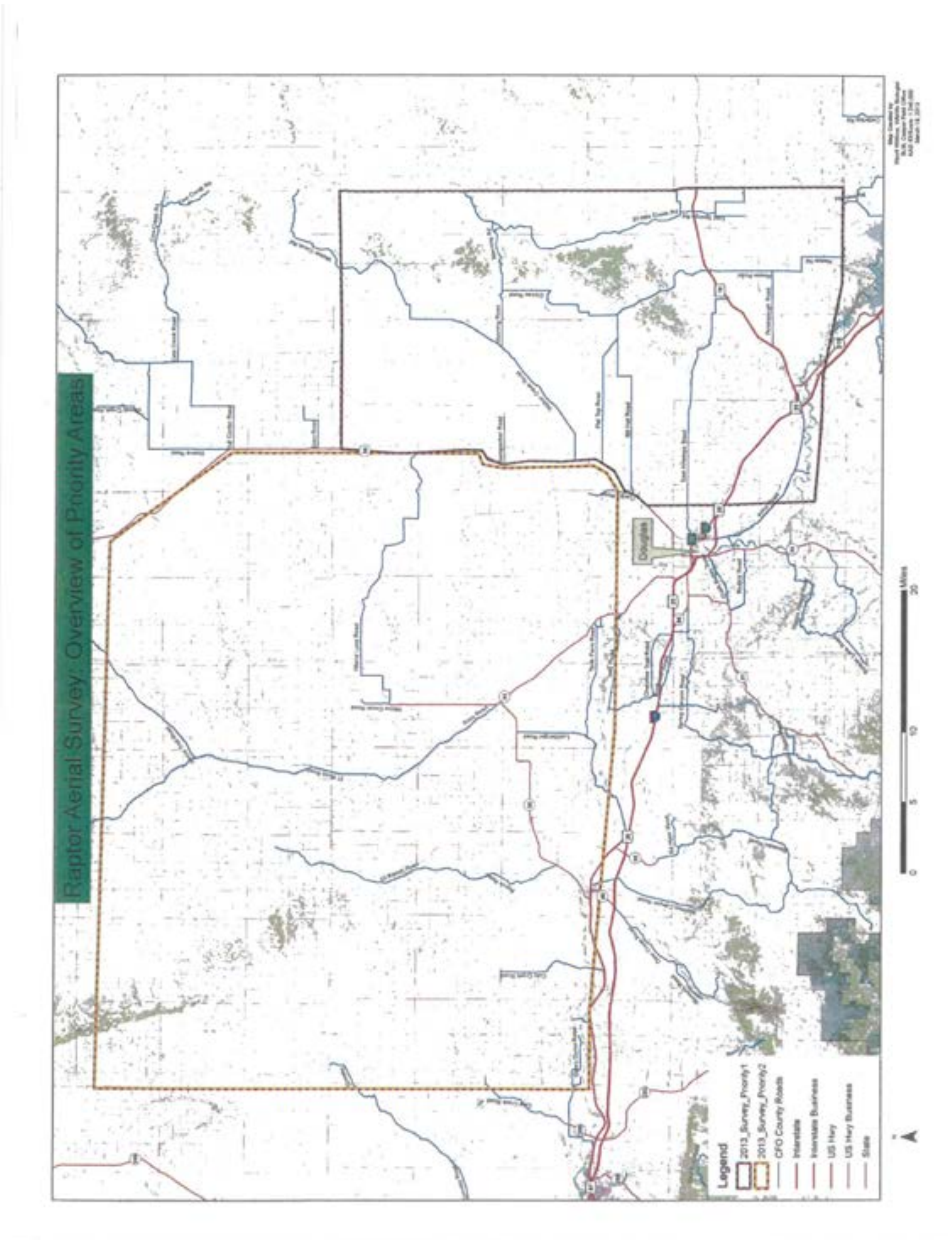

Figure 1. Locations of Priority Areas 1 and 2 for the 2013 aerial survey we conducted for the Bureau of Land Management Casper Field Office.

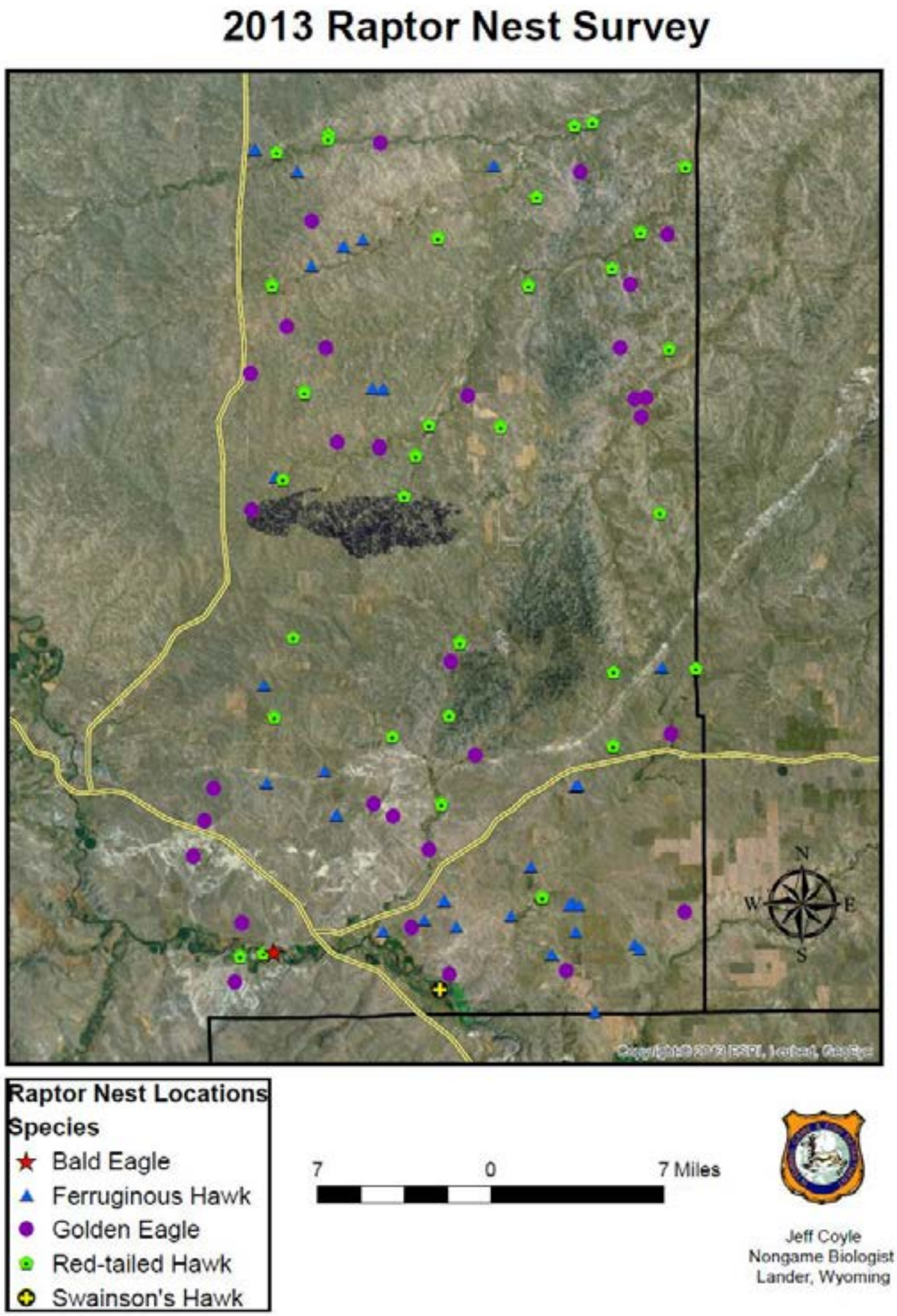

Figure 2. Locations of raptor nests we detected during the 2013 aerial survey in the Bureau of Land Management Casper Field Office Priority Area 1. The Swainson's Hawk we detected was of an adult bird only.

THE STATUS OF GOLDEN EAGLES (*AQUILA CHRYSAETOS*) IN WYOMING: A PRELIMINARY REVIEW

STATE OF WYOMING

NONGAME BIRDS: Golden Eagle

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
Wyoming State Legislature General Fund Appropriations
United States Forest Service Rocky Mountain Research Station
Bureau of Land Management
Wyoming Wildlife – The Foundation
PacifiCorp
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PROJECT DURATION: 1 January 2010 – 14 April 2014

PERIOD COVERED: 15 April 2013 – 14 April 2014

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ABSTRACT

Wyoming is experiencing a rapid increase in energy development, and differing opinions as to potential impacts to Golden Eagles (*Aquila chrysaetos*) are being expressed. The purpose of our work in 2013 and this paper is to provide a focus on the status of nesting Golden Eagles in Wyoming. We reviewed our surveys of 99 random townships in 2010 and 2011 that resulted in an estimate of 701 (95% CI: 547-976) nesting pairs of Golden Eagles in lowland habitats statewide. We evaluated our results with repeat aerial surveys in 2013 and documented that the abundance of nesting eagles was similar to 2010 or lower. We also quantified that leporid abundance since 2009 was not cycling as previous thought and remained at low levels throughout the study, indicating that perhaps our estimate of nesting eagle abundance may be low during years when leporid abundance returns to higher levels. We reviewed results of previous studies found consistent evidence that leporids and nesting eagles in Wyoming experienced severe statewide declines in abundance in 1993. Our review also indicates that the abundance of nesting eagles has remained stable but at low levels since 1993, making it difficult to evaluate the impacts of increasing energy development that has occurred in Wyoming.

However, our 2013 surveys of mountainous habitats in western Wyoming documented that Golden Eagles had maintained or increased abundance levels documented during earlier surveys, 1978-1982. Currently, we are using several data sets to develop and recommend a statewide Golden Eagle monitoring program. These data sets include the 82 randomly located nesting territories in lowland habitats, 81 nesting territories located during aerial surveys of mountainous habitats, 35 nesting territories monitored with ground surveys in Yellowstone and Grand Teton National Parks, and numerous nesting territories being monitored by regional studies, mostly associated with energy development.

INTRODUCTION

The Wyoming Game and Fish Department (Department) 2010 State Wildlife Action Plan did not include the Golden Eagle *(Aquila chrysaetos*) as a Species of Greatest Conservation Need because available information indicated the species was widespread and common in Wyoming with an estimate of 4,174 breeding pairs (Phillips et al. 1984). Survey results in mountain habitats of western Wyoming indicated that nearly all large cliff areas were occupied by nesting eagles (Oakleaf and Craig 2003). Evaluations in other states have raised concerns that this species may be declining (Kochert and Steenhof 2002). The US Fish and Wildlife Service concluded that Golden Eagles may be declining in portions of the range and was implementing restrictions on wind energy development based on their understanding of the population status of eagles (USFWS 2009). However, Millsap et al. (2013) presented data indicating stable populations of Golden Eagles in western US. They did, however, admit the level of imprecision and scale of their estimates leaves room for local declines described by Kochert and Steenhof (2002).

Golden Eagles are strongly dependent on leporids as a primary food source (Tjernberg 1983, MacLaren et al. 1988, Steenhof and Kochert 1988, Steenhof et al. 1997, Kochart and Steenhof 2002). Golden Eagles commonly do not lay eggs during periods of low prey abundance prior to the nesting season (Smith and Murphy 1979, Steenhof et al. 1997, McIntyre and Adams 1999). Although pairs that are not breeding may maintain nesting territories, frequency of attendance may be decreased and decrease the probability of detection for short-term occupancy surveys.

We initiated studies of Ferruginous Hawks (*Buteo regalis*) and Golden Eagles in 2010 (Oakleaf et al. 2012). We previously focused specifically on the status of Ferruginous Hawks (Oakleaf et al. 2013). The purpose of our work in 2013 and this paper is to provide a focus on the status of nesting Golden Eagles in Wyoming. Our studies were implemented during a period of low cottontail rabbit (*Sylvilagus* spp.) cycles as indicated by hunter harvest surveys (WGFD 2013) and focused on habitats where leporid abundance appeared to be the primary driver in determining the abundance of nesting eagles. Fedy and Doherty (2011) documented that cottontail rabbits in Wyoming cycle on an eight year basis with the last low occurring in 2002 and the last high in 2006. These data predicted a low in 2010 with the next high occurring in 2014. Therefore, we felt that additional information collected in 2013 with a potentially increasing rabbit abundance would further our understanding of nesting Golden Eagle abundance.

The objectives of this study were: 1) determine differences or similarities of the abundance of occupied Golden Eagle nesting territories in 2013 as compared to 2010 and 2011, 2) evaluate the impact of energy development on the reproductive status of these nesting territories, 3) review available data sets from previous studies to help establish the status of Golden Eagles in Wyoming, and 4) determine the relative abundance of nesting eagles in mountainous areas of western Wyoming as compared to surveys of the same areas during 1978-1982, where alternative prey may be more important than leporids.

METHODS

Raptor studies have been plagued by a long history of ambiguous terms that sometimes preclude the comparison of data over time and space. In this study, we used terminology and associated definitions provided by Steenhof and Newton (2007). In order to classify a nest as occupied, one or more of the following observations were necessary: one adult associated with a freshly repaired nest, two adults associated with a nest, one adult incubating or brooding, or the presence of eggs or young. A nesting territory was classified as occupied if it contained an occupied nest. We often use the term nesting pair interchangeably with the term occupied nest. We further defined a nesting territory as the area that included all nests ≤2.5 km from a nest or the centroid of a cluster of nests. This radius was selected based publications summarized by Kochert et al. (2002). We also used the term naïve occupancy and naïve density to indicate occupancy and density rates that were calculated without consideration of detection rates.

Chapman et al. (2004) classified the state into ecoregions and published detailed descriptions of each ecoregion. Ecoregions are designed to serve as a special framework for research, management, and monitoring and denote areas of general similarities of environmental factors and resources. Our 2010-2011 study was focused in the Wyoming Basin, Bighorn Basin, Northwestern Great Plains, and High Plains ecoregions (Fig. 1). A detailed assessment and additional description of the Wyoming Basins, including the Bighorn Basin Subecoregion, was provided by Hanser et al. (2011). In addition to Chapman et al. (2004), portions of the Northwestern Great Plains Ecoregion have recently received detailed published descriptions (Doherty et al. 2008), and grassland habitats of both the Great Plains and High Plains were described in Knight (1994) and WGFD (2010). Throughout this paper we refer to lowland habitats which include desert shrubland, sagebrush shrubland, prairie grassland and edges of adjacent juniper wodlands as described in Knight (1994) and WGFD (2010).

Our 2013 surveys also included repeat helicopter surveys of mountain areas of western Wyoming. The mountainous study areas are located in the Middle Rockies Ecoregion (Chapman et al. 2004) in northwest Wyoming. Elevation of cliffs surveyed ranged from 1,343 m to 3,210 m and averaged 2,193 m. Habitats for these areas are detailed in Knight (1994), Chapman et al. (2004), and WGFD (2010) and included portions of the state that were excluded from the 2010 and 2011 surveys of lowland habitats.

Random selection of townships, survey techniques and stratification of energy development are detailed in Oakleaf et al. (2012). A brief summary of these methods and results are presented in this paper. We identified townships available for random selection from modeling of Ferruginous Hawk habitat completed by Keinath et al. (2010). We randomly selected townships (93.3 km^2, 9.66 km on a side) from a stratified sample based on degree of energy development, and surveyed 16 transects running the length of the township and spaced 600 m apart, thus allowing complete coverage of each township. Only townships with centroids contained within the known distribution of Ferruginous Hawks were considered for selection (n = 1,230) as well as any additional townships containing Ferruginous Hawk nest records. Within that distribution, we conducted an aerial survey of nesting Ferruginous Hawks and Golden Eagles. We used two fixed-wing aircraft (Bellanca Scout and Piper PA 18) to search for raptor nests in 60 townships during April and May 2010. We also conducted duplicate surveys on randomly selected transects by helicopter in 2010 and aggressively searched for nests during flights between townships. We surveyed an additional 39 townships in April and May 2011 using the same techniques with fixed-wing aircraft.

We used an independent observer mark-recapture technique (DOBSERV) to estimate detection probability and bird abundance (Pollock and Kendall 1987, Nichols et al. 2000). This method provides an estimate of absolute detection probability for each observer or species (Laake et al. 2008). We used the methods detailed in Nichols et al. (2000) to estimate detection probabilities for Golden Eagle occupied nests for observation teams one and two in fixed-wing planes. We then used this estimate to calculate the number of km^2 of survey area per occupied nest.

We also used program DISTANCE v. 6.0 (Thomas et al. 2009) to provide a comparative estimate of detection probabilities and nest density. Distance methods provide a relative measure of detection probability, since they use the distribution of nest locations within transects to infer the number of nests likely missed by observers (Laake et al. 2008). We selected half-normal or hazard-rate key functions and cosine or hermite polynomial series expansion terms as possible models. We fit these models to the data and used AIC to determine the model with the best fit. We used only occupied Golden Eagle nests for this analysis and truncated the highest 5% of the data to avoid problems fitting the model to a long-tailed distribution (Thomas et al. 2010).

Between 27 March and 3 April 2013, we surveyed the occupancy status of a random sample Golden Eagle nests (n = 225) located in lowland habitats in Wyoming. The nests in this sample were initially located during the aerial, transect-based surveys in 2010 (n = 143) and 2011 (n = 82; Oakleaf et al. 2012). We determined occupancy of all nests in the original survey by flying from the transect to an observed nest. We revisited this sample of nests in 2013, using a fixed-wing aircraft (Cessna 205). Surveys began with a visit to the known nest location. If the nest was not occupied or could not be located, we initiated an active search within a 2.5 km radius around the nest location. The search consisted of a high altitude pass over the area, followed by a series of slower, low-level passes over all possible nesting habitats, with the pilot and observer visually scanning from both sides of the plane. Speed, altitude, and search time varied at the discretion of the observer and the pilot, based on the topographic complexity of the area, the abundance of potential nesting substrates, and safety considerations. Circular buffer shapes were loaded into a Global Positioning System (GPS) in the plane to provide a clear delineation of survey boundaries. We recorded the occupancy status of each nest according to the criteria of Steenhof and Newton (2007). We used a GPS to record the locations of any previously unknown nest structures. Following the survey, we divided the 225 nest structures into 159 circular putative nesting territories, 2.5 km in radius. We gave preference to nests occupied in 2013 as the centroids of territories, and then arranged buffers around unoccupied nests to create a maximum number of minimally-overlapping territories. The goal of this approach was to estimate the colonization rate of putative vacant territories.

We reviewed results and unpublished data of previous Department studies of nesting raptors in lowland habitats and present findings applicable to our recent statewide results. In order to potentially explain changes in nesting Golden Eagle abundance, we reviewed information on energy development according to the Oil and Gas Conservation Commission, accessed April 2012, and hunter harvest trends of cottontail rabbits (WGFD 2013) as an indication of prey abundance for nesting Golden Eagles. We also compiled results of wildlife inventories from annual reports of associated with 14 coal mines in Wyoming.

Also in April 2013, we repeated helicopter surveys of cliffs that we surveyed for Peregrine Falcons (*Falco peregrinus*) during cooperative surveys with the Bridger-Teton, Shoshone, and Bighorn National Forests from 1978-1982. These surveys included extensive cliffs and canyons that extended past Forest Service boundaries (Fig. 2). The original survey did not include many smaller cliffs and rims (<25 m in height) located in foothills or lowlands. Even though nesting eagles commonly occupy these smaller cliffs, we were careful not to include such cliffs in the 2013 survey unless we were certain that they were included in the original survey. The recent surveys were conducted with a Bell 47 Soloy, while the early surveys were conducted with a Hiller 12E. We recorded the location of cliffs surveyed in 2013 with a Garmin GPS map60CS unit and used the track function and a start and stop location. Tracks were then converted to shape files and measured with ESRI's ArcMap program. We recorded locations of nesting raptors on topographic maps during early surveys and with a Garmin GPS map60CS unit in 2013. Our objective was to determine if the number of Golden Eagle nesting pairs on these cliffs was similar in 2013 compared to >30 years prior. In addition, during 2013 we conducted a survey of cliffs in the Southern Bighorn Study Area (Fig. 2). Baseline nesting data for this area were not available for a temporal comparison. However, results offered a potential comparison of linear densities with other study areas and baseline data for future studies.

Some of these cliffs were periodically surveyed from the ground or helicopter flights of short duration during the 1990s. However, these surveys were also focused on locating Peregrine Falcons, and, when nesting Golden Eagles were located, these cliffs became low priority for repeat surveys, precluding the opportunity to collect occupancy data or trends. Thus surveys during the late 1980s and 1990s were not complete and in any given year represented only partial surveys that could not be used for comparisons.

We also evaluated naïve occupancy rates of nesting territories observed during 2013 helicopter surveys that were documented previously during early (1978-1982) surveys. In addition, in these same areas, we recorded 17 occupied nesting territories during ground surveys (1983-1993) in Yellowstone and Grand Teton National Parks and nearby nesting territories in the Bridger-Teton National Forest (BTNF). We documented the naïve occupancy rate of these nesting territories by conducting ground surveys in 2012 and 2013 with help from volunteers and cooperators who were given specific instructions. Ground surveys consisted of 2 site visits with ≥4 hrs of observation each day. At least one of the surveys occurred in June and one survey ≥30 days prior to the June survey. However, timing of surveys at higher elevations depended on site accessibility, and some were conducted later. Survey effort was terminated when an occupied nest was located

RESULTS

During 2010 and 2011 surveys of transects in 99 randomly selected townships, we recorded 29 occupied nesting territories of Golden Eagles that were eligible for calculation of detection rates and estimates of statewide abundance. These results indicate a naïve density of 272 km^2 per occupied nest. We recorded an additional 22 occupied nests during helicopter surveys between transects within random townships and during flights between townships. While these additional nests were not used to calculate abundance estimates, we included these nests for occupancy surveys for a total of 51 nesting territories. We also recorded 192 Golden Eagle nests that were not occupied and 101 eagles that were soaring or perched and not associated with a nest site in 2010. We did not locate a nesting pair of eagles in 60 of our 99 random townships. Even the 33 townships with nesting eagles had only one or two nesting pairs, 46-93 km^2 per nesting pair, while we recorded one township with three nesting pairs or a maximum naïve density of 31 km^2 per nesting pair.

We used the double-observer data collected in 2010 to determine the probability of detection calculated for each observer and each species. For teams one and two, we used only occupied Golden Eagle nests that were found on transects surveyed by both fixed-wing and helicopter in 2010. Using this dataset, the estimated detection probability for team one was 0.50 (95% CI: 0.22-0.78) for Golden Eagles. For team 2, we estimated a detection probability of 0.67 (95% CI: 0.58-0.76) for Golden Eagles. We then used these estimates of detection probability averaged over both observers (0.585, 95% CI: 0.42-0.75) to determine the density for each year as well as an overall estimate of density of 163 km^2 (95% CI: 117-209 km^2) per occupied nest of Golden Eagles (Table 1). Using program DISTANCE, our truncated data set resulted in 29 occupied nests, and we estimated 230 km^2 (95% CI: 138.7-381.7 km^2) per occupied nest of Golden Eagles (Table 2).

We used density estimates from both distance-sampling (Buckland et al. 1993) and the DOBSERV density calculation of number of nests found over area surveyed, weighted by probability of detection as determined by the double-observer survey, to evaluate statewide abundance (Table 3). We calculated statewide abundance based on the total number of townships in lowland habitats available for random selection (consisting of 1,230 townships, each approximately 93 km^2; 114,390 km^2 total). The mark-recapture calculations provided smaller confidence intervals and probably more reliable abundance estimates. Overall, based on the double-observer density calculation, we estimate that there were 701 (95% CI: 547-976) nesting pairs of Golden Eagles in the study area (Table 3), which includes approximately 45.2% of Wyoming.

To account for differences in population density based on location, we also divided the state into ecoregions, as defined by the USGS (Chapman et al. 2004), and calculated density separately for each ecoregion (Fig. 1) by using the area divided by the number of occupied nests and weighted by probability of detection as determined by the double-observer approach. Estimated density indexes varied considerably among ecoregions, from 95.21 km^2 and 96.00 km^2 per occupied nest in the High Plains and NW Great Plains, respectively, to 272.03 km^2 per occupied nest in the Bighorn Basin and Wyoming Basin. Two townships were actually within the boundaries of the Southern Rockies Ecoregion but did not have any occupied nests (Fig. 1). We used these densities to calculate abundance estimates for lowland habitats, which varied from 30 nesting pairs in Bighorn Basin to 305 nesting pairs in the Northwestern Great Plains Ecoregion (Table 4).

Our 2013 survey of all nests recorded previously (2010, 2011) located 56 occupied nests compared to 55 occupied nests in 2010 and 2011. However, only 27 (48.2%) of the original occupied nesting territories were documented as occupied in 2013, while 29 occupied nesting territories in 2013 were recorded as not occupied during the previous survey. Our 2.5-km evaluation of nest clusters indicated a putative sample size of 159 nesting territories. If we eliminate nesting territories located during helicopter flights between random townships and limit our comparison to only nesting territories that were originally located within random townships, we located 35 occupied nests originally and 29 occupied nesting territories in 2013. Eighteen (51%) of the 35 nesting territories occupied in 2010-2011 were occupied in 2013.

Our random sample of townships was stratified as low (0), medium (1–30), and high (>30) density of active wells, with 33 townships in each strata. Using the 2 years of pooled data and additional nests located by helicopter on random transects in 2010, we located 48 occupied nests during surveys of transects in these 99 random townships. Within the low, medium, and high strata, 13, 17, and 18 occupied nests were located, respectively, during the 2010-2011 survey. The 2013 survey located 6, 11, and 12 occupied nesting territories in low, medium, and high well density townships, respectively.

Results of previous Department studies of nesting raptors in lowland habitats have been presented in Cerovski (1999), Ayers et al. (2009), and Young et al. (2010) with findings applicable to our recent statewide results. In the Baggs Study Area (BSA) there were 16 occupied Golden Eagle nests (49 km^2 per pair) in 1993, 0 in 1994 (>783 km^2 per pair), and 3 (261 km^2 per pair) in 2008 (Ayers et al. 2009). In the Medicine Bow Study Area (MBSA), there were 50 occupied Golden Eagle nests in 1978, the abundance of occupied nests ranged from 25 to 39 and averaged 28.5 occupied nests during 1997-2000, and 27 occupied nests were documented in 2009. These results indicate naïve densities of 64.3, 112.8, and 119.1 km^2 per occupied nest for 1978, 1997-2000, and 2009, respectively. Our 2010 and 2011 statewide surveys included 13 townships that were surveyed in 1998 by fixed-wing aircraft following north-south transects and using similar techniques (Cerovski 1999). We refer to these townships as the Powder River Basin Study Area (PRBSA). A total of 7 occupied nests were located in 1998, for a naïve density of 173 km^2 per occupied nest, and 9 occupied nests were located in 2010 and 2011 (134 km^2 per occupied nest).

The progress of energy development in our random sample of townships is presented for the NW Great Plains and Wyoming Basin Ecoregions (Figs. 3 and 4). The number of producing oil and gas wells went from 528 in 1996 to 1,176 in 2011 in the NW Great Plains and from 1,775 in 1996 to 3,885 in 2011 in the Wyoming Basin Ecoregion. The number of producing wells in the BSA and PRBSA are presented (Figs. 5 and 6) and show trends similar to the ecoregion graphs.

Hunter harvest trends of cottontail rabbits (WGFD 2013) as an indication of prey abundance for nesting Golden Eagles are presented (Fig. 7). We focused primarily on statewide results as regression analysis of the data indicated that the seven different management areas were highly correlated among themselves with R^2 values varying from 0.780 to 0.890, except for Management Area 1 (Teton County), which had low harvest rates and habitats not considered relevant for our evaluation of lowland eagles. In general, statewide harvest rates were at lows in 1985-1986, 1993, 2002- 2003, and the years of our study, 2010-2013 (Fig. 7). Peaks occurred in 1983, 1990, 1997, and 2005-2006. However, the latter two peaks were substantially lower than peaks in earlier decades (Fig. 7).

We also compiled results of wildlife inventories reported in annual reports of habitats associated with 14 coal mines (Table 5, Fig. 8). Five of the mines are located in the Wyoming Basin Ecoregion, three in southwestern Wyoming, and two in southeastern Wyoming. Three have data sets extending back to 1980, 1983, and 1985 (Bridger Coal Company 2012; Westmoreland Kemmerer, Inc. 2012; Intermountain Resources 2013). Surveys at the other two mines were initiated in 1993 (Arch of Wyoming, LLC 2013a, b). The remaining nine mines are located in the NW Great Plains Ecoregion. Two of these mines have data sets starting in 1987 (Alpha Coal West, Inc. 2013). Surveys by other mines were initiated in 1993 (Cordero Mining, LLC 2012; Peabody Caballo Mining, LLC 2012a, 2012b; Peabody Powder River Mining, LLC 2012; WyoDak Resource Development Corporation 2012; Thunder Basin Coal, LLC 2012, 2013; Antelope Coal, LLC 2013; and Buckskin Mining Company 2013).

We noted that the length of leporid survey routes and reporting units varied among mines; therefore, we converted all data to animals per km. Regression analysis of the number of cottontails with jackrabbits at each mine showed low R^2 values that typically were not significant. Similar results were obtained with regression analysis of leporid transects between mines. We did, however, note that jackrabbit counts were typically lowest when cottontail counts were low, and that mines tended to have low and high counts of cottontails and jackrabbits that were temporally similar, although the scale varied enough to preclude high R^2 values. The year of lowest number of leporids per km occurred in 1993-1994 for most survey routes (10 of 14) and highs in 2005-2006 (12 of 14 routes), which are also temporally similar to the low and high of cottontails in the statewide hunter harvest data during the years 1993-2012 when most surveys were conducted (Fig 7). An average of 0.21 leporids per km was reported during the low count year of each mine, while an average of 13.88 leporids per km was reported during high count years (Table 5). These surveys showed an average of 0.35 leporids per km during 2010 when we initiated our study of lowland habitats in Wyoming.

Survey data of nesting Golden Eagles associated with mines were difficult to interpret as different reports were not clear as to the criteria for determining occupancy or differentiating between nests and nesting territories. We assumed that empirical count data of young fledged per survey area will result in the least ambiguity and adequately indicates the reproductive status of nesting eagles. Table 6 presents the total number of Golden Eagles fledged in mine survey areas during years of low and high leporid counts and in 2010. A total of only 10 eagles fledged in 14 mine survey areas during years of low leporid counts, while 44 eagles fledged in the same areas during years of high leporid counts. It is likely that prey abundance during the fall and winter of one year has a greater affect on the immediate following breeding season. Therefore, we also present the number of eagles fledged the year following low and high leporid results (Table 6). Results appeared similar with the years after a low year fledging 7 eagles and high years fledging 42 eagles. In 2010, when we initiated our study, leporid surveys at these 14 mines (Table 5) and cottontail hunter harvest trends (Fig. 7) indicated a low in leporid abundance, which has extended through at least 2013. In 2010, only 13 eagles fledged from these 14 survey areas, also indicating a low year for eagle production.

In April 2013, we conducted helicopter surveys of 888 km of cliffs in mountainous areas of northwestern Wyoming that had been previously surveyed in 1978-1982 (Fig. 9). We also conducted similar surveys in June 2013 of 173 km in the Bighorn South study area, which lacked adequate data for long-term temporal comparisons but provided an opportunity to document relative abundance in an area reported to have high numbers of eagles and an abundance of potential nesting habitat.

We documented 51 occupied eagle nests in 2013 compared to results of 44 occupied nests during 1978-1982 (Table 7, Fig. 10). We located an additional 10 occupied nests in the southern Bighorns. In 2013, the density index (km of cliff per occupied nest) varied among study areas from a high density of 8 km per occupied nest in the Shoshone South study area to a low density of 27.8 km per occupied nest in the Bridger-Teton Study Area.

During 2013 helicopter surveys, we checked 44 Golden Eagle nesting territories recorded as occupied during baseline helicopter surveys from 1978-1982. Twenty–five (60.0%) of these territories were occupied (Table 8). Naïve occupancy rates varied from 20.0% in the Bridger-Teton Study Area to 72.7% in the Bighorn North study area.

Although we did not conduct extensive helicopter surveys in Grand Teton (GTNP) and Yellowstone National Parks (YNP), we did conduct ground surveys in 1983-1993 and recorded 17 occupied Golden Eagle nests in the Parks and adjacent areas of BTNF. Fourteen of these nesting territories were adequately surveyed in 2012 or 2013, with naïve occupancy of 10 of 14 sites (71.4%). However, if we separate results in YNP from GTNP and adjacent BTNF, four of the five (80%) nesting territories were occupied in YNP and six of nine known territories (66.7%) in the GTNP and adjacent BTNF were occupied (Table 9).

DISCUSSION

We documented a naïve density of 272 km^2 per nesting pair of Golden Eagles during our statewide surveys of 99 random townships in lowland habitats during 2010 and 2011. We used calculated detection rates from the double-observer survey and the portion of the habitat surveyed to estimate a statewide abundance of 701 (95% CI: 547-976) nesting pairs of Golden Eagles in lowland habitats of Wyoming. We found no evidence that the abundance of nesting eagles was lower in high energy development townships. However, our study did not include townships with well densities >500 wells per township. For example, one township in the

Pinedale Anticline and one in the Jonah Infill Drilling Project Areas, located in Sublette County, south of Pinedale, had >1,300 producing wells each (Wyoming Oil and Gas Conservation Commission 2012). Such intense development in the future may become more common and preclude eagle nesting. In addition, we are still evaluating prey densities, which may be greater in developed areas and promote eagle nesting near development.

Our estimate was specific for townships containing lowland habitats that represent approximately 50% of the state. If we assume that most of the state is suitable habitat for nesting eagles and double our estimate, a statewide estimate of 1,402 pairs of Golden Eagles were nesting in 2011. These estimates are considerably less than provided by Phillips et al. (1984), who estimated there were ≥4,174 breeding pairs in Wyoming based on data collected over a 7 year period (1976-1982).

We were expecting studies in the early 1980s to indicate Golden Eagles were more abundant than compared to more recent years. Strychnine and other poisons were regulated, illegal killing of eagles was enforced, and programs to minimize electrocutions were all intensified in the early 1970s (Robinson 2005, Drabelle 2008, Lehman et al. 2010). Most importantly, jackrabbit numbers were at an all-time high in the late 1970s as indicated by intensive control efforts by ranchers (D. Schram, pers. comm.; J. Reynolds, pers. comm.). These factors (mitigating causes of mortality and an abundant prey) would tend to promote high densities of nesting eagles.

In addition, Phillips et al. (1984) may have overestimated the abundance of nesting eagles. Their estimate was based on surveys of 12 study areas, most of which were selected due to existing or proposed mining applications and a potential need to avoid impacts to nesting eagles. Although information as to how the boundaries of these study areas were selected was not provided, it seems likely that economic considerations of extending aerial surveys into adjacent habitats not suitable for eagle nesting may have biased the survey towards high densities as opposed to landscape-scale densities or abundance. The naïve density of these 12 study areas ranged from 34 km^2 per nesting pair to 89 km^2 per nesting pair and averaged 60 km^2 per nesting pair, which far exceeds the densities we recorded in 99 random townships. However, one large study area (Gillette) of 7,115 km^2 probably avoided the bias of arbitrary boundaries and included 120 nesting pairs (59 km^2 per pair). This study area was expanded to 14,554 km^2 and additional survey effort from 1981-1989 and documented a naïve density of 72 km^2 per nesting pair of eagles (Phillips and Beske 1990). This expanded study includes a portion (~25%) of the NW Great Plains Ecoregion, where we estimated a density of 96 km^2 per nesting pair. While the estimate of Phillips and Beske (1990) is a naïve density, it was based on a smaller area and numerous surveys, and they noted it was probably close to an actual count.

Comparing our 2010-2011 results with Phillips et al. (1984), the abundance of nesting Golden Eagles in Wyoming could be as low as 34% of numbers in the 1980s or as high as 60% as indicated by the example of the NW Great Plains Ecoregion. Our random selection of townships for the 2010-2011 study included 13 townships surveyed in the PRB during 1998. A total of 7 occupied nests were located in 1998, for a naïve density of 173 km^2 per occupied nest, and 9 occupied nests were located in 2010-2011, for a naïve density of 134 km^2 per occupied nest, which is still far below the 72 km^2 per nesting pair reported in Phillips and Beske (1990).

We were concerned that our 2010 and 2011 surveys were conducted during a low in cottontail abundance (WGFD 2013) that would result in a low in eagle nesting activity. We were especially concerned that a limited temporal perspective could result in a misunderstanding of the status of nesting Golden Eagles in Wyoming. Information presented by Fedy and Doherty (2011) indicated that cottontails would be approaching highs in 2013, and we solicited additional funding for increased studies. However, cottontail rabbits have remained in a low part of their cycle since 2007 and have not exhibited a return to the eight-year cycle reported by Fedy and Dougherty (2011). In addition, our review of leporid surveys reported by mines indicates that jackrabbit abundance has also remained minimal during the same period. Therefore, we were not able to test the hypothesis that the abundance of nesting eagles would increase as cottontail abundance increased, and our 2013 results indicate abundance levels of nesting eagles are similar to or less than in 2010 and 2011. In addition, it is also difficult to evaluate potential impacts, such as energy development, when the abundance of eagle prey is minimal, or to assess whether eagle numbers would increase in areas that lack energy development as prey numbers return to higher levels.

Other studies in Wyoming also indicate that the number of nesting pairs of Golden Eagles is considerably fewer than in previous decades. Ayers and Anderson (1999) selected their study area based on a known high density of nesting raptors. However, township boundaries for their 783-km^2 study area were selected prior to their study documenting 16 occupied Golden Eagle nests (49 km^2 per pair) in 1993, 0 in 1994 (>783 km^2 per pair), and 3 (261 km^2 per pair) in 2008 (Ayers et al. 2009). Results in 1993 and 1994 probably closely reflect the actual number of nesting pairs of Golden Eagles in the study area due to the intensity of surveys (Ayers and Anderson 1999), while the 2008 results are more accurately reported as a naïve density (Ayers et al. 2009). Even though the intensity of surveys was somewhat less, Ayers et al. (2009) did intensively check the previously known nesting territories, and, even if the probability of detection was as low as 0.50, the abundance of nesting eagles would be <38% of the1993 levels. The crash in eagle nesting activity in 1994 was attributed to a crash in jackrabbit abundance (Ayers and Anderson 1999).

A 3,215-km^2 study area near Medicine Bow was surveyed by helicopter in 1978 (B. Oakleaf, unpubl. data), on an annual basis from 1997-2000, and again in 2009 (Young et al. 2010). Fifty occupied Golden Eagle nests were documented in 1978. The number of nesting pairs ranged from 25 to 39 and averaged 28.5 occupied nests during 1997-2000, while 27 occupied nests were documented in 2009. These results indicate naïve densities of 64.3, 112.8, and 119.1 km^2 per occupied nest for 1978, 1997-2000, and 2009, respectively. The Phillips et al. (1984) study area near Medicine Bow comprised <25% of the study area reported by Young et al. (2010) but reported during approximately the same time frame nearly twice the naïve density (34 km^2 per pair), indicating a potential problem with relatively small (787 km^2) study areas and a nonrandom selection process for boundaries of survey areas. However, results presented by Young et al. (2010) suggest that the abundance of nesting Golden Eagles remained stable from 1997-2009 but at low levels approximating 50-60% of the 1978 results.

The Medicine Bow study has been the focus of wind-energy development increasing from 5 to 102 km^2 (3.2%) of the study area from 1997 to 2009. The large drop in nesting density occurred prior to the development and appears to have stabilized. Available information indicates that this decrease may also be attributed to a catastrophic decrease in jackrabbit abundance that also occurred in 1993.

B. Oakleaf (unpubl. data) estimated there were >25 jackrabbits per km in 1992 on a 15-km route approximately 30 km north of Medicine Bow. This route was driven repeatedly throughout the night during black-footed ferret (*Mustela nigripes*) surveys. Along the same route, no leporids were recorded in 1994, and only four jackrabbits and one cottontail (0.33 leporids per km) in 2013. Other members of the ferret survey crew reported similar observations with their survey routes in 1992 and 1994. Serology monitoring of coyotes in the area north of Medicine Bow documented that sylvatic plague and tularemia, which impacts lagomorphs, were widespread and active in 1994 as compared to low levels in 1991-1993 (Williams et al. 1995). Since 1994, jackrabbits appeared abundant during some years, one of the few areas in the state where high numbers continued to reappear. However, our impression is that jackrabbits have not reached highs of 1991-1992. Near Medicine Bow, 5 32-km roadside transects for leporids were conducted in 1997-1999 and again in 2009. Overall there was no significant change of total leporids per km during the 1990s (n = 0.75) and 2009 (n = 0.53; Young et al. 2010).

Studies of nesting Golden Eagles in Wyoming during the 1980s repeatedly stated that the habitat was saturated, lacking vacant potential nest sites, and nesting territories remained occupied for the length of the studies (Phillips et al. 1984, Phillips and Beske 1990, Phillips et al. 1990). This is certainly not the paradigm we see in recent studies. Our 2013 survey of all nests recorded previously (2010 and 2011) in lowland habitats delineated 159 punitive Golden Eagle nesting territories. Only 84 (53%) were occupied one or more years of the study, and only 27 (48.2%) of the original 55 nesting territories documented as occupied in 2010-2011 were documented as occupied in 2013. One of the goals of this approach was to estimate the colonization rate of vacant territories. Both the occupancy and the colonization rates are considered naïve rates as they were based on only one survey. We acknowledge that nest structures are an imperfect indicator of the extent of habitat available for colonization, due to the variability in their persistence, the potential construction of new nests, and perhaps our inability to assign vacant nests to a single raptor species with certainty. We believe, however, that this method was useful insofar as it offered a view of the processes of colonization and extinction over the single transition period available for the study (2010-2011 to 2013) and provided evidence that vacant habitat is available in any given year. A sample in which all nests are occupied at t-1 (as in the occupancy survey) requires ≥2 transition periods to estimate colonization, because some nests must first become extinct before they can be colonized. Z. Wallace (unpubl. data) studied the probability of detecting occupancy and the influence of covariates on nesting territories found occupied in 2010 or 2011. He will be presenting more detailed information on the issue.

During the Medicine Bow Study, B. Oakleaf (unpubl. data) conducted aerial surveys of 96 known Golden Eagle nesting territories, many of which were included in the results of the study area reported by Young et al. (2010) and additional adjacent areas not included in the report. Only 25 nesting territories were occupied, for a naïve occupancy rate of 26%. Even if we only analyze the nesting territories that were known to be occupied at least once during the 1996-2000 phase of the study, we obtain a naïve occupancy rate of 19 of 75 (25%) nesting territories in 2009. Yet the total number of occupied nests did not vary significantly.

Leporid and eagle surveys conducted in habitats adjacent to mines tended to support our review of other studies in lowland habitats. Mine data, however, were not sufficient to evaluate abundance levels prior to 1993 for either leporids or eagles. Ten of the 14 mines reported low counts of leporids in 1993-1994, indicating a rather dramatic low in potential prey for nesting eagles and a corresponding low in eagle production, which also occurred during the years of our current study (2010-2013). During years of high leporid counts, results indicate four to six times as many eagles were fledged. The degree that fledging rates relate to differences in naïve occupancy rates is not known. However, it seems likely that if our study was conducted during years of high leporid abundance, our estimate of eagle abundance would be higher.

We conducted helicopter surveys for nesting Golden Eagles along cliffs in mountainous areas of northwestern Wyoming where other prey than leporids are probably more important and not as subject to radical fluctuations in abundance. In addition, these mountainous areas have not received the intensity of development that has occurred in lowland habitats during recent decades. These cliffs were originally surveyed in 1978-1982 and again in 2013. The number of nesting pairs appeared to have increased somewhat or remained stable in the four study areas (Table 7). Certainly the combined results of the four study areas with 51 nesting pairs in 2013 as compared to 44 nesting pairs previously tends to support the conclusion that Golden Eagles nesting in mountainous habitats are as abundant today as they were previously. Although sample size was extremely small, the abundance of nesting eagles may have decreased in one study area (Bridger-Teton).

We located an additional 10 occupied nests in the southern Bighorns with a linear density index of 17.3 km of cliff per occupied nest, which was similar to the combined total of the other four study areas of 17.4 km of cliff per occupied nest. However, the density index varied among study areas from a high density of 8 km per occupied nest in the Shoshone South study area to a low density of 27.8 km per occupied nest in the Bridger-Teton Study Area. The high density of the Shoshone South study area may reflect the low ratio of km of cliffs surveyed to the high km^2 of associated landscape (Fig. 8).

During 2013 helicopter surveys in western mountains, we checked 44 Golden Eagle nesting territories recorded as occupied during baseline surveys in 1978-1982. The naïve occupancy rates of these nesting territories were considerably higher than occupancy rates we presented for nesting territories in lowland habitats, indicating that higher naïve occupancy rates are associated with stable or increasing nesting populations. Interestingly, the only mountain study area (Bridger-Teton) with fewer occupied nests than previous surveys also had the lowest naïve occupancy and highest number of km per occupied nest. We do not have a potential explanation for these results, especially since ground surveys in adjacent areas of GTNP and YNP indicate high naïve occupancy rates (71.4%). Recent surveys in YNP have documented a rather strong population of 22 occupied Golden Eagle nesting territories with high re-occupancy rates during the last three years (D. Smith, pers. comm.). In addition, a study area north of YNP near Livingston, Montana reported nearly 100% occupancy of nesting territories studied over several decades (B. Bedrosian, pers. comm.).

Review of early publications (pre-1993), Department file data, mine wildlife survey reports, and our studies (2010-2013) all indicate nesting Golden Eagles in lowland habitats and their primary prey base were more abundant than currently estimated, with a major statewide crash of both leporids and eagles occurring in 1993. In at least one area (MBSA) this crash appeared associated with a sylvatic plague and tularemia outbreak. Perhaps the synchronized crash that occurred statewide was also associated with an epizootic, but we could find no data that a statewide epizootic was occurring in 1993. Eagles with alternative prey in mountainous habitats of northwestern Wyoming have maintained a stable level of nesting pairs for over four decades. One of our mountain study areas, however, did not follow this trend and deserves more attention.

We are not suggesting that management should attempt to return leporid and eagle abundance to pre-1993 levels or that 1400+ nesting pairs is not an adequate abundance level. However, there are enough uncertainties that Golden Eagles may warrant additional study and certainly a well-designed monitoring program. We listed several mortality factors that were addressed in the 1970s and 1980s. However, there are several new factors that have not been adequately quantified or addressed, such as the impact of West Nile virus (*Flavivirus* spp.), mortality associated with wind farms, or the recent wide-spread use of Rozol to control prairie dogs (*Cynomys* spp.).

Much of our data on nesting eagles were collected during studies primarily focused on Ferruginous Hawks or Peregrine Falcons. We are currently modeling Golden Eagle nesting habitat to determine if there may have been significant portions of preferred habitats that were not adequately sampled or included in our statewide estimate of lowland habitats. We are also using several data sets to develop and recommend a statewide Golden Eagle monitoring program. These data sets include the 82 randomly located nesting territories in lowland habitats, 81 nesting territories located during aerial surveys of mountainous habitats, 35 nesting territories monitored with ground surveys in Yellowstone and Grand Teton National Parks, and numerous nesting territories being monitored by regional studies, mostly associated with energy development.

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Lucas. J. Dacey assisted with compiling data from mine reports. Department Nongame Biologist N. Cudworth provided excellent editing and comment that greatly improved the report

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Table 1. Number of nests (*n*), density (km^2 per nest), 95% confidence intervals (95% CI), and number of nests per township of occupied Golden Eagle (*Aquila chrysaetos*) nests found on random survey transects throughout Wyoming, 2010-2011. Density was calculated by using the probability of detection as calculated with program DOBSERV.

Year	*n*	Density	95% CI	Nests per township
2010	19	171.8	102.8-297.0	0.32
2011	14	129.5	57.7-201.4	0.36
Total	33	163.2	117.2-209.3	0.33

Table 2. Number of nests (n), density (km^2 per nest), and 95% confidence interval (95% CI) of occupied Golden Eagle (*Aquilus chrysaetos*) nests throughout Wyoming, 2010-2011, as determined with distance sampling. Number of nests reflects the number used in analysis, which was truncated at 300 m.

Year	*n*	Density	95% CI
2010	18	172.2	95.3-311.2
2011	11	265.7	183.0-577.5
Total	29	230.1	138.7-381.7

Table 3. Comparison of estimates calculated via distance sampling and mark-recapture (DOBSERV) for density (km^2 per nest), abundance (number of pairs), and 95% confidence interval (95% CI) for Golden Eagles (*Aquila chrysaetos*) throughout Wyoming, 2010-2011.

Method	Density	Abundance	95% CI
Distance sampling	230.1	497.1	299.7-824.6
DOBSERV	163.2	700.9	546.7-976.2

Table 4. Number of townships surveyed (*n*), total number of townships within distribution available for sampling (total *n*), total area of townships (km^2), number of nests, density (km^2 per nest), number of nests per township, and estimated abundance (number of pairs) of Golden Eagles (*Aquila chrysaetos*) throughout lowland habitats of Wyoming by ecoregion, 2010-2011.

Ecoregion	*n*	Total *n*	Township area	No. of nests	Density	Nests per township	Abundance
Bighorn Basin	5	88	8184	1	272.03	0.2	30
High Plains	7	99	9207	4	95.21	0.6	97
NW Great Plains	30	315	29295	17	96.00	0.6	305
Wyoming Basin	55	682	63426	11	272.03	0.2	233
Southern Rockies	2			0			
Middle Rockies	0						

Table 5. Number of leporids per km counted on roadside transects near coal mines during the lowest count year, the highest count year, and in 2010.

Mine name	Year survey started	Low count year	Leporids per km	High count year	Leporids per km	Leporids per km, 2010
Bell Ayr	1987	1995	0.06	2004	12.55	0.25
Black Thunder	1993	1993	0.12	2006	22.3	0.37
Buckskin	1995	1995	0.12	2006	7.08	0.25
Caballo	1993	1994	0.19	2006	16.46	0.25
Coal Creek	1993	1997	0.12	2006	28.57	0.99
Cordero	1993	1994	0.19	2006	8.17	0.11
Eagle Butte	1987	1994	0.14	2006	6.46	0.37
North Antelope	1993	1994	0.25	2006	34.66	0.3
Rawhide	1993	1993	0.12	2006	7.08	0.25
Medicine Bow	1993	1993	0.16	2007	2.78	0.31
Seminoe2	1993	1995	0.1	2006	2.16	NA
Black Butte	1980	1993	0.17	2005	3.78	0.17
Bridger	1982	1993	0.42	2006	31.77	0.4
Kemmerer	1985	1997	0.76	1991	10.51	0.5
Avg. leporid/km			0.21		13.88	0.35
SD			0.18		11.10	

Table 6. Number of Golden Eagles (*Aquila chrysaetos*) fledged in mine survey areas during years of low and high leporid counts, in the year following highs and lows (N+1), and in 2010.

Mine	Year of low count	Eagles fledged	N+1yr	Year of high count	Eagles fledged	N+1yr	2010 eagles fledged
Bell Ayr	1995	1	1	2004	1	0	0
Black Thunder	1993	2	0	2006	2	1	0
Buckskin	1995	0	0	2006	1	0	0
Caballo	1994	0	0	2006	2	1	0
Coal Creek	1997	0	0	2006	0	4	0
Cordero	1994	0	1	2006	1	2	0
Eagle Butte	1994	0	0	2006	1	0	0
North Antelope	1994	1	2	2006	8	15	2
Rawhide	1993	0	0	2006	1	0	0
Medicine Bow	1993	5	2	2007	9	9	2
Seminoe2	1993	1	0	2006	3	2	0
Black Butte	1993	0	0	2005	6	3	2
Bridger	1993	0	0	2006	9	4	2
Kemmerer	1997	0	1	1991	0	1	5
Totals		10	7		44	42	13

Table 7. Study areas, year of baseline helicopter surveys, and number of occupied Golden Eagle (*Aquila chrysaetos*) nests located during baseline and 2013 surveys and the calculated density index of km per occupied nest.

Study area	Year	Occupied eagle nests	2013 occupied nests	Km of cliffs surveyed	Km per occupied nest, 2013
Bridger Teton	1978-79	9	5	111	22.2
Shoshone South	1979	9	13	104	8.0
Shoshone North	1981-82	16	20	390	19.5
Bighorn North	1980	11	14	283	20.2
Subtotals		44	52	888	17.1
Bighorn South	NA	NA	10	173	17.3
Totals			67	1061	15.8

Table 8. Naïve occupancy of known (1978-1982) Golden Eagle (*Aquila chrysaetos*) nesting territories as documented during 2013 helicopter surveys.

Study area	No. known occupied nest territories	No. of known occupied nest territories, 2013	Naïve occupancy rate (%)
Bridger Teton	9	2	2/10 (20.0)
Shoshone South	9	6	6/9 (66.7)
Shoshone North	16	9	9/16 (56.3)
Bighorn North	11	8	8/11 (72.7)
Totals	44	25	25/44 (56.8)

Table 9. Number of occupied Golden Eagle (*Aquila chrysaetos*) nesting territories located during ground surveys (1983-1993) compared to 2012 and 2013 in Yellowstone National Park (YNP), Grand Teton National Park (GTNP), and adjacent areas of the Bridger-Teton National Forest (BTNF).

Area	Base no. of occupied territories	No. occupied territories, 2012-2013	Rate (%)
YNP	5	4	4/5 (80)
GTNP & BTNF	12	6	6/12 (50)
Total	17	10	10/17 (58.8)

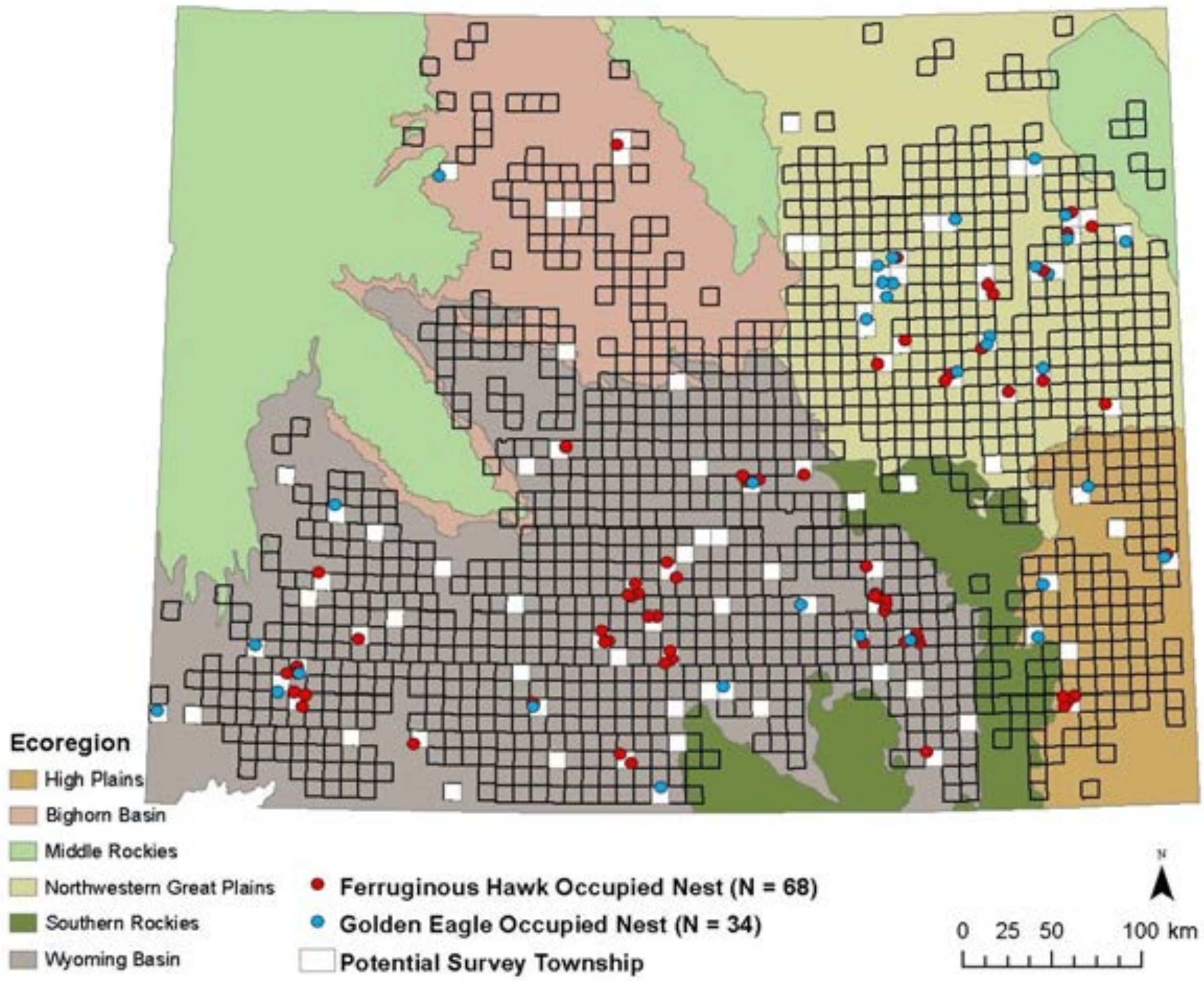

Figure 1. Locations of occupied Ferruginous Hawk (*Buteo regalis*; red dots) and Golden Eagle (*Aquila chrysaetos*; blue dots) nests detected during transect surveys in Wyoming, 2010-2011. Surveyed townships are shown in white and overlay ecoregions as defined by the US Geological Survey (Chapman et al. 2004).

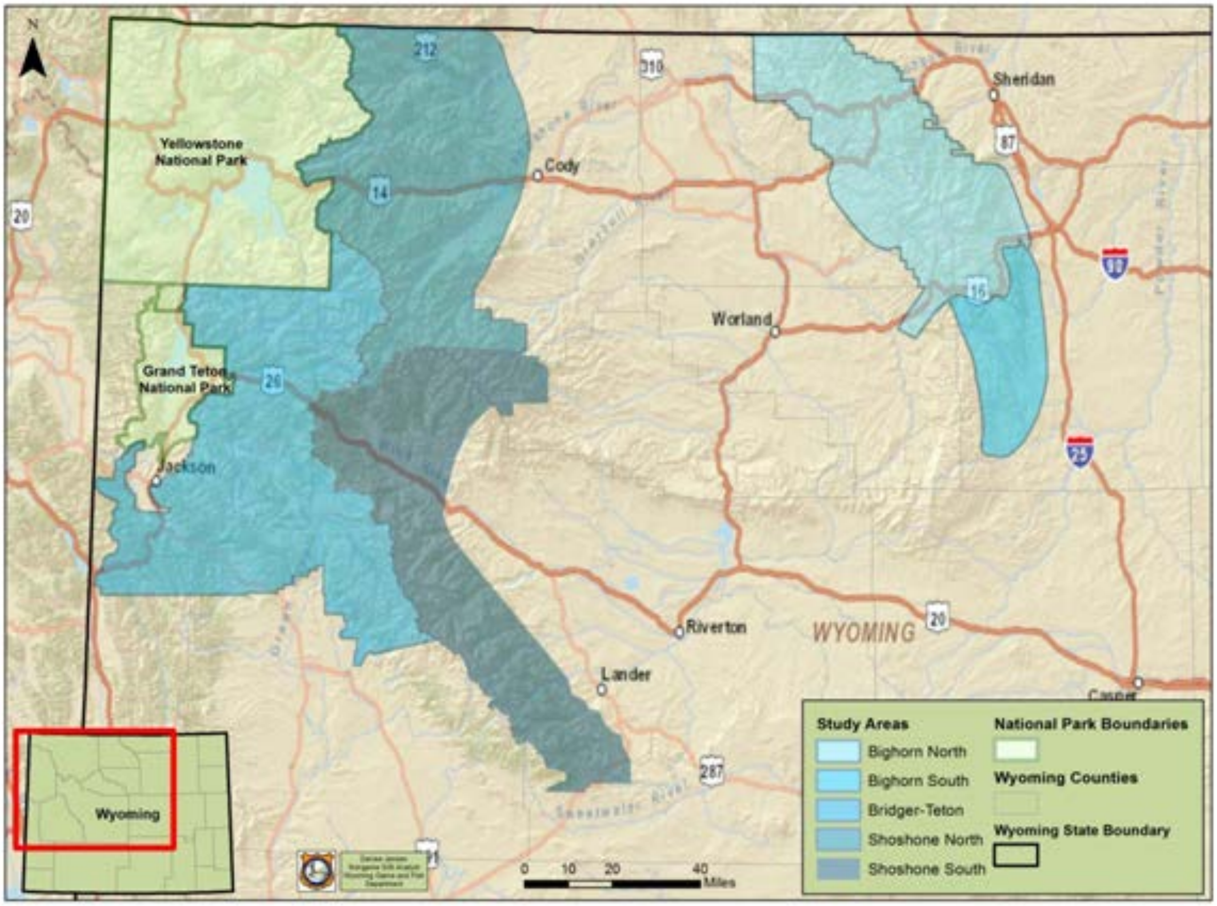

Figure 2. Location of five mountain study areas with cliffs surveyed by helicopter in 1978-1982 and again in 2013.

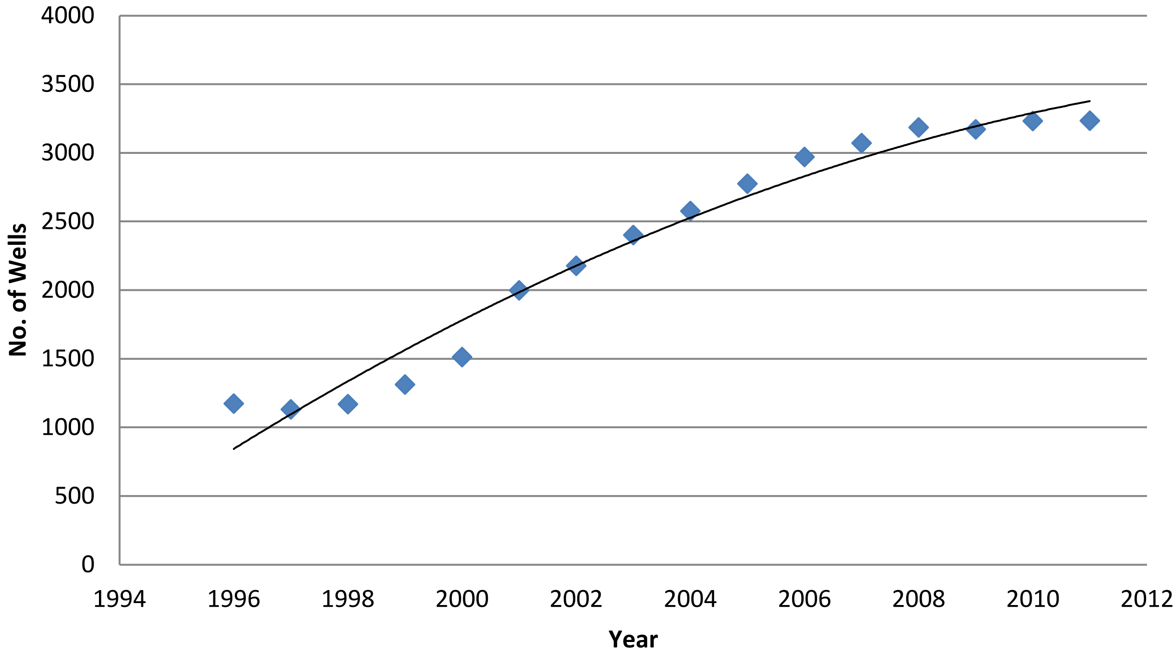

Figure 3. Number of producing wells in sample townships of the Northwestern Great Plains Ecoregion.

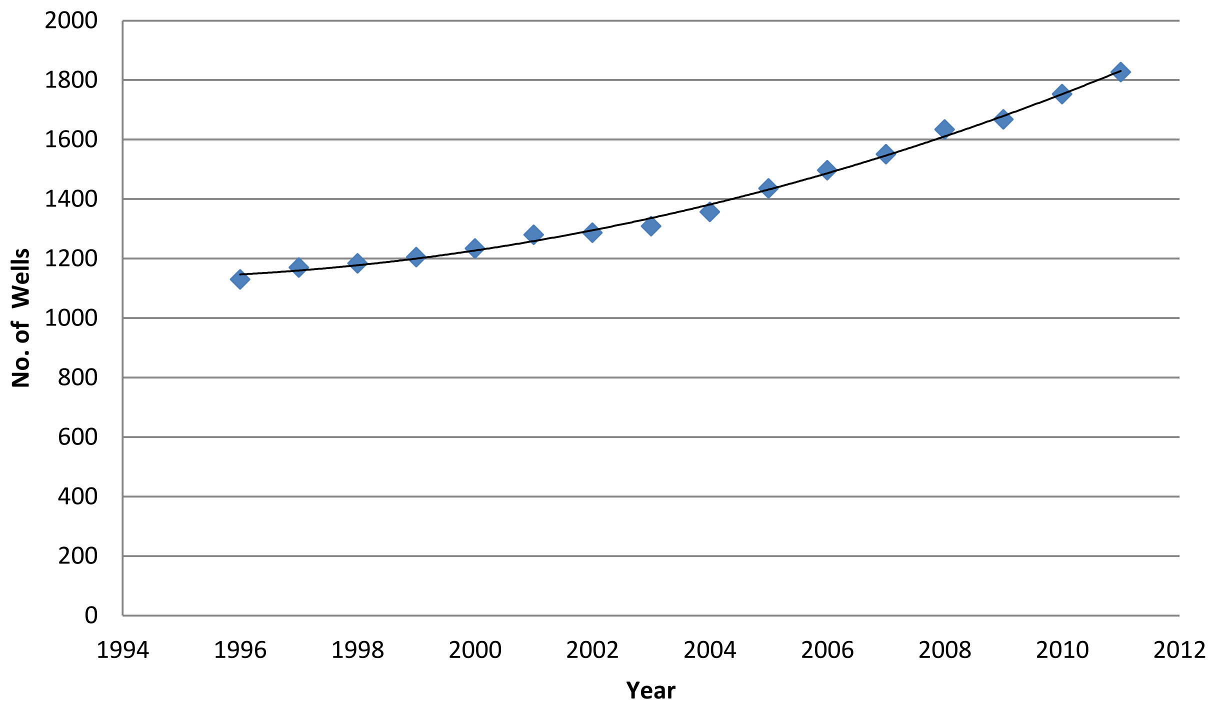

Figure 4. Number of producing wells in sample townships of the Wyoming Basin Ecoregion.

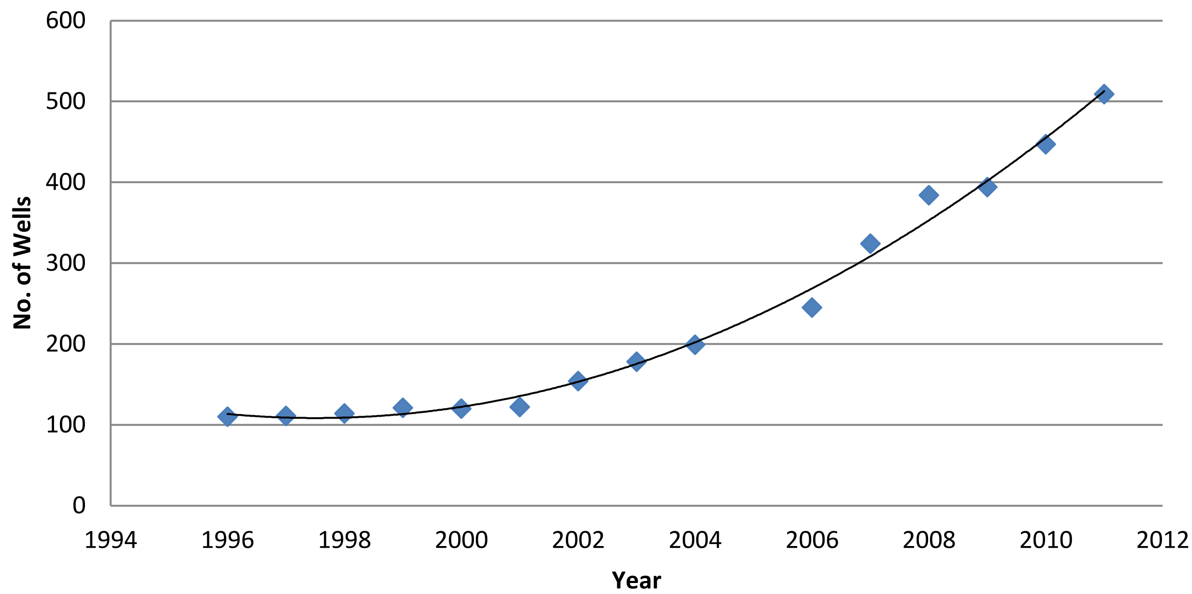

Figure 5. Number of producing wells in the Baggs Study Area.

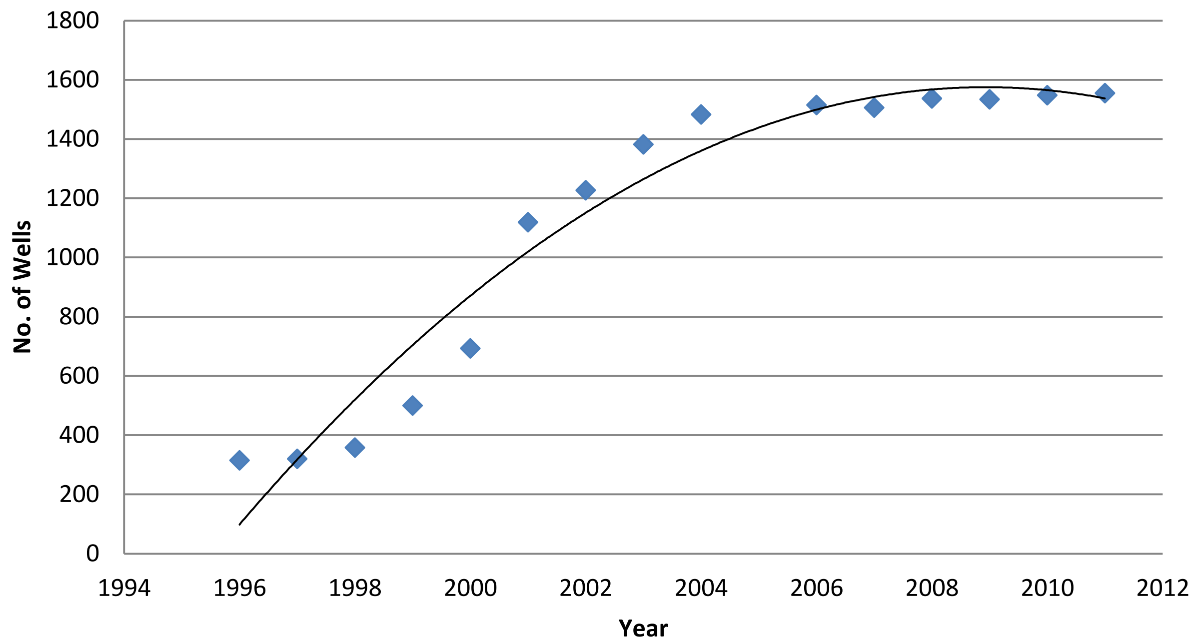

Figure 6. Number of producing wells in sample townships the Powder River Basin Study Area.

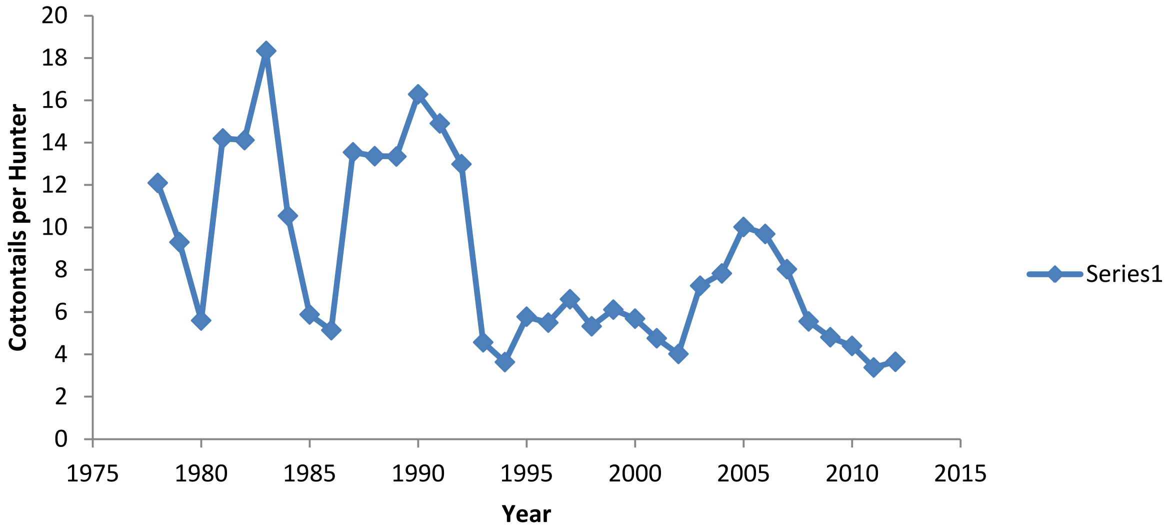

Figure 7. Cottontail rabbits (*Sylvilagus* spp.) harvest per hunter in Wyoming (WGFD 2013).

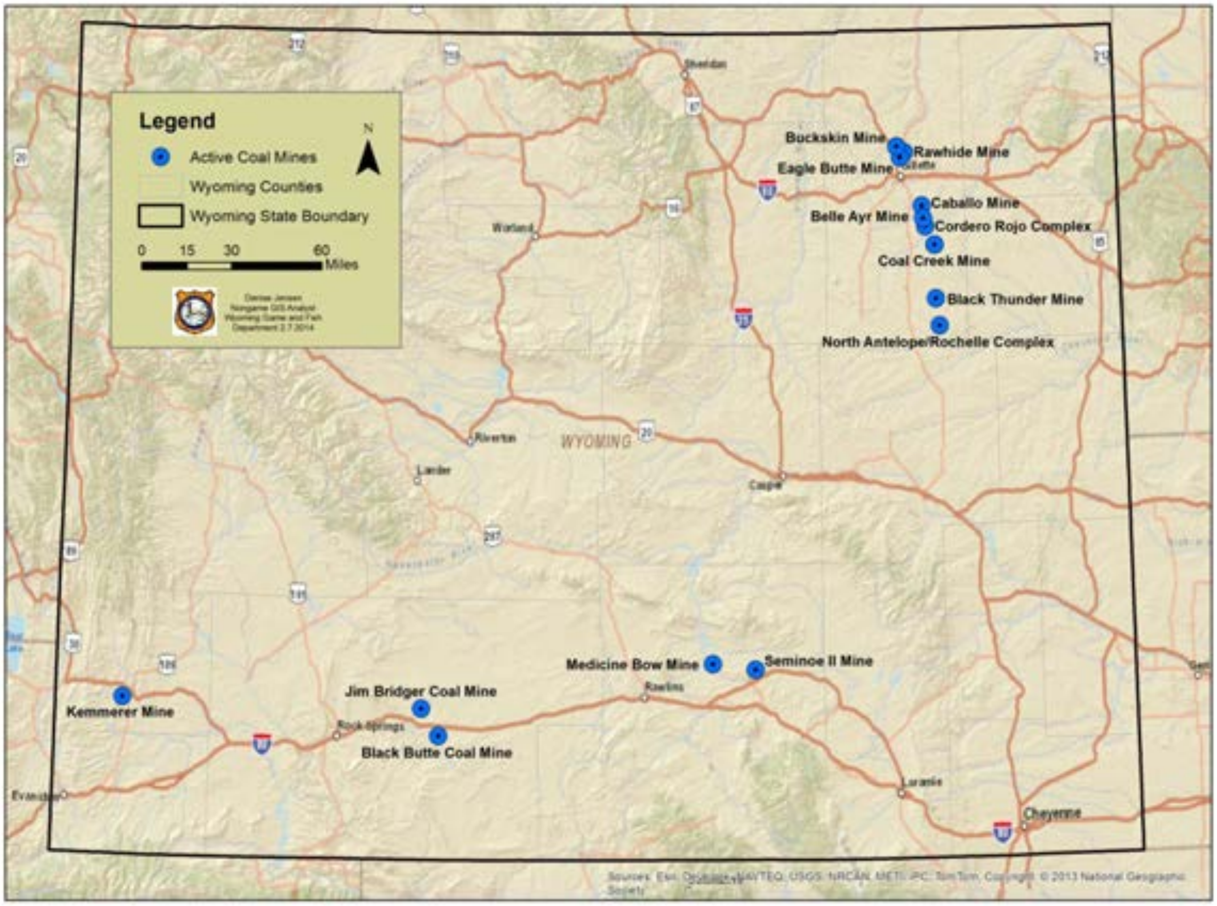

Figure 8. Location of coal mines reporting wildlife surveys in Wyoming.

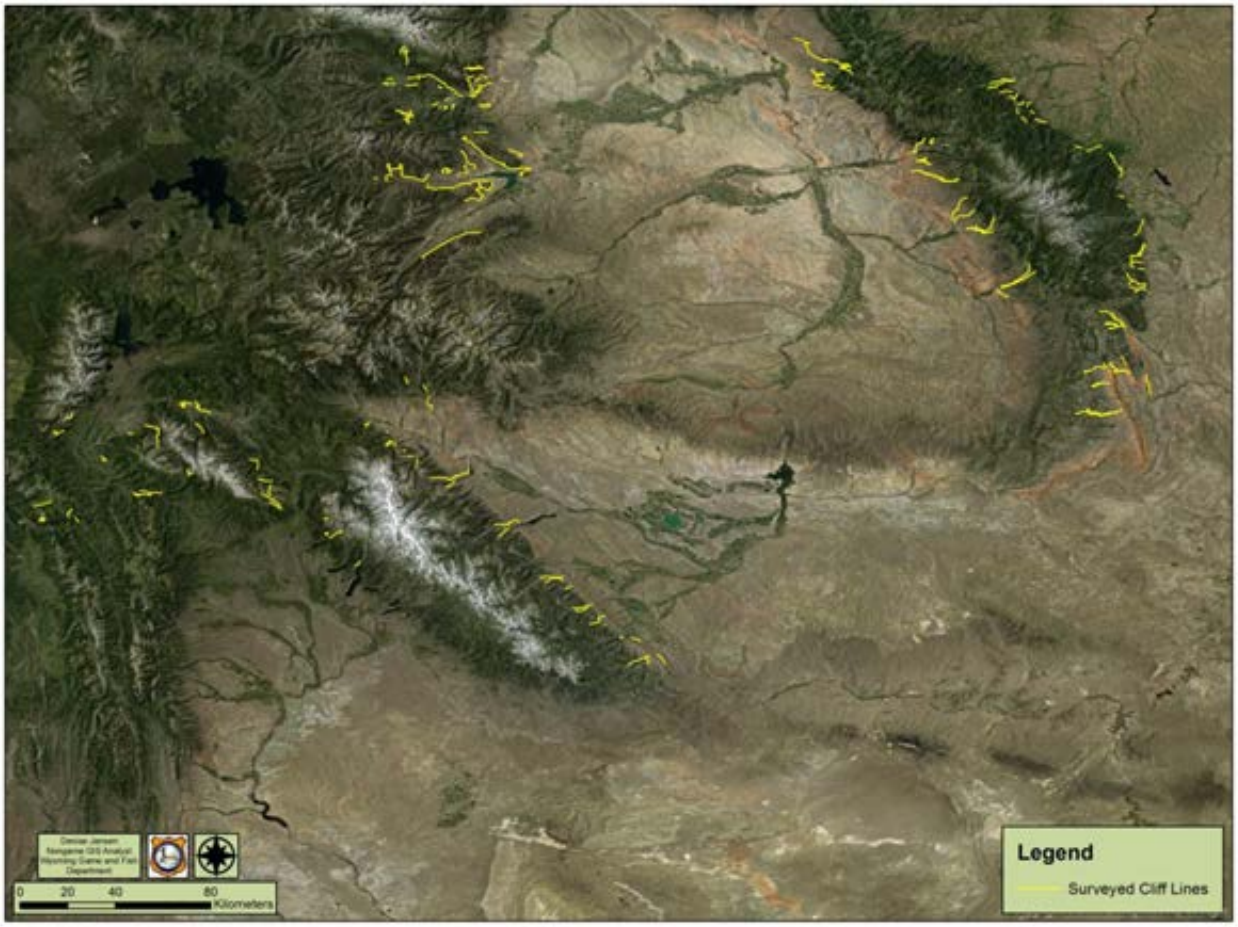

Figure 9. Cliffs surveyed in 1978-1982 and in 2013.

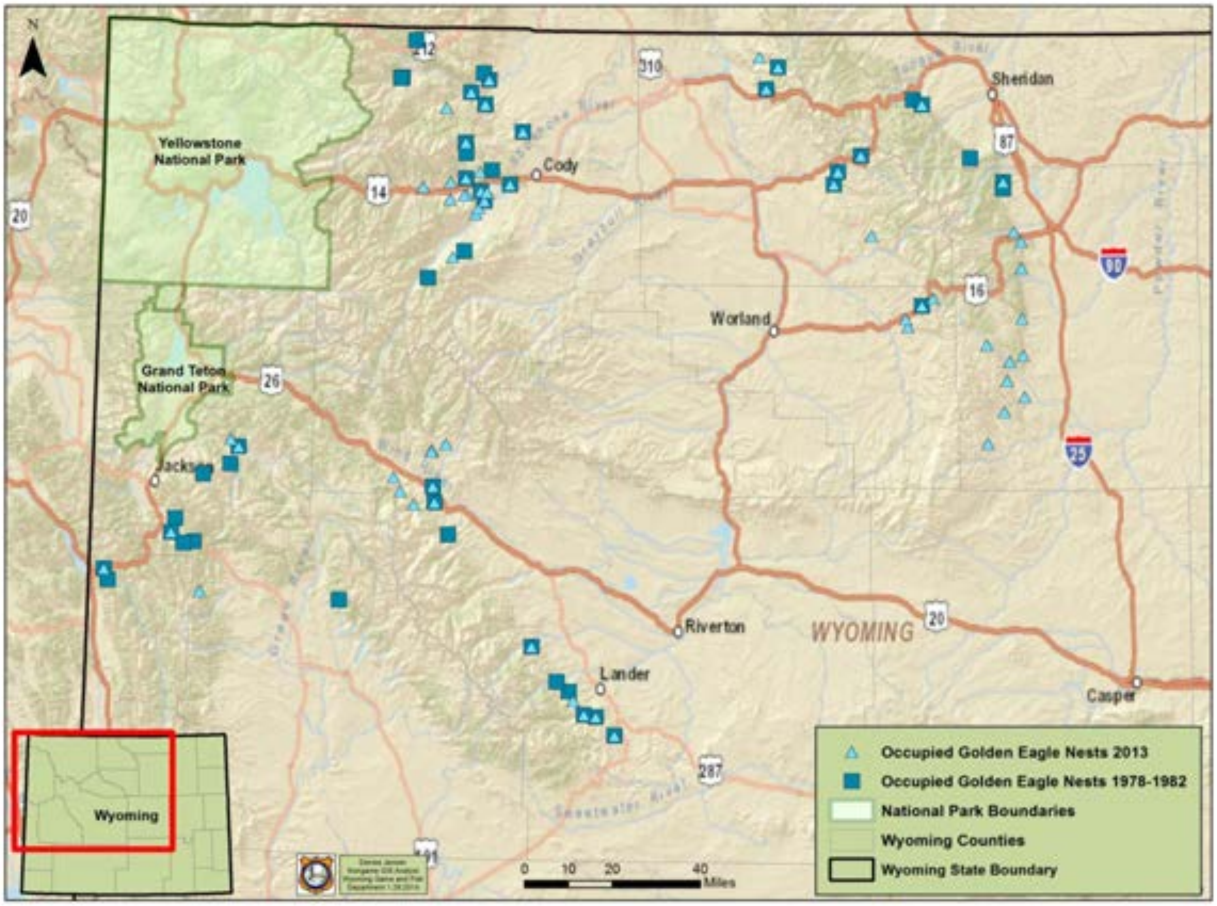

Figure 10. Occupied Golden Eagle (*Aquila chrysaetos*) nests located during helicopter surveys during 1978-1982 (squares) and during repeat surveys in 2013 (triangles).

USING THE BREEDING BIRD SURVEY TO MONITOR POPULATION TRENDS OF AVIAN SPECIES IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Other Nongame

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
National Park Service Cooperative Agreement
United States Forest Service Cooperative Agreement
Bureau of Land Management Cooperative Agreement
United States Fish and Wildlife Service Cooperative Agreement
Bureau of Reclamation Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
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Unites States Geological Survey – Biological Resources Division

ABSTRACT

The Breeding Bird Survey has provided long-term monitoring of a variety of avian species in Wyoming since 1968. In 2012, volunteers surveyed 58 Breeding Bird Survey routes across the state. Overall, survey effort and number of detections per survey route have decreased, while the number of species detected per route has increased. Similar to last year, population trend analysis was not available for 2013 at the time of publication. Recruiting knowledgeable volunteers to conduct Breeding Bird Survey routes is critical to ensuring the success of the Breeding Bird Survey and our ability to continue to monitor breeding bird populations along roadside surveys.

INTRODUCTION

Forty-four nongame avian species are classified as Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (Department; WGFD 2010). However, only a small number of these are adequately monitored with species-specific surveys. Consequently, the Department utilizes data from other large-scale, multi-species survey efforts to monitor trends in avian populations. The Breeding Bird Survey (BBS) is used to monitor trends of breeding birds across North America. The BBS is sponsored jointly by the United States

Geological Survey – Biological Resources Division (USGS-BRD; formerly the United States Fish and Wildlife Service) and the Canadian Wildlife Service. Over 4,500 BBS routes are located across the continental US and Canada, with 108 established routes in Wyoming. The USGS-BRD has reviewed and analyzed data collected from the BBS since the survey's inception in 1966 in the East and 1968 in the West. BBS data provide indices of population abundance and can be used to estimate population trends and relative abundance of individual species at the continental, western region, statewide, and physiographic region scale.

Our original objectives in 2013 were to: 1) add additional data to the BBS, and 2) interpret current trends of nongame breeding birds in Wyoming. We were able to accomplish the first objective. However, due to the unavailability of 2013 population trend analysis for reasons beyond our control, we were unable to accomplish our second objective. In order to alleviate this problem in the future, we present 2012 results in this report and will present 2013 results in next year's report. While 2013 population trend analysis had not been completed by publication time, it is available through 2010 for over 420 species of birds (Sauer et al. 2011). All raw data can be accessed on the BBS web site <http://www.pwrc.usgs.gov/bbs/>.

METHODS

Volunteers are instructed to conduct BBS routes during the height of the avian breeding season when birds are most vocal. This is typically during the month of June, although routes in higher elevations can be conducted through the first week of July. Each route is 39.4 km long and consists of 50 stops spaced every 0.8 km. Beginning 0.5 hr before sunrise, observers record birds seen within a 0.4-km radius and all birds heard at each stop during a 3-min period. Each route is surveyed once annually, and data are submitted to the USGS-BRD for analysis. For all summary statistics on survey effort, we report averages ±SE. We only include data from those routes that had data submitted to the BBS by the due date. All analyses on abundance of breeding birds in Wyoming were conducted by USGS-BRD.

RESULTS

In 2012, observers surveyed approximately 2,527 of 3,511 (72 %) available routes in the US (USGS-BRD will not have final 2012 counts for available and surveyed routes until summer 2013). In Wyoming, observers attempted to survey 64 of the 108 (59%) established routes. We report results for 58 (90%) of the 64 attempted routes that were surveyed. The remaining six (9%) routes were surveyed but were not included in the analysis because data were not submitted to USGS-BRD by the due date (Table 1). Since 1990, the number of routes surveyed in Wyoming has decreased by 0.88 routes per year (P<0.001; R^2=0.5786; Fig. 1). Consistent with this trend, the number of routes surveyed in 2012 (i.e., 58 routes) was less than the mean number of routes completed from 1990-2011 (65.0 ±1.69 routes).

Observers detected a total of 26,699 individual birds representing 181 species in Wyoming (Table 2). Since 1990, the number of individuals detected has decreased by 5.0 individuals per route per year (P<0.001; R^2=0.570; Fig. 2), but the number of species detected has increased by 0.19 species per route per year (*P*<0.001; R^2=0.638; Fig. 3). Consistent with these trends, the number of individuals detected per route in 2012 (i.e., 458.6 ±39.2 individuals) was less than the mean number of individuals detected per route between 1990–2-11 (i.e., 536.8 ±9.1 individuals), but the number of species detected per route (i.e., 38.2 ±1.7 species) was similar to the mean number of species detected per route between 1990-2011 (i.e., 38.1 ±0.4 species).

DISCUSSION

A complete history of BBS observers and routes surveyed in Wyoming from 1968 through 2012 is available from the Department's Nongame Bird Biologist in the Lander Regional Office. Because the primary purpose of the BBS is to monitor population trends of avian species nationwide, it is important that each route is conducted annually, preferably by the same observer. However, in Wyoming fewer than 20 of the 108 total routes have been surveyed annually or with minimal interruptions in the annual survey cycle for >10 years. Most routes contain gaps in surveys of ≥2 years or have had ≥2 observers. There are several causes of BBS observer disruption: change in location or job duties during the course of an observer's career, loss of observers as they age and have increasing difficulty detecting vocalizations, and a limited pool of new and skillful observers in Wyoming from which to draw. In addition, as the degree of urbanization steadily increases, associated problems with safety and noise are an issue on some BBS routes. Dangerous routes have been altered or to address these problems, while the data gathered from progressively urbanized routes are important to the BBS's ability to measure changes on the landscape that birds are experiencing.

Overall, survey effort has decreased in the last 22 years. On average, the number of routes completed decreased by 0.88 routes per year. While 2012 recorded the third lowest number of routes completed since 1990 at 60 routes completed, this was an increase by 5 routes from 2011, advancing us from the 26-50% completion bracket to the 51-75% completion bracket. While the number of individual birds detected per route has decreased steadily, the number of species detected per route has increased over time. This increase in number of species per route is interesting, and may represent changes in species distributions or increases in identification skills of observers over time.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would like to thank the many volunteers and biologists from this and other natural resources management agencies for their valuable contributions to the 2013 Breeding Bird Survey (see names in Table 1). The continued dedication of these individuals and agencies to this monitoring effort makes it possible to collect long-term population trend data on numerous avian species in Wyoming.

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Table 1. Latitudinal/longitudinal (latilong) degree block, observer, number of avian species detected, and number of individuals recorded for each Breeding Bird Survey route in Wyoming, 2012. Data are presented in numerical order by survey route. Late data are not included in analyses and are represented by 'not available.'

Route number and name	Latilong	Observer	Species	Individuals
1 – NE Entrance, YNP	1	Amanda Boyd	48	677
2 – Cody	2	Grace Nutting	31	252
3 – Otto	3	Observer needed		
4 – Basin	4	N/A – discontinued		
5 – Wyarno	5	John Berry	42	1163
6 – Clarkelen	6	N/A – discontinued		
7 – Sundance	7	Jennifer Adams	57	538
8 – Colter Bay	8	N/A – discontinued		
9 – Dubois	9	Jazmyn McDonald	55	324
10 – Midvale	10	Observer needed		
11 – Nowood	11	Donna Walgren	38	266
12 – Natrona	12	N/A – discontinued		
13 – Bill	13	Observer needed		
14 – Redbird	14	N/A – discontinued		
15 – Fontenelle	15	Carol Deno	52	443
16 – Elk Horn	16	Sid Johnson	Not available	Not available
17 – Bear Creek	17	Andrea Orabona	Not conducted	Not conducted
18 – Ervay	18	Jazmyn McDonald	31	246
19 – Brookhurst	19	Bruce Walgren	50	340
20 – Glenrock	20	N/A – discontinued		
21 – Dwyer	21	Martin Hicks	Not conducted	Not conducted
22 – Cumberland	22	Carol Deno	21	175
23 – McKinnon	23	N/A – discontinued		
24 – Patrick Draw		N/A – discontinued		
25 – Savery	25	Marie Adams	46	367
26 – Riverside	26	Steve Loose	46	749
27 – Buford	27	Suzanne Fellows	Not conducted	Not conducted
28 – Yoder	28	Jim Lawrence	50	1003
29 – Canyon		N/A – discontinued		
30 – Mammoth, YNP	1	Amanda Boyd	54	548
31 – West Thumb	--	N/A – discontinued		
32 – Hunter Peak	2	Kathryn Hicks	Not conducted	Not conducted
33 – Clark	2	Observer needed		
34 – no route		N/A – no route		
35 – Frannie	3	Observer needed		
36 – Moose	8	Christine Paige	44	479
37 – Lovell	3	Observer needed		
38 – Meeteetse	3	Jazmyn McDonald	55	596
39 – Ten Sleep	4	C.J. Grimes	45	370
40 – Dayton	4	Tracey Ostheimer	59	704

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
41 – Bald Mountain	4	Observer needed		
42 – Crazy Woman	5	Grace Nutting	43	192
43 – Schoonover	5	Observer needed		
44 – Arvada	5	Donald Brewer	31	449
45 – Recluse	6	Observer needed		
46 – Soda Well	6	Observer needed		
47 – Piney		N/A – discontinued		
48 – Seely		N/A – discontinued		
49 – Upton	7	Laurie Van Fleet	32	742
50 – Moskee		N/A – discontinued		
51 – Alpine	8	Susan Patla	50	381
52 – Wilson	8	Observer needed		
53 – Horse Creek	9	Eva Crane	48	310
54 – no route		N/A – no route		
55 – Crowheart	9	James Downham	Not conducted	Not conducted
56 – Ethete	10	Jim Downham	Not conducted	Not conducted
57 – Anchor	10	Pat Hnilicka	Not conducted	Not conducted
58 – Gebo	10	Jazmyn McDonald	39	397
59 – Arminto	11	Heather O'Brien	30	331
60 – Lysite	11	Greg Anderson	21	450
61 – Worland	11	C.J. Grimes	36	353
62 – Teapot Dome	12	Observer needed		
63 – Mayoworth	12	Observer needed		
64 – Sussex	12	Bill Ostheimer	39	499
65 – Harland Flats	13	Observer needed		
66 – Pine Tree	13	Observer needed		
67 – Highlight		N/A – discontinued		
68 – Riverview	14	Observer needed		
69 – Newcastle	14	Laurie Van Fleet	32	733
70 – Raven	14	Nichole Cudworth	26	405
71 – Soda Lake	15	Observer needed		
72 – Buckskin Mountain	15	Lara Oles	Not available	Not available
73 – Daniel		N/A – discontinued		
74 – Boulder	16	Susan Patla	45	435
75 – Big Sandy	16	Susan Patla	44	350
76 – Farson	16	Sid Johnson	Not available	Not available
77 – Fiddler Lake	17	Eva Crane	41	266
78 – Sand Draw	17	Jazmyn McDonald	25	326
79 – Sweetwater	17	Stan Harter	Not conducted	Not conducted
80 – Gas Hills	18	Courtney Rudd	18	255
81 – Bairoil	18	Greg Hiatt	21	185
82 – Lamont	18	Greg Hiatt	39	249
83 – Pathfinder	19	Laurie Schwieger	33	323

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
84 – Leo	19	Donna Walgren	36	223
85 – Shirley	19	Linda Drury	22	248
86 – Warbonnet	20	James Lawrence	57	451
87 – Fletcher Peak	20	Gloria Lawrence	56	445
88 – Shawnee	20	Observer needed		
89 – Meadowdale	21	Martin Hicks	Not conducted	Not conducted
90 – Lusk	21	Gloria Lawrence	28	840
91 – Lingle	21	Observer needed		
92 – Diamondville		N/A – discontinued		
93 – Mountain View	22	Martin Hicks	Not conducted	Not conducted
94 – no route		N/A – discontinued		
95 – Green River		N/A – discontinued		
96 – Reliance	23	Observer needed		
97 – Rock Springs	23	Fern Linton	30	209
98 – Black Rock		N/A – discontinued		
99 – no route		N/A – no route		
100 – no route		N/A – no route		
101 – Wamsutter	25	Tony Mong	Not conducted	Not conducted
102 – Rawlins	25	Observer needed		
103 – Baggs	25	Tony Mong	Not conducted	Not conducted
104 – Walcott	26	Frank Blomquist	46	439
105 – Fox Park	26	Observer needed		
106 – Ryan Park	26	Debbie Wagner	39	277
107 – Sybille Canyon	27	Ian Abernethy	51	646
108 – Rock River	27	Matt Carling	Not available	Not available
109 – Harmony	27	Observer needed		
110 – Cheyenne	28	Chuck Seniawski	23	357
111 – Chugwater	**28**	**Chuck Seniawski**	28	441
112 – Pine Bluff	28	Chuck Seniawski	22	513
120 – Welch	20	Chris Michelson	39	336
123 – Flaming Gorge	23	Observer needed		
147 – Rozet	6	Observer needed		
148 – Seely 2	7	Mary Yemington	41	502
150 – Government Valley	7	Jennifer Adams	42	701
167 – Thunder Basin	13	Nichole Cudworth	21	313
173 – Rye Grass	15	Observer needed		
192 – Carter	23	Observer needed		
195 – Seedskadee	23	Observer needed		
198 – Black Rock 2	24	Andrea Orabona	11	201
204 – Basin 2	4	Observer needed		
206 – Caballa Creek	6	Sandra Johnson	31	450
208 – Moran	8	Susan Wolff	Not available	Not available
212 – Bucknum	12	Larry Keffer	Not available	Not available

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
214 – Hampshire	14	Observer needed		
224 – Patrick Draw III		N/A – discontinued		
250 – Moskee 2	7	Jennifer Adams	Not conducted	Not conducted
524 – Patrick Draw VI	24	Laurie Van Fleet	23	315
900 – Hayden Valley		N/A – discontinued		
901 – Yellowstone, YNP	1	Amanda Boyd	48	1921
902 – Pryor Flats	1	Observer needed		

Table 2. Number of individuals and relative abundance of each species detected on Breeding Bird Survey routes in Wyoming, 2012. Data are presented in phylogenetic order. The 30 most abundant species detected on BBS routes in 2012 are denoted by an asterisk.

Order	Species (common name)	Number detected	Relative abundance (%)
Anseriformes	*Canada Goose	1488	5.57
	Trumpeter Swan	7	0.03
	Gadwall	10	0.04
	American Wigeon	66	0.25
	*Mallard	181	0.68
	Blue-winged Teal	16	0.06
	Cinnamon Teal	7	0.03
	Northern Shoveler	20	0.07
	Northern Pintail	9	0.03
	Green-winged Teal	13	0.05
	Canvasback	1	<0.01
	Redhead	3	0.01
	Ring-necked Duck	34	0.13
	Lesser Scaup	22	0.08
	Bufflehead	2	0.01
	Barrow's Goldeneye	21	0.08
	Common Merganser	21	0.08
	Ruddy Duck	1	<0.01
Galliformes	Northern Bobwhite	1	<0.01
	Chukar	3	0.01
	Gray Partridge	2	0.01
	Ring-necked Pheasant	105	0.39
	Ruffed Grouse	2	0.01
	Greater Sage-Grouse	92	0.34
	Dusky Grouse	1	<0.01
	Sharp-tailed Grouse	30	0.11
	Wild Turkey	32	0.12
Podicipediformes	Eared Grebe	22	0.08
	Western Grebe	3	0.01
Suliformes	Double-crested Cormorant	5	0.02
Pelecaniformes	American White Pelican	57	0.21
	Great Blue Heron	17	0.06
Accipitriformes	Turkey Vulture	59	0.22
	Osprey	2	0.01
	Bald Eagle	5	0.02
	Northern Harrier	13	0.05
	Northern Goshawk	2	0.01
	Broad-winged Hawk	1	<0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
	Swainson's Hawk	24	0.09
	Red-tailed Hawk	92	0.34
	Ferruginous Hawk	27	0.10
	Golden Eagle	25	0.09
Falconiformes	American Kestrel	54	0.20
	Merlin	2	0.01
	Peregrine Falcon	1	<0.01
	Prairie Falcon	9	0.03
Gruiformes	Sora	4	0.01
	American Coot	16	0.06
	Sandhill Crane	69	0.26
Charadriiformes	Killdeer	169	0.63
	Mountain Plover	1	<0.01
	American Avocet	27	0.10
	Spotted Sandpiper	52	0.19
	Willet	26	0.10
	Upland Sandpiper	47	0.18
	Long-billed Curlew	9	0.03
	Wilson's Snipe	120	0.45
	Wilson's Phalarope	14	0.05
	Franklin's Gull	1	<0.01
	California Gull	19	0.07
	Unid. Gull	8	0.03
Columbiformes	Rock Pigeon	83	0.31
	Eurasian Collared-Dove	28	0.10
	*Mourning Dove	744	2.79
Strigiformes	Great Horned Owl	7	0.03
	Burrowing Owl	3	0.01
	Short-eared Owl	6	0.02
Caprimulgiformes	Common Nighthawk	134	0.50
	Common Poorwill	1	<0.01
Apodiformes	Broad-tailed Hummingbird	14	0.05
Coraciiformes	Belted Kingfisher	6	0.02
Piciformes	Lewis's Woodpecker	4	0.01
	Red-headed Woodpecker	1	<0.01
	Williamson's Sapsucker	1	<0.01
	Red-naped Sapsucker	8	0.03
	Downy Woodpecker	4	0.01
	Hairy Woodpecker	9	0.03
	American Three-toed Woodpecker	5	0.02

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Piciformes	Northern Flicker	154	0.58
Passeriformes	Olive-sided Flycatcher	7	0.03
	Western Wood-Pewee	121	0.45
	Willow Flycatcher	24	0.09
	Least Flycatcher	2	0.01
	Hammond’s Flycatcher	18	0.07
	Dusky Flycatcher	48	0.18
	Cordilleran Flycatcher	12	0.04
	Say’s Phoebe	46	0.17
	*Western Kingbird	187	0.70
	Eastern Kingbird	63	0.24
	Loggerhead Shrike	62	0.23
	Plumbeous Vireo	25	0.09
	*Warbling Vireo	272	1.02
	Red-eyed Vireo	2	0.01
	Gray Jay	12	0.04
	Blue Jay	10	0.04
	Pinyon Jay	5	0.02
	Clark’s Nutcracker	50	0.19
	*Black-billed Magpie	417	1.56
	*American Crow	170	0.64
	Common Raven	170	0.64
	*Horned Lark	1965	7.36
	Tree Swallow	134	0.50
	Violet-green Swallow	101	0.38
	Northern Rough-winged Swallow	115	0.43
	Bank Swallow	108	0.40
	*Cliff Swallow	1122	4.20
	*Barn Swallow	192	0.72
	Black-capped Chickadee	33	0.12
	Mountain Chickadee	70	0.26
	Bushtit	1	<0.01
	Red-breasted Nuthatch	41	0.15
	White-breasted Nuthatch	13	0.05
	*Rock Wren	209	0.78
	House Wren	129	0.48
	Marsh Wren	1	<0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	American Dipper	2	0.01
	Golden-crowned Kinglet	1	<0.01
	*Ruby-crowned Kinglet	272	1.02
	Mountain Bluebird	165	0.62
	Townsend’s Solitaire	16	0.06
	Veery	17	0.06
	Swainson’s Thrush	26	0.10
	Hermit Thrush	50	0.19
	*American Robin	1092	4.09
	Gray Catbird	36	0.13
	Northern Mockingbird	1	<0.01
	*Sage Thrasher	491	1.84
	Brown Thrasher	2	0.01
	*European Starling	419	1.57
	Cedar Waxwing	30	0.11
	Chestnut-collared Longspur	9	0.03
	McCown’s Longspur	75	0.28
	Ovenbird	40	0.15
	Orange-crowned Warbler	6	0.02
	MacGillivray’s Warbler	35	0.13
	Common Yellowthroat	59	0.22
	American Redstart	14	0.05
	*Yellow Warbler	324	1.21
	Chestnut-sided Warbler	1	<0.01
	Yellow-rumped Warbler	149	0.56
	Wilson’s Warbler	12	0.04
	Yellow-breasted Chat	9	0.03
	*Green-tailed Towhee	228	0.85
	Spotted Towhee	85	0.32
	Cassin’s Sparrow	2	0.01
	*Chipping Sparrow	207	0.78
	Clay-colored Sparrow	10	0.04
	*Brewer’s Sparrow	810	3.03
	*Vesper Sparrow	1100	4.12
	*Lark Sparrow	310	1.16
	*Sage Sparrow	199	0.75
	*Lark Bunting	1723	6.45
	*Savannah Sparrow	187	0.70
	Grasshopper Sparrow	100	0.37
	Fox Sparrow	9	0.03
	Song Sparrow	144	0.54

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	Lincoln's Sparrow	103	0.39
	White-crowned Sparrow	96	0.36
	Dark-eyed Junco	217	0.81
	Western Tanager	44	0.16
	Black-headed Grosbeak	32	0.12
	Blue Grosbeak	9	0.03
	Lazuli Bunting	30	0.11
	Dickcissel	17	0.06
	Bobolink	19	0.07
	*Red-winged Blackbird	1209	4.53
	*Western Meadowlark	3790	14.20
	Yellow-headed Blackbird	32	0.12
	*Brewer's Blackbird	940	3.52
	*Common Grackle	259	0.97
	Great-tailed Grackle	1	<0.01
	*Brown-headed Cowbird	344	1.29
	Orchard Oriole	1	<0.01
	Bullock's Oriole	89	0.33
	Cassin's Finch	32	0.12
	House Finch	16	0.06
	Red Crossbill	82	0.31
	*Pine Siskin	269	1.01
	American Goldfinch	76	0.28
	Evening Grosbeak	3	0.01
	House Sparrow	160	0.60
	Total Individuals	26699	
	Total Species	181	

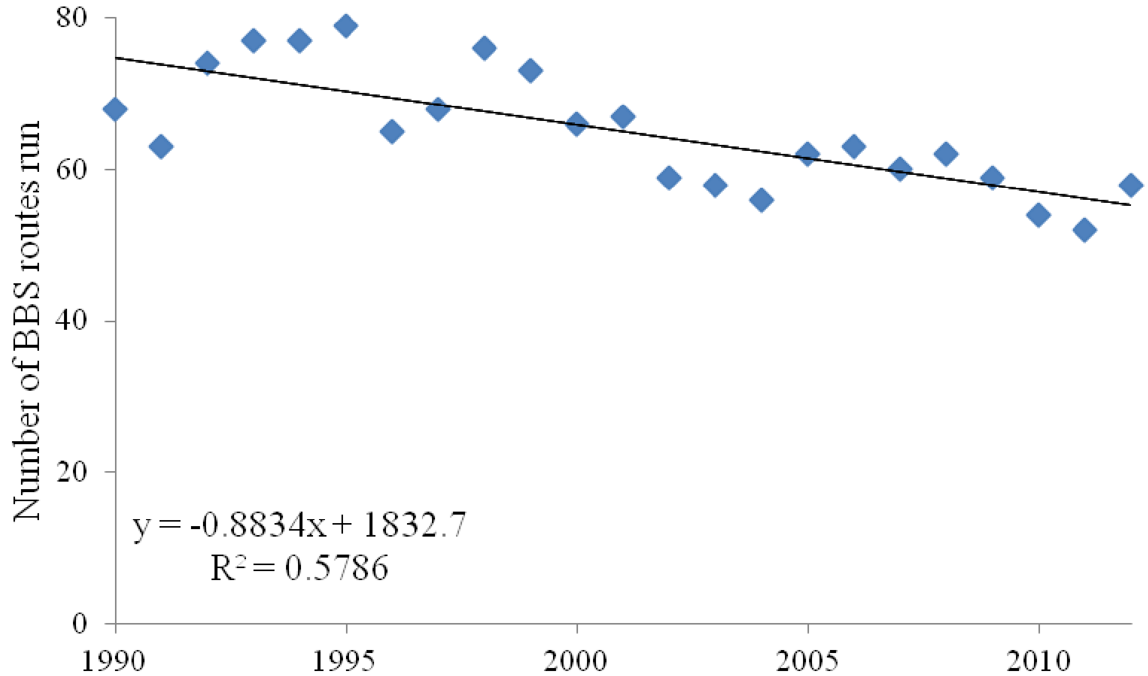

Figure 1. Number of Breeding Bird Survey routes completed in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

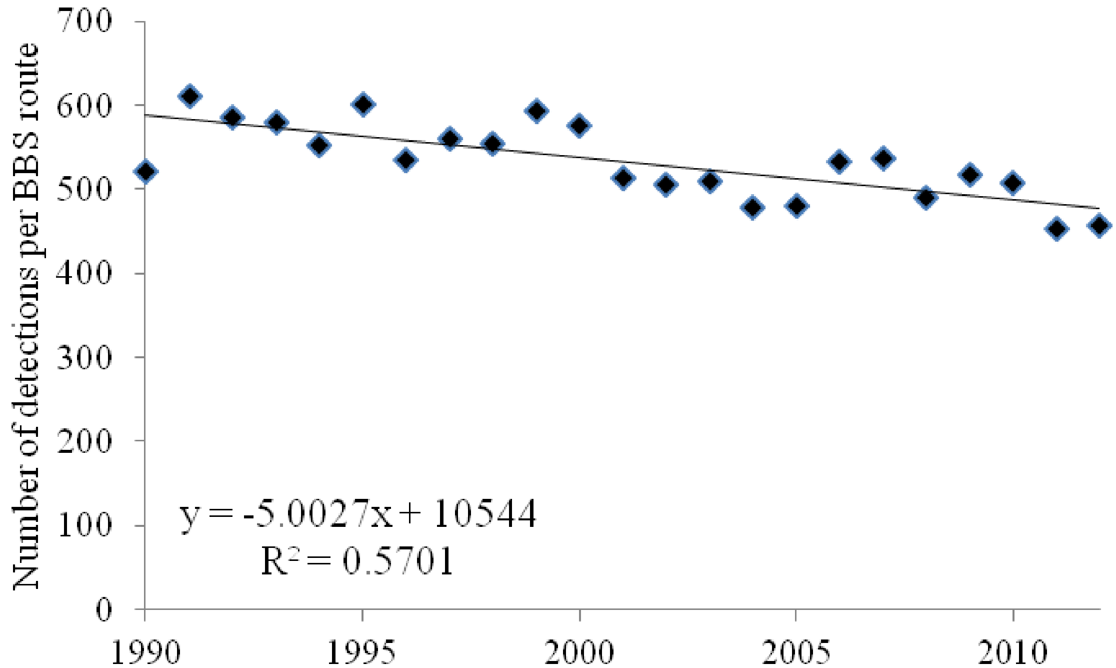

Figure 2. Average number of individual detections of birds per Breeding Bird Survey route in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

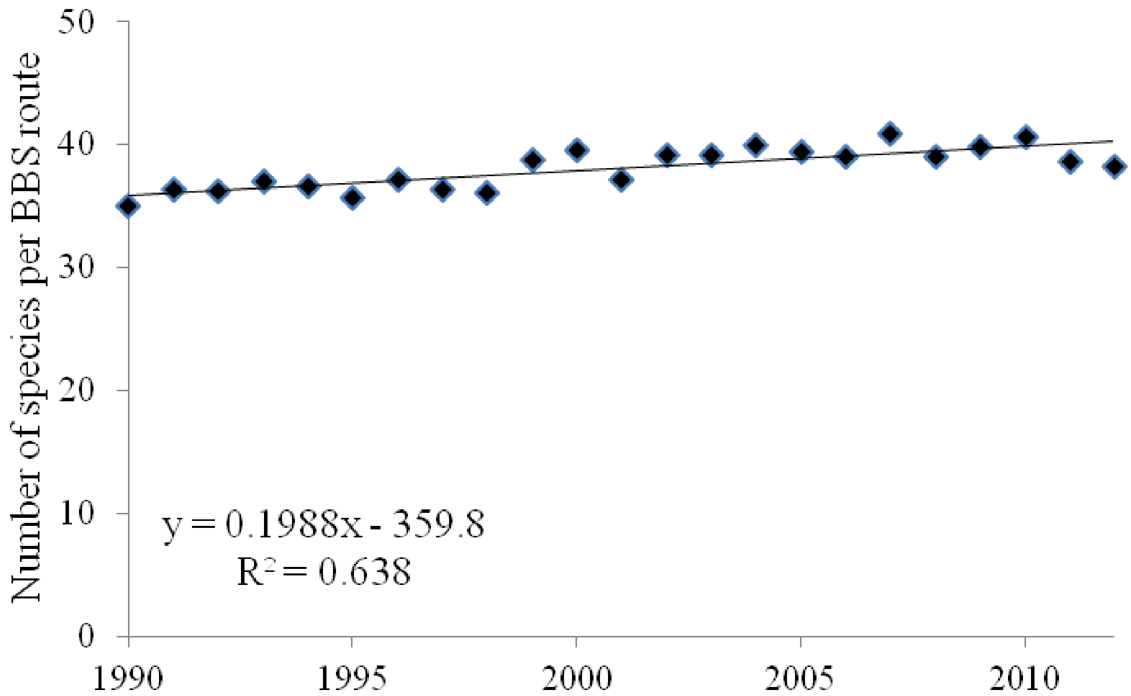

Figure 3. Average number of species detected per Breeding Bird Survey route in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

WYOMING PARTNERS IN FLIGHT AND INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Funds
Bureau of Land Management Cooperative Agreement
United States Fish and Wildlife Service State Wildlife Grants
United States Forest Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

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ABSTRACT

Landbird populations have declined due to a variety of influences, both natural and human-caused. The Partners in Flight program was initiated in 1990 to address these declines through comprehensive bird conservation planning efforts. Wyoming's working group, Wyoming Partners in Flight, produced the Wyoming Bird Conservation Plan, Version 2.0, which presents avian population objectives, habitat objectives, Best Management Practices to benefit birds, and recommendations to ensure the viability of birds and their habitats, and was used to develop portions of the State Wildlife Action Plan (Nicholoff 2003, WGFD 2010). Monitoring is a key component of the Wyoming Bird Conservation Plan. Through cooperative funding via Wyoming Partners in Flight, numerous partners have cooperatively implemented the Integrated Monitoring in Bird Conservation Regions (formerly Monitoring Wyoming's Birds) program, which allows us to estimate density, population size, occupancy, and detection probabilities for numerous avian species, including Species of Greatest Conservation Need. In 2013, field

technicians completed 2,814 point counts on 216 of the 217 planned grids within 4 Bird Conservation Regions in Wyoming, and detected 172 species, including 24 Species of Greatest Conservation Need (SGCN). Biometricians determined occupancy for 138 species, including 13 SGCN; data provided robust estimates for all 138 species. Biometricians estimated density and population size for 137 species, including 15 SGCN; data provided robust estimates for 62 species, including 4 SGCN. The Integrated Monitoring in Bird Conservation Regions design allows us to monitor trends of avian Species of Greatest Conservation Need that may be overlooked or under-represented by other survey techniques, including sagebrush- and grassland-obligate species; permits slight modifications to the design in order to investigate other priority species as needs arise; reduces monitoring costs through coordination and collaboration with monitoring partners; and can be stepped up to evaluate population parameters on a regional scale.

INTRODUCTION

Long-term data analyses indicate that trends for many populations of North American landbirds have declined due to land use changes; habitat loss, fragmentation, and deterioration; pesticide use; and human influences and disturbance (Robbins et al. 1989, Peterjohn et al. 1995, Sauer et al. 1996, Boren et al. 1999, Donovan and Flather 2002). The International Partners in Flight (PIF) program was initiated in 1990 to address and reverse these declines. The PIF mission is to help species at risk and to keep common birds common through voluntary partnerships that benefit birds, habitats, and people. State, regional, national, and international Bird Conservation Plans comprehensively address the issues of avian and habitat conservation on a landscape scale. The North American Bird Conservation Initiative (NABCI) was initiated in 1998 to ensure the long-term health of North America's native bird populations through effective conservation initiatives, enhanced coordination among the initiatives, and increased cooperation among the governments and citizens of Canada, the US, and Mexico (NABCI 2012).

The state PIF working group, Wyoming Partners in Flight (WYPIF), was established in 1991 and is comprised of participants from the Wyoming Game and Fish Department (Department), Bureau of Land Management (BLM), US Forest Service (USFS), US Fish and Wildlife Service, Bureau of Reclamation, National Park Service, Rocky Mountain Bird Observatory (RMBO), Audubon Rockies and affiliate chapters, Wyoming Natural Diversity Database (WYNDD), University of Wyoming, and The Nature Conservancy. The Department's Nongame Bird Biologist has served as the WYPIF chairperson since its inception. As a group, WYPIF produced the Wyoming Bird Conservation Plan, Version 2.0 (Plan; Nicholoff 2003). The Plan presents objectives for populations of birds and major habitat groups in the State, Best Management Practices to benefit birds, and recommendations to ensure that birds and the habitats they require remain intact and viable into the future through proactive and restorative management techniques. Many components of the Plan have been used to develop portions of the Wyoming State Wildlife Action Plan (WGFD 2010).

One of the highest priority objectives throughout the Plan for populations of birds is to implement *Monitoring Wyoming's birds: the plan for count-based monitoring* (Leukering et al.

2001). Monitoring of populations is an essential component of effective wildlife management and conservation (Witmer 2005, Marsh and Trenham 2008). Besides improving distribution data, monitoring allows us to evaluate populations of target species and detect changes over time (Thompson et al. 1998, Sauer and Knutson 2008), identify species that are at risk (Dreitz et al. 2006), and evaluate responses of populations to management actions (Lyons et al. 2008, Alexander et al. 2009) and landscape and climate change (Baron et al. 2008, Lindenmayer and Likens 2009).

For the 13th consecutive year, biologists from the Department, RMBO, BLM, USFS, Audubon Rockies, and WYNDD have collaborated to execute a state-of-the-art avian monitoring program across Wyoming. Resources are provided by numerous federal agency cooperative agreements, State Wildlife Grants funds, and dollars from the Wyoming Governor's Endangered Species Account Fund and Wyoming State Legislature General Fund Appropriations. This cooperative effort allows us to execute a statewide monitoring program for birds and revise distributions and estimate abundance of numerous avian species, including Species of Greatest Conservation Need (SGCN; WGFD 2010). Funding is also provided to develop educational materials and improve outreach opportunities that focus on birds in Wyoming. The RMBO is responsible for implementing the monitoring program, which originally focused on six habitats in Wyoming (i.e., aspen, grassland, juniper woodland, mid-elevation conifer, montane riparian, and shrub-steppe) under the Monitoring Wyoming's Birds design. Since 2009, this monitoring program, now called Integrated Monitoring in Bird Conservation Regions (IMBCR), incorporates a region-wide approach and uses a stratified, spatially balanced, grid-based design (Hanni et al. 2009). The BLM, USFS, and Department (through State Wildlife Grants support) contribute funding to the program, and WYNDD assists in program monitoring. Audubon Rockies assists with inventory and monitoring for those species that require techniques other than point-counts (e.g., Monitoring Avian Productivity and Survivorship [MAPS] bird banding stations), producing and distributing educational materials on birds and their habitats, and providing nature-based outreach opportunities for the public. The Department conducts annual monitoring for SGCN that require species-specific survey methods [e.g., Common Loon (*Gavia immer*) American Bittern (*Botaurus lentiginosus*), Long-billed Curlew (*Numenius americanus*), Mountain Plover (*Charadrius montanus*), Upland Sandpiper (*Bartramia longicauda*), and raptors), prints and distributes PIF educational materials, and provides point data via the Wildlife Observation System database.

METHODS

Bird Conservation Regions (BCRs) constitute the sampling frame for the IMBCR program (Fig. 1). The IMBCR area of inference includes all or parts of 13 western states (Fig. 2). Within the BCR sampling frame, all monitoring partners collaborated to define strata and super-strata based on smaller-scale areas to which we wanted to make inferences (e.g., National Forests, BLM lands, individual states). Within each stratum, the IMBCR design used a spatially balanced sampling algorithm (i.e., generalized random-tessellation stratification) to select sample units (Stevens and Olsen 2004). Biometricians overlaid BCRs with 1-km^2 sample grids, randomly selected sample grids, and used a 4 × 4 array spaced 250 m apart to establish 16 survey points within each sample grid (Hanni et al. 2009).

Prior to surveys, field technicians completed an intensive training program covering protocols, bird identification, and distance estimation. Field technicians used IMBCR sampling protocols established by RMBO to conduct point counts (Buckland et al. 2001, Hanni et al. 2009). These technicians surveyed grids in the morning from 0.5 hr before sunrise to 1100 hrs. They surveyed each survey point for 6 min to facilitate estimation of site occupancy. For each bird detected, field technicians recorded species, sex, horizontal distance from the observer, minute of detection, and type of detection (e.g., song, call, visual). Other information, such as flyovers, clusters, and the presence of species difficult to detect, was also noted. Technicians recorded time, ambient temperature, cloud cover, precipitation, and wind speed at the start and end of each grid. They also recorded vegetation data within a 50-m radius of each survey point and included dominant habitat type, structural stage, relative abundance, percent cover and mean height of trees, species of shrubs, grass height, and groundcover. Distance from a road, if within 100 m, was also recorded.

Biometricians from RMBO used Distance 6.0 to estimate detection probabilities (Thomas et al. 2010). They used the SPSURVEY package in Program R to estimate density, population size, and its variance for each bird species (T. Kincaid, unpubl. data). Lastly, they used a removal design to estimate detection probability for each species (MacKenzie et al. 2006).

RESULTS

In 2013, the IMBCR program encompassed 3 entire states (Colorado, Montana and Wyoming), portions of 9 additional states, 2 entire USFS Regions (Regions 1 and 2), portions of 2 additional USFS Regions, all of 2 BCRs, and portions of 9 additional BCRs (White et al. 2014; Fig. 2).

Between 18 May and 19 July 2013, field technicians and biologists with RMBO and WYNDD completed 2,814 point counts on 216 of the 217 (99%) grids that were planned for surveys within in 4 of the 5 BCRs in Wyoming (White et al. 2014; Table 1; Figs. 1 and 3). The portion of BCR 9 within Wyoming is extremely small compared to the other BCRs in the state, and funding for surveys was unavailable. Statewide results were obtained by compiling and jointly analyzing data from survey locations within 37 different strata (Table 1).

A total of 172 species were detected in 2013, including 24 SGCN (White et al. 2014). RMBO biometricians were able to estimate occupancy (Psi; ψ) for 138 species in 2013, 13 of which are SGCN; data provided robust estimates (i.e., CV <50%) for all 138 species, including 13 SGCN (Table 2). RMBO biometricians were able to estimate density (D) and population size (N) for 137 species in 2013, 15 of which are SGCN; data provided robust density estimates for 62 species, including 4 SGCN (Table 3).

Annual and multi-year reports, species accounts, and density estimate tables and graphs from this monitoring program are available on the Rocky Mountain Avian Data Center web site (RMBO 2013). To view survey locations in Wyoming, occupancy and density results, and species counts across all years of the IMBCR program, follow this link http://www.rmbo.org/new_site/adc/QueryWindow.aspx#N4IgzgrgDgpgTmALnAhoiBbEAuEB1ATRAF8gAA and click the "Run Query" button highlighted in red near the top of the page. To limit the results to just the 2013 field season, follow the link, select "Year" from the Filter drop down box on the top left of the screen, click the "Add" button, select 2013, click "Add Filter", and then click "Run Query" (White et al. 2014).

DISCUSSION

The methods employed by RMBO and project partners to monitor avian populations for the IMBCR program enable us to estimate occupancy, density, and population size for each species when sample sizes are large enough. These robust data not only allow for continuous monitoring of species trends, but also provide information on species abundance and distribution, habitat associations, and evaluation of land management activities (White et al. 2014). The IMBCR provides density and occupancy estimates for a number of avian SGCN at risk in Wyoming due to habitat loss or alteration or for which data on population and trends are lacking. Consequently, the IMBCR provides the Department with an opportunity to monitor trends of avian SGCN that may be overlooked or under-represented by other survey techniques.

Currently, RBMO has completed the Avian Data Center automated analyses, and is working on posting all habitat data under the Monitoring Wyoming's Birds protocol from 2000-2009 to the current IMBCR grid-based design.

As in previous years, the 2013 IMBCR will provide robust density and occupancy estimates for avian SGCN in Wyoming, which helps fill gaps in current monitoring efforts by the Department. Data collected on all species, including SGCN, help address a number of management challenges, including data deficiencies, habitat loss or degradation, and population declines. Specifically, the IMBCR program provides a quantified approach for monitoring several SGCN. The American Three-toed Woodpecker (*Picoides tridactylus*) is found in higher elevation mature and old-growth coniferous forests, and is classified as a Native Species Status Unknown (NSSU) due to unknown population status and trends resulting from existing monitoring efforts that were insufficient to adequately detect this species (WGFD 2010). Three additional species, Brewer's Sparrow (*Spizella breweri*), Sagebrush Sparrow (*Artemesiospiza nevadensis*), and Sage Thrasher (*Oreoscoptes montanus*), are considered sagebrush obligates, and the Grasshopper Sparrow (*Ammodramus savannarum*), Lark Bunting (*Calamospiza melanocorys*), McCown's Longspur (*Rhynchophanes mccownii*), and Chestnut-collared Longspur (*Calcarius ornatus*) are associated with grasslands. Both of these habitats are at high risk for degradation, alteration, or loss, with grasslands listed among the most imperiled habitats in the US and exhibiting dramatic declines in avian populations (WYPIF 2002, WGFD 2010). Consequently, by monitoring SGCN, the IMBCR program can provide an indication of trends for these species, as well as a suite of sagebrush and grassland associated species. However, several SGCN, including the Lewis's Woodpecker (*Melanerpes lewis*), Willow Flycatcher (*Empidonax traillii*), Bobolink (*Dolichonys oryzivorus*), and Dickcissel (*Spiza americana*), have not been detected in sufficient numbers to estimate occupancy or density. If this trend continues, we will need to implement a more targeted approach for these species to obtain adequate population information.

The IMBCR's spatially balanced sampling design is more efficient than simple random sampling and can increase precision in density, occupancy, and detection probability estimates (Stevens and Olsen 2004, White et al. 2014). Additionally, this sampling design provides the flexibility to generate population estimates at various scales relevant to land and wildlife management agencies, enabling managers to use population estimates to make informed management decisions about where to focus conservation efforts. It also allows sampling of all habitats, which enables managers to relate changes in bird populations to changes on the landscape over time. These results support both local and regional conservation efforts in Wyoming. Moreover, the IMBCR design allows us to monitor trends of avian SGCN that may be omitted or inadequately represented by other survey techniques, permits slight modifications to the design in order to investigate other priority species as needs arise, and reduces monitoring costs through coordination and collaboration with monitoring partners.

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Table 1. Number of strata, survey grids, points counts, and species detected, including Species of Greatest Conservation Need in each Bird Conservation Region (BCR) in Wyoming during the 2013 Integrated Monitoring in Bird Conservation Regions program.

BCR name	BCR number	Number of strata	Number of grids completed/ planned	Number of point counts	Number of avian species detected	Number of SGCN detected
Great Basin	9	0	0	0	0	0
Northern Rockies	10	23	119/120	1,616	151	20
Southern Rockies/Colorado Plateau	16	4	41/41	531	100	8
Badlands and Prairies	17	6	40/40	498	104	12
Shortgrass Prairie	18	3	14/14	157	61	6

Table 2. Estimated proportion of sample units occupied (ψ), standard error (SE), percent coefficient of variation (% CV), and number of grids with $\geq$1 detections (n) of 17 avian Species of Greatest Conservation Need on 216 grids surveyed throughout Wyoming from 2009-2013. Occupancy estimates are considered robust if % CV <50%, and are noted in italics.

Species	Year	ψ	SE	% CV	n
American Three-toed Woodpecker	*2010*	*0.034*	*0.012*	*34*	*12*
American Three-toed Woodpecker	*2011*	*0.067*	*0.006*	*9*	*15*
American Three-toed Woodpecker	*2012*	*0.025*	*0.004*	*16*	*8*
American Three-toed Woodpecker	*2013*	*0.047*	*0.009*	*19*	*8*
Ash-throated Flycatcher	2010	0	0	71	1
Brewer's Sparrow	*2010*	*0.541*	*0.051*	*9*	*80*
Brewer's Sparrow	*2011*	*0.505*	*0.052*	*10*	*77*
Brewer's Sparrow	*2012*	*0.534*	*0.015*	*3*	*87*
Brewer's Sparrow	*2013*	*0.602*	*0.015*	*2*	*97*
Chestnut-collared Longspur	2010	0.033	0.021	64	3
Chestnut-collared Longspur	*2012*	*0.023*	*0.006*	*27*	*2*
Chestnut-collared Longspur	*2013*	*0.025*	*0.006*	*25*	*3*
Grasshopper Sparrow	*2010*	*0.128*	*0.036*	*28*	*27*
Grasshopper Sparrow	*2011*	*0.103*	*0.028*	*27*	*26*
Grasshopper Sparrow	*2012*	*0.107*	*0.009*	*8*	*16*
Grasshopper Sparrow	*2013*	*0.062*	*0.009*	*14*	*13*
Lark Bunting	*2010*	*0.199*	*0.037*	*18*	*37*
Lark Bunting	*2011*	*0.144*	*0.029*	*20*	*37*
Lark Bunting	*2012*	*0.177*	*0.011*	*6*	*26*
Lark Bunting	*2013*	*0.196*	*0.013*	*6*	*34*
Lewis's Woodpecker	2011	0.003	0.003	90	1
McCown's Longspur	2010	0.045	0.023	52	5
McCown's Longspur	*2011*	*0.022*	*0.01*	*47*	*4*
McCown's Longspur	*2012*	*0.045*	*0.007*	*15*	*6*
McCown's Longspur	*2013*	*0.024*	*0.003*	*13*	*4*
Mountain Plover	2010	0	0	71	1
Mountain Plover	*2013*	*0.003*	*0.001*	*19*	*2*
Northern Goshawk	*2012*	*0.031*	*0.008*	*26*	*3*
Northern Pygmy-Owl	*2013*	*0.001*	*0*	*33*	*1*
Pygmy Nuthatch	2010	0.001	0.001	59	2
Pygmy Nuthatch	2011	0.008	0.004	58	2
Pygmy Nuthatch	*2012*	*0.004*	*0*	*13*	*4*
Pygmy Nuthatch	*2013*	*0.002*	*0*	*20*	*2*

Table 2. Continued.

Species	Year	ψ	SE	% CV	*n*
Sagebrush Sparrow	*2010*	*0.191*	*0.038*	*20*	*24*
Sagebrush Sparrow	*2011*	*0.161*	*0.029*	*18*	*23*
Sagebrush Sparrow	*2012*	*0.152*	*0.01*	*7*	*22*
Sagebrush Sparrow	*2013*	*0.144*	*0.01*	*7*	*20*
Sage Thrasher	*2010*	*0.252*	*0.047*	*18*	*34*
Sage Thrasher	*2011*	*0.238*	*0.039*	*16*	*33*
Sage Thrasher	*2012*	*0.353*	*0.024*	*7*	*38*
Sage Thrasher	*2013*	*0.182*	*0.012*	*6*	*26*
Swainson's Hawk	2010	0.017	0.017	101	2
Swainson's Hawk	*2012*	*0.003*	*0.001*	*29*	*2*
Swainson's Hawk	*2013*	*0.141*	*0.038*	*27*	*2*
Upland Sandpiper	2010	0.038	0.029	77	5
Upland Sandpiper	2011	0.024	0.02	83	6
Upland Sandpiper	*2012*	*0.014*	*0.003*	*18*	*2*
Willow Flycatcher	2010	0.06	0.04	67	4
Willow Flycatcher	*2012*	*0.059*	*0.018*	*30*	*2*
Willow Flycatcher	*2013*	*0.001*	*0*	*29*	*1*

Table 3. Estimated density (D; individuals per km^2), population size (*N*), percent coefficient of variation (% CV), and number of independent detections (*n*) of 14 avian Species of Greatest Conservation Need on 216 grids surveyed throughout Wyoming from 2009-2013. Density estimates are considered robust if % CV <50%, and are denoted in italics.

Species of Greatest Conservation Need	Year	D	*N*	% CV	*n*
American Three-toed Woodpecker	*2009*	*0.26*	*48,436*	*33*	*12*
American Three-toed Woodpecker	*2010*	*0.41*	*101,950*	*36*	*25*
American Three-toed Woodpecker	*2011*	*0.28*	*71,550*	*29*	*24*
American Three-toed Woodpecker	2012	0.41	103,059	102	10
American Three-toed Woodpecker	2013	0.62	157,450	78	7
Brewer's Sparrow	*2009*	*44.26*	*8,328,561*	*24*	*828*
Brewer's Sparrow	*2010*	*29.75*	*7,481,986*	*13*	*804*
Brewer's Sparrow	*2011*	*30.69*	*7,707,408*	*15*	*824*
Brewer's Sparrow	*2012*	*22.57*	*5,670,208*	*15*	*873*
Brewer's Sparrow	*2013*	*24.2*	*6,134,460*	*16*	*1235*
Chestnut-collared Longspur	2010	0.44	109,983	54	6
Chestnut-collared Longspur	2012	1.2	302,303	106	9
Chestnut-collared Longspur	2013	0.14	35,401	102	4
Grasshopper Sparrow	*2009*	*2*	*376,107*	*37*	*45*
Grasshopper Sparrow	*2010*	*3.35*	*843,508*	*31*	*98*
Grasshopper Sparrow	*2011*	*3.96*	*994,665*	*24*	*185*
Grasshopper Sparrow	*2012*	*2.82*	*708,620*	*32*	*103*
Grasshopper Sparrow	2013	1.01	256,991	51	52
Lark Bunting	*2009*	*17.71*	*3,331,982*	*32*	*937*
Lark Bunting	*2010*	*16.85*	*4,236,699*	*26*	*814*
Lark Bunting	*2011*	*14.14*	*3,550,626*	*28*	*814*
Lark Bunting	*2012*	*7.64*	*1,920,207*	*29*	*436*
Lark Bunting	*2013*	*10.46*	*2,650,654*	*30*	*938*
Long-billed Curlew	2011	0.16	41,209	86	3
Long-billed Curlew	2012	0.14	34,494	108	3
McCown's Longspur	2009	2.69	505,993	60	26
McCown's Longspur	2010	1.7	427,797	50	34
McCown's Longspur	2011	1.65	414,502	68	50
McCown's Longspur	2012	2.41	604,745	60	117
McCown's Longspur	2013	2.2	558,239	65	105
Pygmy Nuthatch	2009	0.06	11,493	61	4
Pygmy Nuthatch	2010	0.03	6,868	81	2
Pygmy Nuthatch	2011	0.08	19,321	77	2
Pygmy Nuthatch	2012	0.08	18,969	81	8
Pygmy Nuthatch	2013	0.01	1,980	72	2

Table 3. Continued.

Species of Greatest Conservation Need	Year	D	*N*	% CV	*n*
Sagebrush Sparrow	*2009*	*5.57*	*1,047,864*	*18*	*281*
Sagebrush Sparrow	*2010*	*5.01*	*1,260,838*	*23*	*252*
Sagebrush Sparrow	*2011*	*5.79*	*1,453,124*	*21*	*271*
Sagebrush Sparrow	*2012*	*4.25*	*1,067,892*	*30*	*254*
Sagebrush Sparrow	*2013*	*2.49*	*631,410*	*27*	*320*
Sage Thrasher	*2009*	*2.78*	*522,260*	*16*	*231*
Sage Thrasher	*2010*	*2.63*	*661,911*	*18*	*284*
Sage Thrasher	*2011*	*2.31*	*581,212*	*13*	*405*
Sage Thrasher	*2012*	*2.37*	*594,478*	*17*	*252*
Sage Thrasher	*2013*	*1.22*	*310,125*	*23*	*411*
Sandhill Crane	2009	0	113	101	1
Sandhill Crane	2010	0.01	2,812	87	9
Sandhill Crane	2011	0.06	14,455	55	19
Sandhill Crane	2012	0.04	10,663	78	19
Sandhill Crane	2013	0.08	19,327	56	27
Swainson’s Hawk	2009	0.09	16,237	57	9
Swainson’s Hawk	2010	0.01	3,587	77	4
Swainson’s Hawk	2011	0.02	4,496	71	3
Swainson’s Hawk	2012	0	794	80	3
Swainson’s Hawk	2013	0.03	8,687	70	3
Upland Sandpiper	2010	0.15	38,587	71	12
Upland Sandpiper	2011	0.12	30,357	54	22
Upland Sandpiper	2012	0.02	4,554	70	3
Upland Sandpiper	2013	0.06	14,010	87	8
Willow Flycatcher	2013	0.01	2,429	107	1

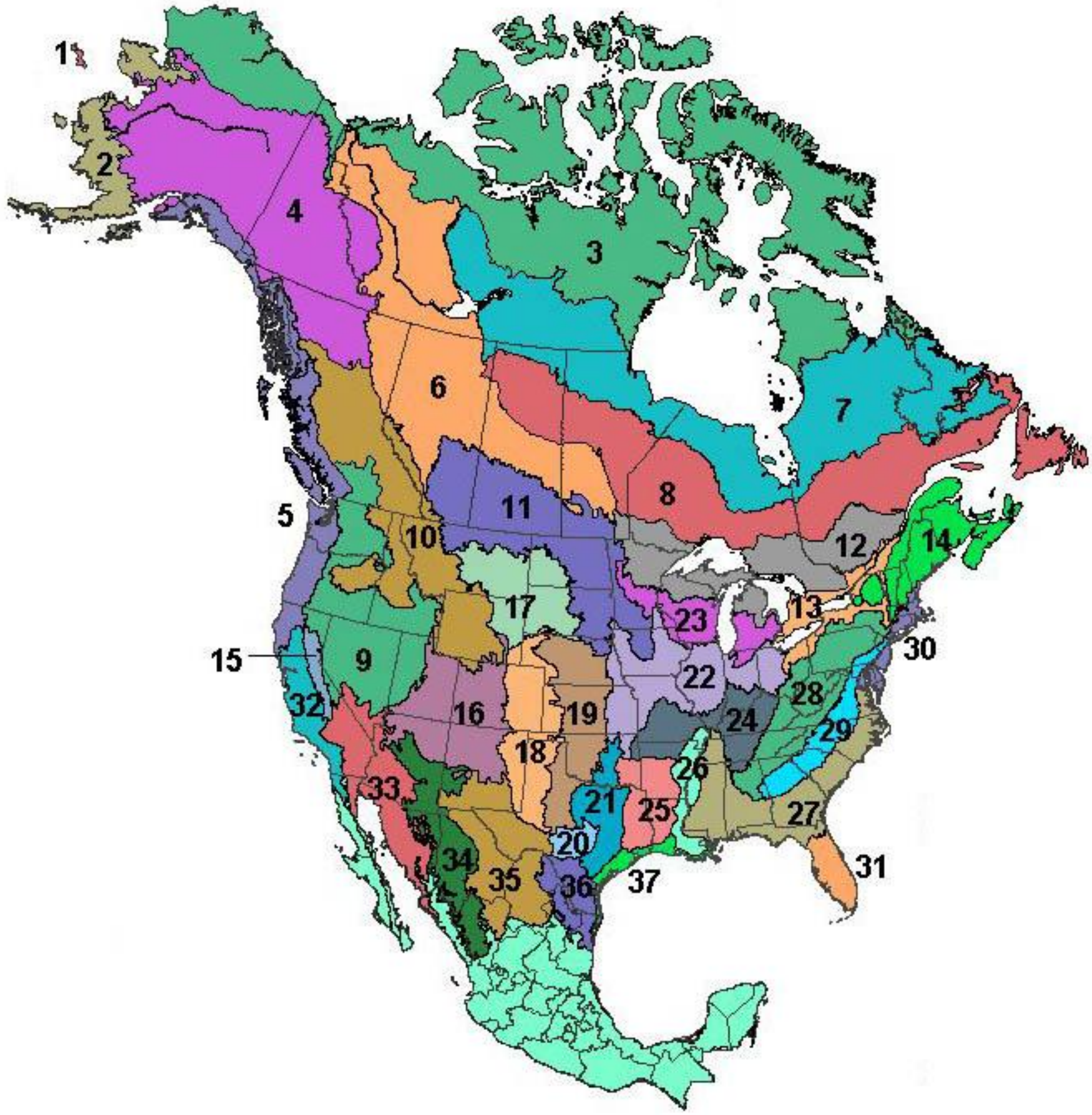

Figure 1. The North American Bird Conservation Region (BCR) map, excluding Hawaii and Mexico. Portions of BCRs that occur in Wyoming are: 9 – Great Basin, 10 – Northern Rockies, 16 – Southern Rockies/Colorado Plateau, 17 – Badlands and Prairies, and 18 – Shortgrass Prairie. Surveys were conducted in all five BCRs in 2013.

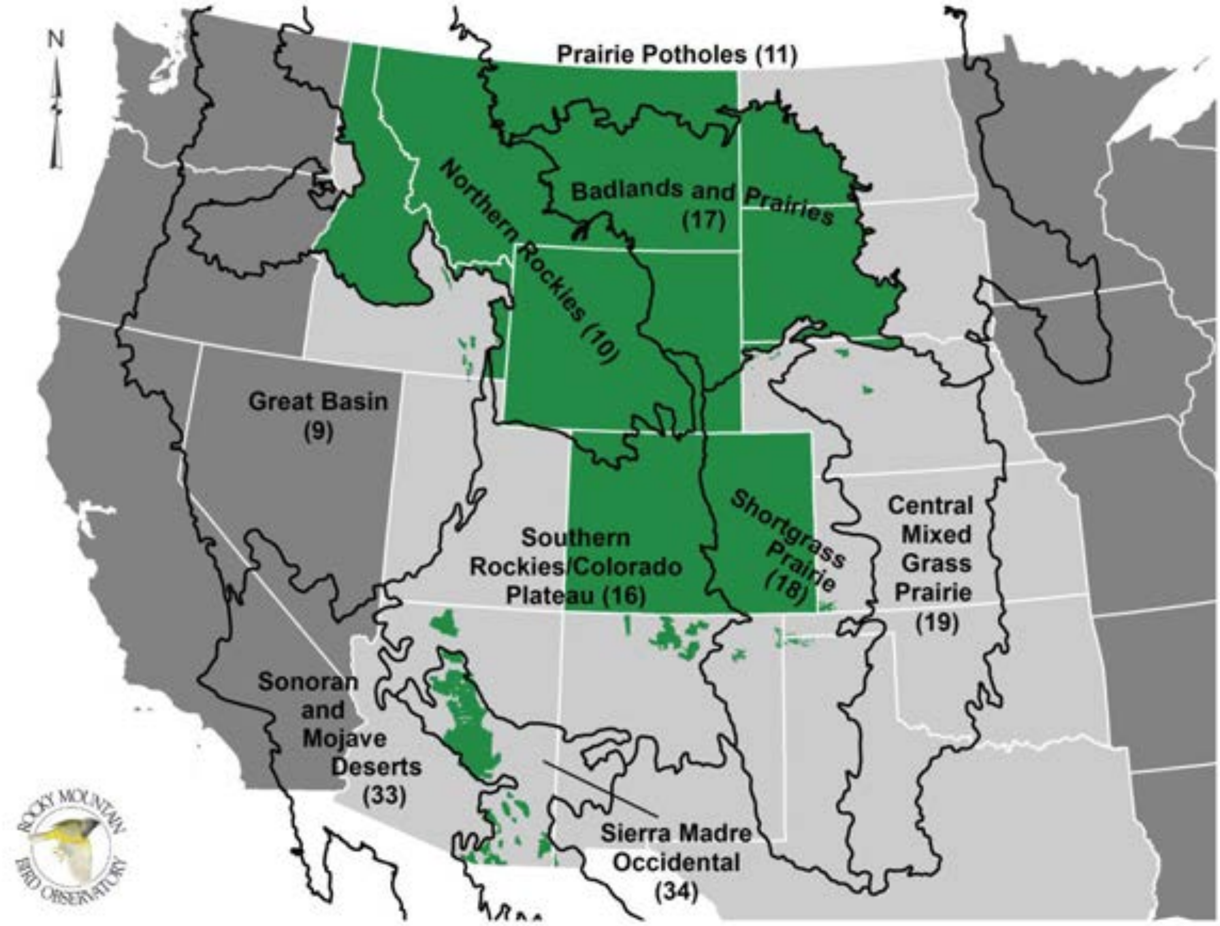

Figure 2. Spatial extent (in green) of the IMBCR program in 2013 (White et al. 2014).

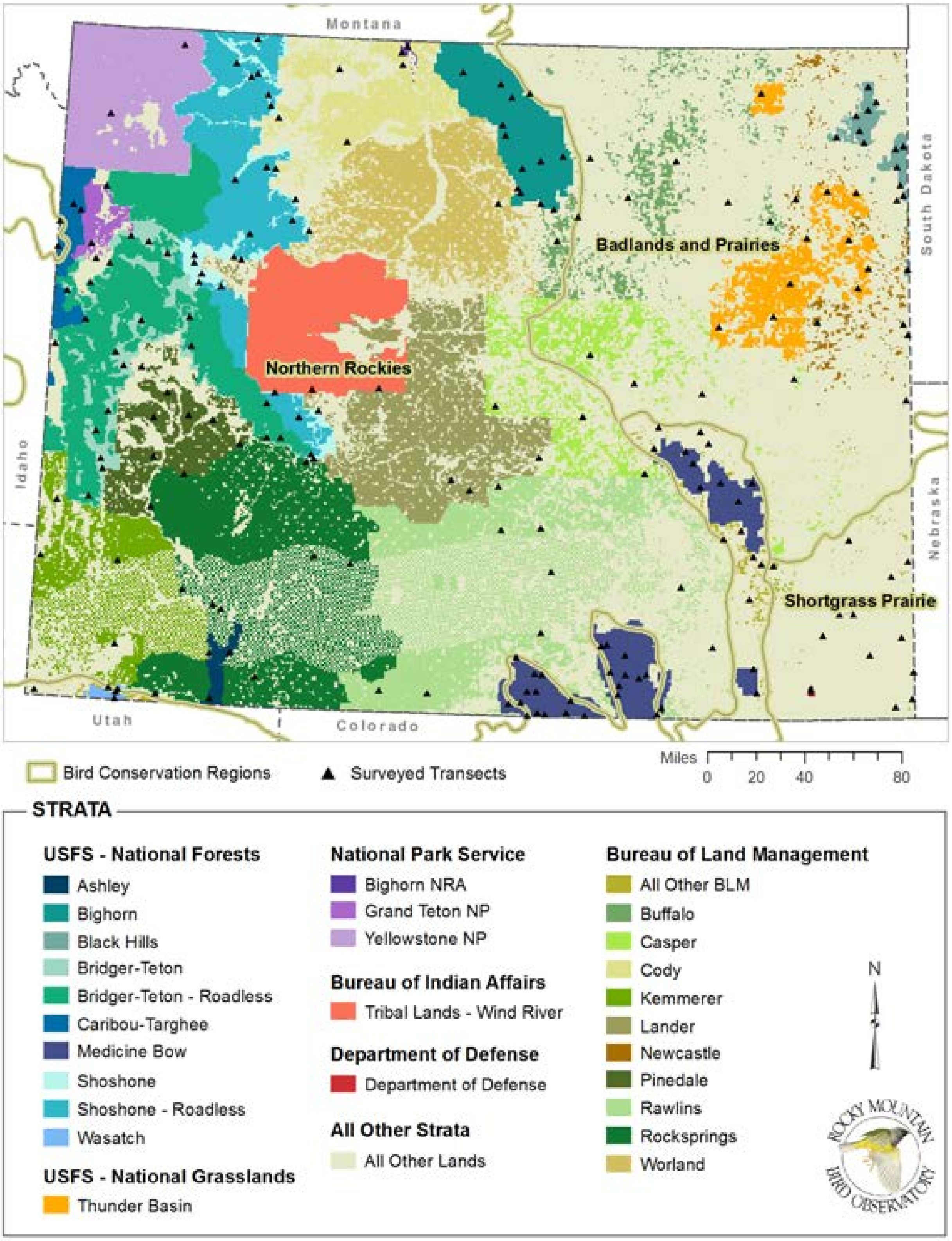

Figure 3. Integrated Monitoring in Bird Conservation Regions strata and survey grid locations in Wyoming, 2013 (White et al. 2014).

OTHER NONGAME – MAMMALS

EVALUATION OF ORAL SYLVATIC PLAGUE VACCINE IN WHITE-TAILED PRAIRIE DOGS: YEAR ONE

STATE OF WYOMING

NONGAME MAMMALS: White-tailed Prairie Dog

FUNDING SOURCE: Western Association of Fish and Wildlife Agencies
Wyoming State Legislature General Fund Appropriations
United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: June 1, 2013 – June 30, 2018

PERIOD COVERED: June 1, 2013 – April 15, 2014

PREPARED BY: Jesse Boulerice, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Since being unintentionally introduced to North America in the early 1900s, sylvatic plague, an exotic disease, has been a major contributor to the decline of populations of prairie dogs (*Cynomys* spp.). Several species of wildlife have either an obligate or facultative dependency on prairie dogs, which has prompted conservation efforts to focus on developing a deliverable and effective vaccine for sylvatic plague in these keystone species. Recently, the US Geological Survey has developed a new oral vaccine shown to increase titers to sylvatic plague in prairie dogs within a laboratory environment. In 2013, the US Geological Survey initiated a nationwide, multi-agency collaborative endeavor to conduct field trials of this vaccine on four species of prairie dogs in the wild. The Nongame Program of the Wyoming Game and Fish Department agreed to participate in this effort, and began fieldwork specific to white-tailed prairie dogs (*C. leucurus*) in Wyoming. During the first of this three-year study, we distributed vaccine-laden baits at two colonies of white-tailed prairie dog at Pitchfork Ranch, Meeteetse. We then conducted mark-recapture surveys to develop baseline estimates of abundance that will be compared to abundances in 2014-2015 to measure the ability of the vaccine to combat the effects of plague. During 3,200 trap days, we captured 282 unique white-tailed prairie dogs and estimated abundance to be 167.9 (95% CI: 163.4-178.4) and 154.7 (95% CI: 140.0-184.2) at each colony. Density at both colonies was approximately five prairie dogs per hectare, which suggested that composition of populations of prairie dog was similar across our study area. In an effort to assess populations of small mammals at the colonies, we also captured American deer mouse (*Peromyscus maniculatus*, $n = 14$), olive-backed pocket mouse (*Perognathus fasciatus*, $n = 6$), and northern grasshopper mouse (*Onychomys leucogaster*, $n = 1$). Additionally, we determined that our sampling protocol to estimate the abundance of prairie dogs at Meeteetse

may be optimized by surveying for eight sampling occasions, and recommend this approach be incorporated in 2014-2015. We also suggested that vaccine-laden baits may be an effective tool to mitigating the effects of plague in prairie dogs at least at a small scale, based on our observed rates of distribution and consumption in 2013.

INTRODUCTION

Sylvatic plague is a exotic disease caused by bacteria *Yersinia pestis* that has affected a multitude of North American species of wildlife since being introduced to North American in the early 1900s (Gage and Kosoy 2005). Transmitted between hosts primarily by infected fleas, *Y. pestis* can be especially wide-spread within social species, such as prairie dogs (*Cynomys* spp.). With mortality rates of >90% in infected individuals, outbreaks of sylvatic plague often result in localized or even regional extirpation of colonies of prairie dogs (Cully and Williams 2001). Plague, coupled with decades of poisoning, shooting, and habitat loss, are thought to have diminished populations of prairie dogs by >98% for ≥1 species (Miller and Cully 2001). Moreover, declines in populations of prairie dogs have been directly linked to declines in abundances of the Endangered black-footed ferret (*Mustela nigripes*; ferret; Williams et al. 1994). Ferrets are affected not only from the loss of food and shelter as populations of prairie dogs decrease, but also from direct transmission of fleas infected with plague to which this Endangered species is vulnerable (Grenier et al. 2009, Jachowski and Lockhart 2009). In addition, along with the ferret, several other species with either an obligate or facultative dependency on prairie dogs are also affected by declines of this keystone species (Kotliar et al. 1999). Given these impacts to prairie dogs and affiliated communities, conservation efforts have been focused on developing a deliverable and effective vaccine for combating sylvatic plague (Abbott et al. 2012).

Recently, the US Geological Survey (USGS), in conjunction with the University of Wisconsin and Western Association of Fish and Wildlife Agencies (WAFWA), has begun evaluating a new vaccine for sylvatic plague (Rocke et al. 2010). This vaccine was designed to be delivered to prairie dogs via edible vaccine-laden baits, modeled after the oral vaccination program for rabies in carnivores (Abbott et al. 2012). Compared to dusting burrows with insecticide, vaccine-laden baits are purported to be cheaper to produce, easier to distribute, and less harmful to non-target species (Seery et al. 2003, Abbott et al. 2012). This new management approach represents a proactive, rather than reactive method to mitigate plague outbreaks in prairie dogs (Abbott et al. 2012). Laboratory tests have shown that baits are readily consumed by prairie dogs in a lab environment (Rocke et al. 2010). Once consumed, the vaccine has produced significant increases in antibody titers to sylvatic plague antigens, as well as increased survival rate of prairie dogs when challenged with *Y. pestis* (Rocke et al. 2010). Encouraged by these results, the USGS, WAFWA, and the Black-footed Ferret Recovery and Implementation Team initiated a nationwide multi-agency collaborative endeavor in 2013 to evaluate the effectiveness of these vaccine-laden baits in combating sylvatic plague in wild populations of four prairie dog species in North America.

The Wyoming Game and Fish Department agreed to participate in this collaborative project and selected a site near Meeteetse, due to a well-documented history with prairie dogs, plague, and ferrets in the region (WGFD 1990, Menkens and Anderson 1991). As one of only two sites participating in this endeavor to focus on colonies of white-tailed prairie dogs (*C. leucurus*; WTPD), our efforts have the potential to represent a valuable contribution in measuring the efficacy of oral vaccines in mitigating the impacts of sylvatic plague specific to this species. This is particularly important, as the less-social nature of WTPD compared to other species of *Cynomys* has been suggested to result in a species-specific relationship with plague that may inherently hold important implications to efforts of vaccination (Cully and Williams 2001, Antolin et al. 2002). For example, WTPD often occur at lower densities or have fewer social interactions compared to other species of prairie dogs (Cully and Williams 2001). Such behavioral patterns may result in lower transmission rates of *Y. pestis* and may influence differences in distribution rates of the vaccine for WTPD. Therefore, the overall goal of this project in Wyoming is to determine if the vaccine will result in significant increases in survival rates as compared to unvaccinated individuals of WTPD (T. Rocke, pers. comm.). A mark-recapture approach will be employed to compare survival rates between prairie dogs presented vaccine-laden or placebo baits over a three-year period. Our results from Meeteetse will be used by the USGS to inform a multi-species assessment.

While our USGS collaborators are leading the effort to assess the vaccine at a national level, we established several objectives specific to the project at Meeteetse in 2013. First, we conducted a preliminary assessment of biomass of small mammals at our study site. Second, we estimated abundance and density of WTPD to establish a baseline for future comparison. Third, we determined the optimal number of sampling occasions required to estimate abundance in an effort to increase the efficiency of this project in future years. Fourth, we evaluated feasibility of using vaccine-laden baits as a tool to manage plague over large complexes of white-tailed prairie dog. Finally, we compared a commonly used index of abundance to the derived estimates of abundance from mark-recapture models to assess the utility of the index at Meeteetse.

METHODS

During mid-June through mid-August 2013, we surveyed colonies of prairie dogs at Pitchfork Ranch, approximately 24 km west of Meeteetse. WTPD colonies were mapped at Pitchfork Ranch in 2012 (Karsch and Grenier 2013), and these maps were used to select two colonies with similar characteristics, including size, topography, habitat, and prairie dog activity (i.e., colony AB, 109.9 ha and colony CD, 100.9 ha). We established 2, 16.2-ha rectangular plots separated by ≥200 m on each selected colony. For naming convenience, plots established within colony AB were labeled Plot A and Plot B, while plots within colony CD were labeled Plot C and Plot D (Fig. 1).

Prior to distribution of vaccine-laden baits and capturing WTPD, we assessed abundances of small mammals by establishing three trapping grids on colony AB during early June. Small mammal grid A (SMG-A) was positioned at center of plot A, grid B (SMG-B) was centered in plot B, and grid C (SMG-C) was position in between the plots on colony AB (Fig. 1). Each grid consisted of 81 small mammal traps (339A non-folding trap, Sherman Trap, Inc., Tallahassee, FL) spaced 16 m apart in a 9 × 9 array. We trapped small mammals at each grid for two sequences of four consecutive nights (i.e., eight trap occasions). We baited all traps with steel cut oats at approximately 1700 and returned to process captures the following morning at 0800. Each captured individual was marked with a single ear tag (1005-1, National Band and Tag Co., Newport, KY). We also recorded sex, age, and weight of each animal.

We then distributed baits supplied by the USGS between 17-28 June. Baits were provided in two forms, treatment (i.e., with vaccine) and placebo (i.e., without vaccine). We paired plots within the same colony such that one would receive treatment and the other would receive placebo baits. To prevent biases in application, USGS assigned baits to each plot a blind manner, such that field personnel were unaware whether they were distributing treatment or placebo baits. We distributed baits by foot evenly along transects at a rate of 100 pieces of bait per ha for a total of 1,600 baits per plot.

We trapped WTPD at each plot approximately two weeks following the distribution of the baits. We captured and uniquely marked WTPD and collected flea, hair, and blood samples from individuals to assess flea load and composition, uptake of bait, and antibody titers of plague antigens. Specifically, we evenly spaced 160 trapping stations over each plot at a rate of 10 per ha. Each trapping station received either a Tomahawk (Model #102 or #103, Tomahawk Live Trap, LLC, Hazelhurst, WI) or Tru-Catch (Model Tuffy 24, Tru-Catch, Belle Fourche, SD). We distributed the three types of traps randomly across stations. We locked open traps for 3-6 days prior to trapping and pre-baited with sweet horse feed (C.O.B with Molasses, Manna Pro Products LLC, Chesterfield, MI). After pre-batting, we trapped each set of paired plots for 2 sequences of 5 consecutive mornings for a total of 10 trapping occasions per plot. Each morning, between 0630 and 0800, we baited, opened, and reset traps. We began checking traps for captures at 1000 and closed all traps for the day by 1130.

Upon capture, we safely transported prairie dogs to a centralized processing station. We briefly anesthetized prairie dogs by placing animals into a sealed chamber filled with isoflurane gas. Once anesthetized, we collected flea, hair, whisker, and blood samples from prairie dogs. Additionally, we marked each individual with passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) and one ear tag in each ear. We also recorded sex, age, and weight of each animal. We allowed each individual to recover from the effects of isoflurane and released animals at the location of capture. We sent all flea, hair, whisker, and blood samples to the USGS for analysis.

To estimate abundance of prairie dogs, we considered both closed and open population models. Closed population estimates are appropriate when the assumption that no births, deaths, emigration, or immigration occur during the duration of the project can be upheld (Chao and Huggins 2005). However, the lengthy time frame over which we captured individuals (18 days between 5 day trapping sessions for plots A and B) may have inherently violated the assumptions of closure. Thus, we tested for a significant difference ($P \leq 0.05$) between estimates of abundance derived from each modeling approach to determine if open population modeling was necessary.

For both modeling frameworks, estimates and unconditional standard error were calculated by using weighted model-averaging across all models (Burnham and Anderson 2002). Model weights were based on Akaike's Information Criterion adjusted for small sample size

(AIC*c*; Burnham and Anderson 2002). We used a log-transformation to calculate 95% confidence intervals (95% CI) associated with each model-averaged estimate of abundance (Chao 1987). We obtained our closed population estimates of abundance by using Huggins conditional likelihood formulation in program MARK (Huggins 1989, White and Burnham 1999). Our candidate model set for the closed models included eight models that considered all combinations of the three sources of variation in capture probabilities, time effect (p), behavioral responses (c), and individual heterogeneity (π; Otis et al. 1978, White et al. 1982). For open models, we used the POPAN formulation (Schwarz and Arnason 1996) in MARK to derive estimates of abundance. In this case, our model set included seven models that allowed survival (Φ), probability of capture (p), and probability of entry (PENT) to remain constant or vary with time.

By using the same model sets and process described above, we then determined the least number of sampling occasions required to estimate abundance. We pooled data across all four plots in order to generate a conclusion for the entire of study area. For this analysis, we defined "abundance interval" as the range of values contained within the log-transformed 95% CI associated with each estimate of abundance. We first calculated the abundance interval associated with each sampling occasion from one to nine by reducing the dataset to contain only the portion of each capture history up to each respective occasion. We then found the first sampling occasion to produce an abundance interval to fully contain the abundance interval generated from the full capture history (sampling occasion 10), with a reasonable level of precision (SE <20). We considered this point to be the minimum number of sampling occasions required to estimate abundance at our study area.

We conducted 100% burrow counts during early August to generate an additional index of abundance. Specifically, we recorded the location of every burrow within each plot ≥7 cm in diameter, which was deep enough that the terminal end could not be seen. Activity at burrows was also recorded, whereby burrows were considered active if fresh scat from prairie dogs was located ≤1 m. We mapped all active burrows using ArcGIS 10.1.

RESULTS

During small mammal trapping, we captured 21 unique individuals, consisting of 14 American deer mice (*Peromyscus maniculatus*), 6 olive-backed pocket mice (*Perognathus fasciatus*), and 1 northern grasshopper mouse (*Onychomys leucogaster*). Due to small sample sizes, we did not estimate abundances of small mammals. Captures by grid are summarized in Table 1.

We distributed vaccine-laden baits at a density of 100 baits per ha over 64.7 total ha at a rate of 1.3 ha per person per hr. After 2-3 days, baits were no longer observed within the plots. Scat from prairie dogs, distinctively colored the same shade of red as the dye of the baits, was readily observed at the majority of active burrows. In 3,200 trap days, we captured prairie dogs 944 times for a capture rate of 0.3 prairie dogs per trap day. Of those, 282 were unique individuals comprised of 137 males and 145 females (m:f: 0.9:1). Number captured at each plot was 75 for A, 85 for B, 57 for C, and 65 for D. Number captured at each colony was therefore

160 for colony AB and 122 for colony CD. We captured individuals 3× on average (SE ±0.26, range: 1-9) over 10 sampling occasions, and 69% of individuals were recaptured at ≥1×. We collected blood, hair, and whisker samples from all individuals. Fleas were detected on and collected from 34 prairie dogs.

We found no significant difference between estimates of abundance for prairie dogs derived under closed population models compared to open models ($P = 0.19$; Fig. 2). Such congruency between modeling approaches suggests that any violation of assumptions of closure that may have occurred were not severe enough to influence estimates. Therefore, we only reported results for the closed population estimates. AIC*c* values, weights, estimates of abundance, and standard errors for all models from both modeling approaches are shown in Tables 2 and 3.

We estimated the abundance of prairie dogs to be 78.7 individuals (95% CI: 76.3-86.0) for plot A, 89.2 individuals (95% CI: 86.5-96.9) for plot B, 72.2 individuals (95% CI: 64.5-88.0) for plot C, and 82.3 individuals (95% CI: 73.7-99.6) for plot D (Fig. 3). Pooling data for colonies, we estimated abundance of 167.9 individuals (95% CI: 163.4-178.4) for colony AB and 154.7 individuals (95% CI: 140.0-184.2) for colony CD (Fig. 3). We removed models M_{tbh} and M_{bh}, or specifically those models with both a behavioral response and individual heterogeneity, from analysis because each generated unrealistic estimates and held little model weight. Model selection revealed the top model for closed population estimates for both colonies to be model M_{th}, suggesting probability of capture varied by time and by individual. For colony AB, the AIC*c* weight of this top model was 1.00, while for colony CD the weight was 0.995 (Table 2).

In our evaluation of estimates of abundance over time, we found the abundance interval at seven occasions to be the first to completely overlap the abundance interval generated by the full capture history with a reasonable level of precision (specifically SE <20) when data was pooled across colonies (Fig. 4). Each additional sampling occasion after seven further increased the precision of the estimate. We found the same trend to occur when colonies AB and CD were evaluated independently (Fig. 4). However, we were unable to achieve a precision of SE <20 at colony CD. Notably, the variability (range of confidence intervals) associated with estimates of abundance for colony CD was 2.9× greater than that of colony AB. In exploring this discrepancy, we found that the probability of capture for prairie dogs on colony CD was on average 12.0% less than the probability of capture on AB ($P < 0.001$). In addition, we found the ratio of new individuals to recaptures to be nearly 8× greater for colony CD compared to colony AB after 10 sampling occasions (Fig. 5). We therefore attribute the disparity in variability to significant differences in rates of capture between colonies AB and CD.

We estimated density of prairie dogs (i.e., individuals per ha) to be 4.86 (95% CI: 4.71-5.31) for plot A, 5.51 (95% CI: 5.34-5.99) for plot B, 4.46 (95% CI: 3.98-5.44) for plot C, and 5.08 (95% CI: 4.55-6.15) for plot D. We pooled our plots to estimate density for each colony. Number of prairie dogs per ha was 5.19 (95% CI: 5.05-5.51) for colony AB and 4.78 (95% CI: 4.32-5.69) for CD.

Results for burrow counts, revealed a total of 1,354 active burrows on colony AB, for a density of 42.5 (SE = 20.25) burrows per ha. On colony CD, we found 1,207 burrows for a density of 37.5 (SE = 19.25) burrows per ha. Based on the estimates of abundance, we calculated a ratio of 0.124 prairie dogs per burrow on colony AB, and 0.128 prairie dogs per burrow on colony CD. Maps of burrows for each plot are provided in Figs. 6 and 7.

DISCUSSION

Our analysis of prairie dogs captured in 2013 enabled us to establish several valuable baselines for populations of WTPD across our study area from which trends in subsequent years will be directly comparable. Several of the assessments we conducted, including estimates of abundance, density of prairie dogs, density of burrows, and number of prairie dogs per burrow, suggest that the composition of populations of WTPD was relatively consistent across colonies and across plots. Such congruency indicates that abiotic and biotic characteristics were similar at each plot and posits that uncontrollable sources of variation were minimal. Importantly, our ability to ascribe trends we observe in populations of WTPD in years 2014-2015 specifically to the form of bait (treatment or placebo) distributed at each plot will be greatly enhanced due to the paucity of nuisance variables at our study area.

Although the majority of our results indicated that populations of WTPD were analogous across our study area, we detected a noteworthy difference in rates of capture between colonies. Specifically, we found colony AB to yield a significantly higher probability of capture and to produce a substantially smaller ratio of new individuals to recaptures after 10 days of trapping, compared to colony CD. We attributed the significantly lower variation in estimates of abundance (i.e., range of confidence intervals) of colony AB to these differences in rates of capture. Interestingly, we believe that higher probability of capture and lower ratio of new individuals to recaptures on colony AB are the result of the small-mammal trapping we conducted exclusively at this colony prior to trapping of prairie dogs. Prairie dogs at colony AB became noticeably conditioned to our presence (e.g., less fearful, more curious) as small-mammal trapping progressed. Additionally, an increase in disturbance to small-mammal traps suggested that prairie dogs quickly learned to associate traps with a food reward. We strongly believe that this association continued after our switch in trapping from small mammals to prairie dogs, and pre-conditioned prairie dogs at colony AB were more apt to enter traps than those on colony CD. In order to eliminate any biases small-mammal trapping may have on rates of capture for WTPD, we recommend that future attempts to assess small mammals be completed at both colonies with all efforts made to conduct surveys in an identical fashion (i.e., timing, number of trap nights, and size of trapping grid).

Our estimates of abundance suggested that density of prairie dogs in 2013 was approximately five individuals per ha at each colony within our study area. Notably, our estimates of density are low compared to historical data for white-tailed prairie dogs in Wyoming (Table 4). However, we expected abundance to be low as populations of prairie dogs in Meeteetse are continuing to recover from a devastating outbreak of sylvatic plague that occurred in 1985 (Forrest et al. 1988). Abundance of WTPD has markedly decreased in the region since that time, as plague likely remains present in the enzootic form throughout this population (Karsch and Grenier 2013). Given continued persistence of the disease, the relationship in survival rates between individuals we vaccinated and those that received placebo baits will be of particular interest for this project.

Our evaluation of sampling occasions needed to estimate abundance of prairie dogs with reasonable precision suggested that eight is the fewest days required to optimize efficiency. Although we were able to estimate abundance at seven occasions, adding at least one additional sampling occasion decreased the variability of the estimate considerably (Fig. 3). We therefore recommend that ≥eight occasions be considered for 2014-2015. Specifically, we recommend opting for a single capture session lasting 8 days instead of 2 that last 5 days (i.e., 10 total days). This approach would help ensure that closure assumptions of our models are met by reducing the probability of death during the survey period. Decreasing the total number of sampling occasions from 10 to 8 also reduces the number of personnel-hrs required to conduct trapping by 20%. Finally, and importantly, this shortened sampling reduces the direct stress placed on the prairie dogs related to trapping and handling, while also decreasing indirect stresses associated with human presence on the colonies.

Inherently, one of the preliminary steps in developing a vaccine for oral distribution to effectively mitigate the impacts of sylvatic plague is devising a bait that is highly palatable and readily consumed by prairie dogs in the wild. In 2013, prairie dogs readily consumed baits at both of our colonies in Meeteetse. High rates of consumption were supported by our observations of disappearance of baits and detection of red-colored scat (i.e., color of baits) from prairie dogs within 2-3 days after distribution. In addition, analysis of hair samples by USGS revealed that ≤97% of WTPD captured at our colonies consumed the bait. This represented the highest consumption rate of any of the participating sites (T. Rocke, pers. comm.). The rate of consumption observed at Meeteetse suggests that vaccine-laden baits may be an effective medium for transferring the vaccine to wild populations of WTPD.

However, some preliminary observations from our project suggest that effective use of vaccine-laden baits may be limited to small-scale application. We dispersed a high concentration of baits by foot at a rate of roughly 1.32 ha per hr (approximately 100 baits per ha). Although this method may be less labor intensive than the alternative approach of dusting with insecticide, considerable effort would still be required to vaccinate large colonies (i.e., >16 ha in size). We acknowledge that vaccine-laden baits have been developed with the intent of being dispersed by motor-vehicle or aircraft, which may increase rates of distribution (Abbott et al. 2012). However, using this approach likely comes at a substantial increase in cost of distribution (e.g., cost of manpower versus flight time). Additionally, price of production of vaccine-laden baits may be higher than originally expected (T. Rocke, pers. comm.). This unanticipated cost may limit the feasibility of using this approach at a large scales (i.e., region-wide) that may preclude this from being used at a scale that is ecologically meaningful unless density of baits or cost of production is reduced. Nevertheless, as currently structured, vaccine-laden baits may become a valuable tool for localized management in the near future.

Burrow counting is commonly used as an index of abundance for prairie dogs. This approach allows personnel to quickly assess trends in populations without expending valuable resources required to conduct more costly mark-recapture estimates. However, if the coefficient that relates number of prairie dogs per burrow can be estimated, the value of burrow counts increases substantially as abundance becomes quantifiable (e.g., Biggins et al. 1993). Interestingly, we found the estimated abundance of prairie dogs per active burrow to be nearly identical when calculated independently for each colony. We recommend exploring this relationship further in years 2014-2015. With this project we have the opportunity to clearly understand the relationship between burrow counting and estimates of abundance for prairie dogs during the next several years. At a minimum, we believe that 100% burrow counts can be used to compare annual trends in abundance at colonies AB and CD. Consequently, we recommend that counts be conducted in a similar manner in 2014-2015.

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Table 1. Captures of small mammals on grids at Pitchfork Ranch, Meeteetse, conducted June 2013. We captured small mammals at three locations: Small Mammal Grid (SMG) A, B, and C.

Species	SMG-A	SMG-B	SMG-C	Total
Peromyscus maniculatus	4	6	4	14
Perognathus fasciatus	1	3	2	6
Onychomys leucogaster	0	0	1	1
Total	5	11	7	21

Table 2. Results from Huggins closed population models to estimate abundance of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, June-August 2013. We calculated model average estimates by using weighted model-averaging across all models from model weights based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). We used a log-transformation to calculate 95% confidence intervals associated with each model-averaged estimate of abundance (Chao 1987).

CLOSED POPULATION MODELS

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	$\widehat{N}$	$\widehat{SE}$
Colony AB					
Time + Heterogeneity	1902.74	0.00	1.00	167.96	3.59
Heterogeneity	1991.51	88.76	0.00	168.96	3.91
Time + Behavior	2031.50	128.75	0.00	167.23	4.61
Time	2040.91	138.16	0.00	161.39	1.23
Behavior	2058.02	155.27	0.00	175.41	6.76
Null	2112.81	210.06	0.00	161.61	1.31
MODEL AVERAGE				**167.96**	**3.59**
Colony CD					
Time + Heterogeneity	1230.81	0.00	0.93	154.61	10.13
Heterogeneity	1235.87	5.07	0.07	155.41	10.34
Behavior	1268.63	37.83	0.00	172.20	24.67
Time + Behavior	1274.69	43.89	0.00	156.72	23.49
Time	1275.27	44.47	0.00	136.07	4.72
Null	1278.44	47.64	0.00	136.54	4.82
MODEL AVERAGE				**154.67**	**10.15**

Table 3. Results from POPAN formulation of open population models to estimate abundance of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, June-August 2013. We calculated model average estimates by using weighted model-averaging across all models from model weights based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). We used a log-transformation to calculate 95% confidence intervals associated with each model-averaged estimate of abundance (Chao 1987).

OPEN POPULATION MODELS

Model	AIC*c*	Delta AIC*c*	AIC*c* Weight	$\widehat{N}$	$\widehat{SE}$
Colony AB					
Φ(.) p(t) PENT(.)	1352.36	0.00	0.59	170.79	3.64
Φ(.) p(.) PENT(t)	1354.12	1.73	0.25	168.33	3.23
Φ(t) p(.) PENT(t)	1356.83	4.45	0.06	179.30	6.05
Φ(t) p(t) PENT(.)	1357.33	4.95	0.05	189.82	12.97
Φ(.) p(t) PENT(t)	1357.95	5.57	0.04	169.25	3.41
Φ(t) p(t) PENT(t)	1417.37	64.99	0.01	179.13	6.42
Φ(.) p(.) PENT(.)	1427.15	74.76	0.00	179.65	9.70
MODEL AVERAGE				**171.67**	**5.81**
Colony CD					
Φ(.) p(t) PENT(.)	800.36	0.00	0.62	162.03	8.79
Φ(.) p(.) PENT(.)	801.67	1.33	0.32	160.09	8.15
Φ(.) p(t) PENT(t)	805.58	5.24	0.05	159.55	8.47
Φ(.) p(.) PENT(t)	808.01	7.67	0.01	160.66	8.96
Φ(t) p(.) PENT(.)	812.33	11.98	0.00	165.91	9.44
Φ(t) p(t) PENT(.)	814.21	13.86	0.00	170.14	14.35
Φ(t) p(.) PENT(t)	818.16	17.82	0.00	170.14	11.14
MODEL AVERAGE				**161.29**	**8.62**

Table 4. Densities of white-tailed prairie dogs (*Cynomys leucurus*) reported for other locations in Wyoming.

Prairie dogs/hectare	Region	Source
4.8 – 5.2	Meeteetse, WY	This project
5.1 – 15.6	Laramie and Meeteetse, WY	Menkens and Anderson 1991
4.0 – 19.1	Laramie and Meeteetse, WY	Menkens and Anderson 1989
13.9 – 20.9	Meeteetse, WY	Menkens and Anderson 1988
5.7 – 16.0	Meeteetse, WY	Biggins et al. 1993
0.12 – 29	Shirley Basin, WY	Orabona-Cerovski 1991

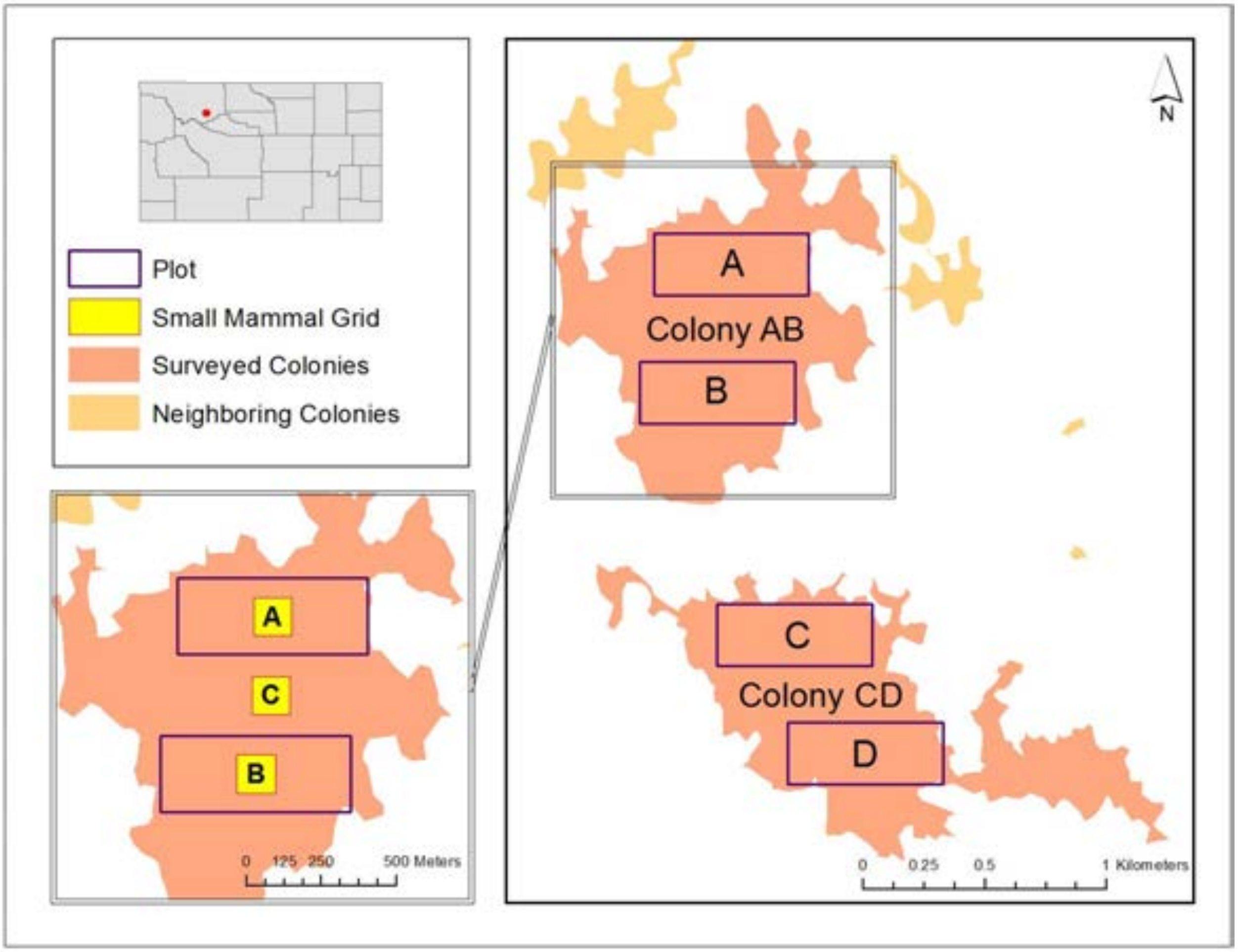

Figure 1. Location of colonies, plots, and small mammal grids at Pitchfork Ranch, Meeteetse, 2013. Plots were paired such that one plot in each colony receive the vaccine-laden baits, while the other receive a placebo. Baits were distributed in blind manner. Small-mammal grids were trapped on at colony AB (insert) prior to distribution of baits.

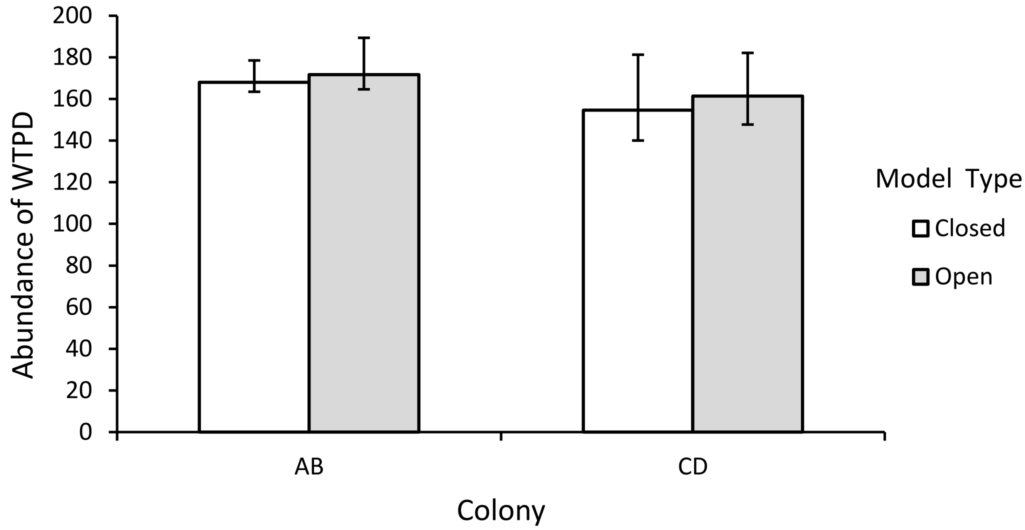

Figure 2. Comparison of closed versus open population estimates of abundance of white-tailed prairie dogs (*Cynomys leucurus*) from colonies AB and CD at Pitchfork Ranch, Meeteetse, June-August 2013. Error bars indicate log-transformed 95% confidence intervals for each estimate. Closed population estimates were derived using Huggins conditional likelihood formulation, while open population estimates were derived using POPAN formulations. All estimates were obtained by weighted modeling averaging based on AIC*c* weights. We found no significant difference in estimates of abundance between the two modeling approaches (P = 0.19).

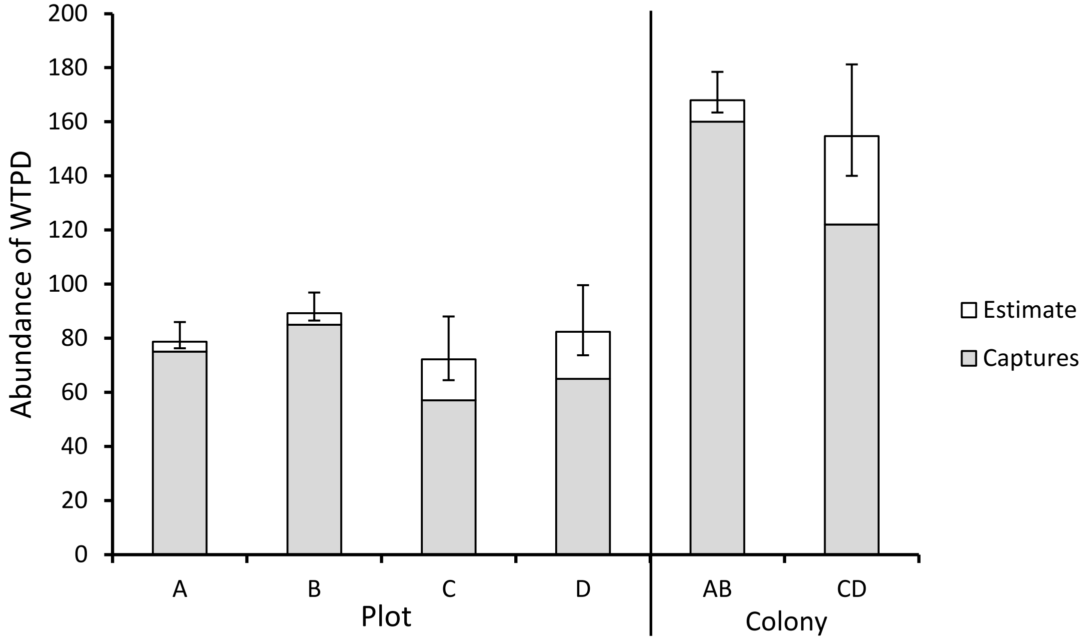

Figure 3. Estimates of abundance of white-tailed prairie dogs (*Cynomys leucurus*) within each plot and within each colony at Pitchfork Ranch, Meeteetse, June-August 2013. Estimates were derived under closed population models using Huggins conditional likelihood formulation. Error bars indicate log-transformed 95% confidence intervals for each estimate (Chao 1987). All estimates were obtained by weighted modeling averaging based on AIC*c* weights.

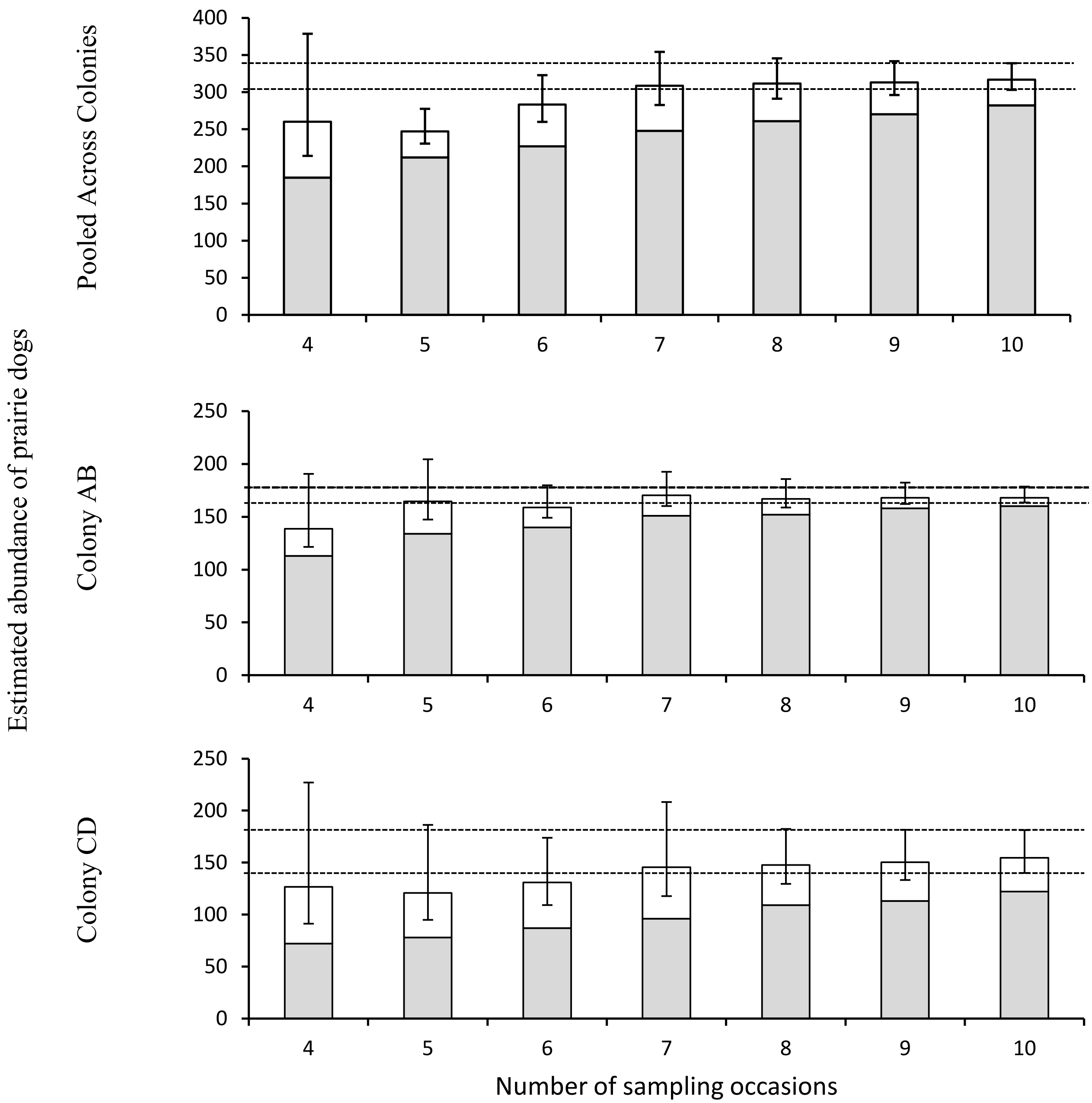

Figure 4. Estimates of abundance at sampling occasions 4-10 of white-tailed prairie dogs (*Cynomys leucurus*) from colonies at Pitchfork Ranch, Meeteetse, June-August 2013. Gray boxes represent number of captures, while white boxes represent estimated abundances. Estimates are based on closed population models calculated using the Huggins conditional likelihood formulations. Error bars indicate log-transformed 95% confidence intervals (abundance intervals) of estimates. Data were pooled across colonies to estimate abundance over the entire study area on top graph. Dashed lines indicate the abundance interval associated with estimates for sampling occasion 10. All estimates were obtained by weighted modeling averaging based on AIC*c* weights.

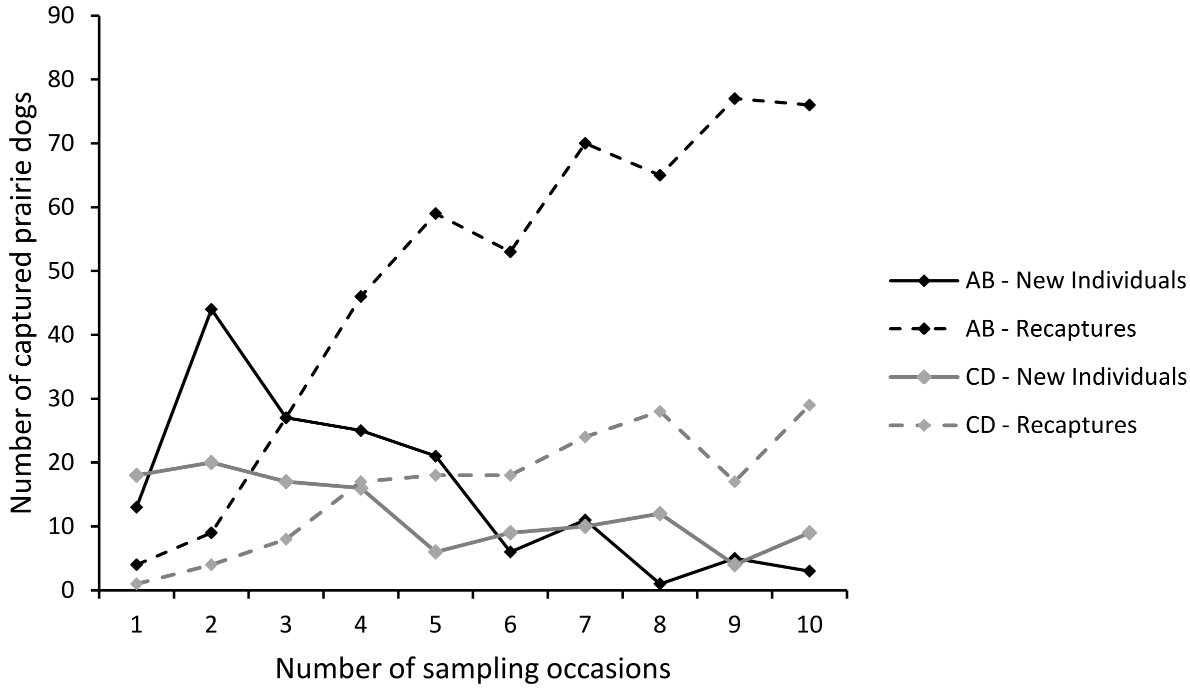

Figure 5. Number of captures of white-tailed prairie dogs (*Cynomys leucurus*) at each sampling occasion from Pitchfork Ranch, Meeteetse, June-August 2013.

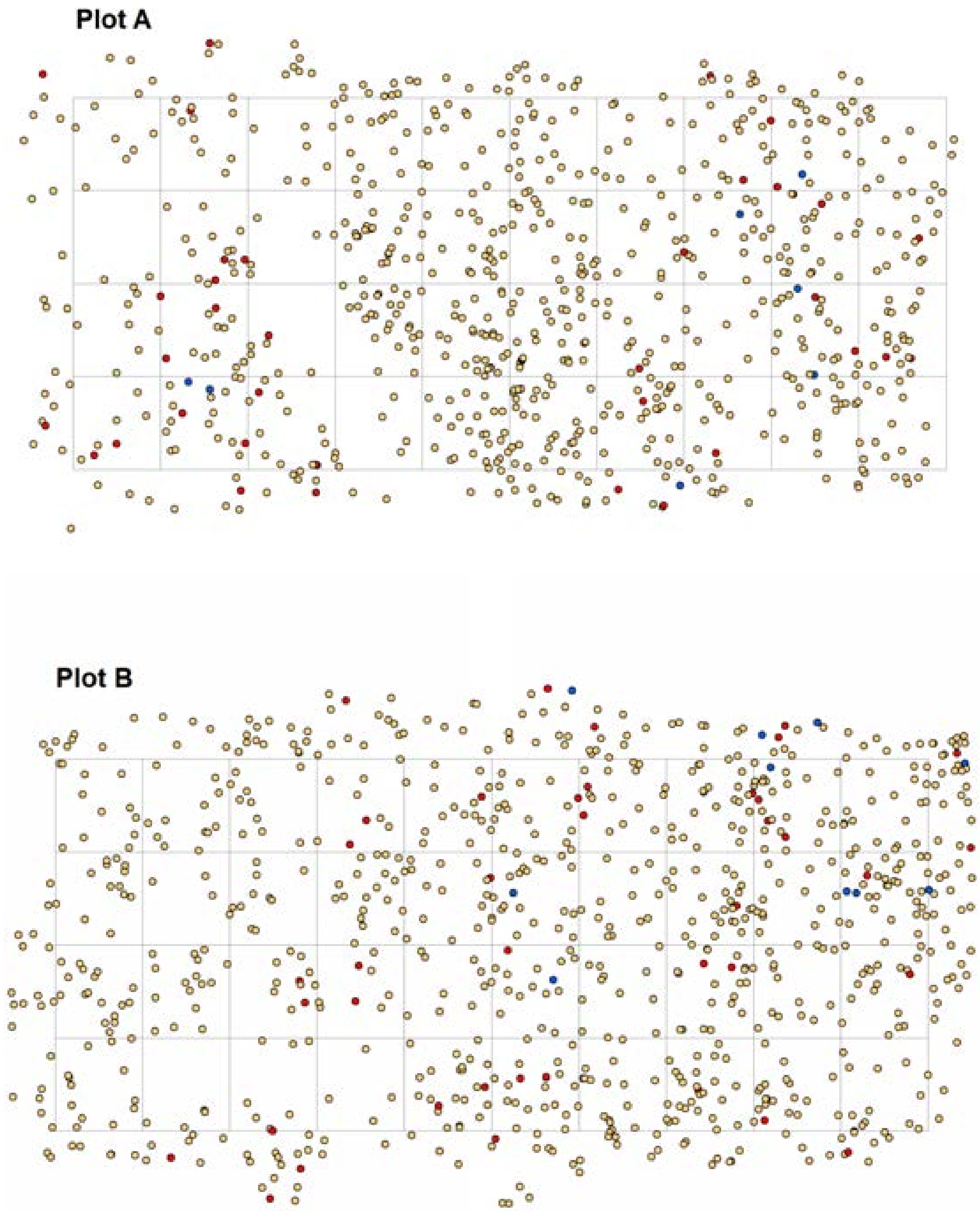

Figure 6. Location of active burrows of white-tailed prairie dogs (*Cynomys leucurus*) on plots A and B at Pitchfork Ranch, Meeteetse, August 2013. Yellow circles indicate one burrow, red circles indicate two to four burrows, and blue circles indicate five to seven burrows. Gray squares are 0.4 ha in size.

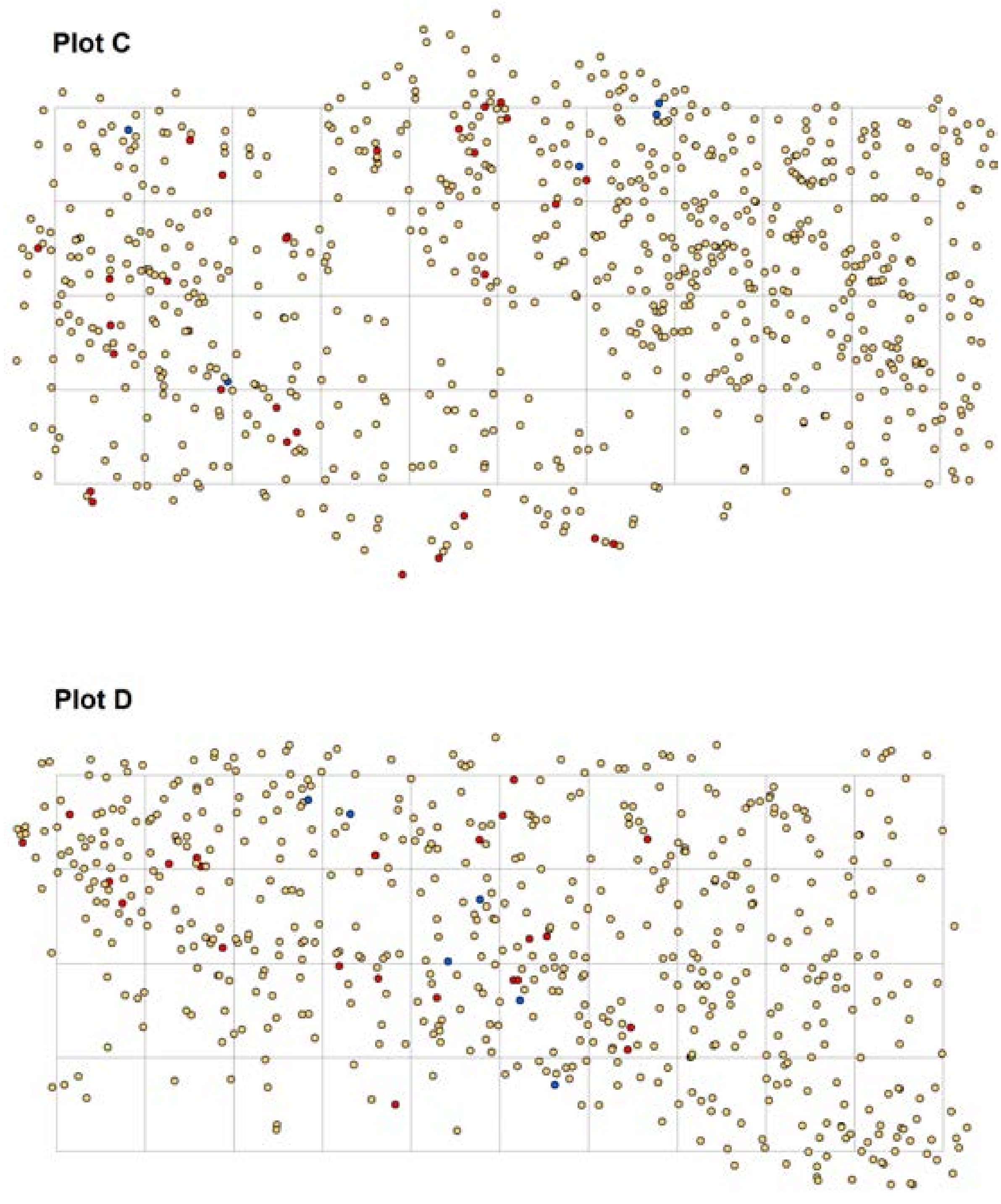

Figure 7. Location of active burrows of white-tailed prairie dogs (*Cynomys leucurus*) on plots C and D at Pitchfork Ranch, Meeteetse, August 2013. Yellow circles indicate one burrow, red circles indicate two to four burrows, and blue circles indicate five to seven burrows. Gray squares are 0.4 ha in size.

TECHNICAL COMMITTEES AND WORKING GROUPS

SUMMARY OF THE ANNUAL ACTIVITIES OF THE CENTRAL FLYWAY NONGAME MIGRATORY BIRD TECHNICAL COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Nongame Migratory Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations
Wyoming Governor's Endangered Species Account Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2013 – 14 April 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

SUMMARY

The Central Flyway Council (CFC) was established in 1951 to represent the 10 states (Montana, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas) and three Canadian provinces (Saskatchewan, Alberta, and the Northwest Territories) that occur within the flyway. The function of the Central Flyway Council is to work with the US Fish and Wildlife Service (USFWS), in conjunction with the councils of the Atlantic and Mississippi flyways, in the cooperative management of North American migratory game birds. Specific responsibilities include season setting of migratory bird hunting regulations. The CFC, via technical committees, also conducts and contributes to a wide variety of migratory bird research and management programs throughout the United States, Canada, and Mexico.

Considerable technical information is required for the flyway councils to accomplish their objectives. Various Technical Committees (TCs) have been established to fulfill this role. The Central Flyway Waterfowl TC and the Pacific Flyway Study Committee were established in 1953 and 1948 respectively. The Central Management Unit TC was formed in 1966 to provide technical input on Mourning Dove management and research issues. In 1967, the scope of this TC was broadened to include species other that doves, and the name was changed to the Central Migratory Shore and Upland Game Bird TC. In 1999, the name was changed to the Central Flyway Webless Game Bird TC, and in 2001, the name was again changed to the Central Flyway Webless Migratory Game Bird TC. The Central Management Unit Mourning Dove TC was established in 2003, and its name was changed to the Central Management Unit Dove TC in 2007 to recognize responsibility for all dove species with regulated hunting seasons. In 2006, the Central Flyway Council established the Central Flyway Nongame Migratory Bird TC to address a growing number of regulatory issues for migratory birds that were not currently

addressed by the other TCs, and to broaden the Flyway Council's focus beyond traditional game birds.

It is the intent of the CFC and TCs that the division of responsibilities for avian species follows the definition for game birds as defined in the migratory bird conventions with Canada and Mexico. The Central Flyway Waterfowl TC is responsible for the families Anatidae (i.e., ducks, geese, and swans) and Rallidae (i.e., American Coots). The Central Flyway Webless Migratory Bird TC is responsible for the families Rallidae (i.e., rails, gallinules, and other coots), Gruidae (i.e., cranes), Charadriidae (i.e., plovers and lapwings), Haematopodidae (i.e., oystercatchers), Recurvirostridae (i.e., stilts and avocets), Scolopacidae (i.e., sandpipers, phalaropes, and allies), Corvidae (i.e., jays, crows, and their allies), and Columbidae (i.e., pigeons). The Central Management Unit Mourning Dove TC is responsible for the Columbidae family (i.e., doves only). The Central Flyway Nongame Migratory Bird TC is responsible for all migratory birds, as per the Migratory Bird Treaty Act, not included in the above division of responsibilities. Technical Committee members do recognize, however, that they may need to collaborate on some issues. For example, the webless TCs should coordinate with the nongame TC on issues related to shorebirds, rails, and federally threatened or endangered species that are not hunted.

The state, provincial, and territorial representatives to the TCs are usually biologists with considerable training and experience in the field of waterfowl, migratory shore and upland game bird, dove, or migratory nongame bird management and research, respectively. The function of the TCs is to serve the CFC, with primary responsibility for the technical information needs of the Flyway Council related to management of migratory game birds, wetland resources, and nongame migratory birds. The TCs may also recommend research projects, surveys, and management programs to the Flyway Council for their collective consideration or implementation. The Wyoming Game and Fish Department's Nongame Bird Biologist serves as the state's representatives on the Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC).

Since the its inception, the CFNMBTC has submitted 9 recommendations to the CFC for signing and submission, and 29 letters of correspondence to a variety of recipients on a diversity of nongame issues, both regulatory and non-regulatory. A summary of the recommendations and correspondence is presented below (Tables 1 and 2).

Table 1. Summary of recommendations submitted by the Central Flyway Nongame Migratory Bird Technical Committee, 2007-2013. Atlantic Flyway (AF); Central Flyway (CF); Central Flyway Committee (CFC); Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC); Mississippi Flyway (MF); Technical Committee (TC).

Date	Recommendation #	Pertaining to	Recommendation
March 20, 2007	10	Selection of shorebird species for Avian Influenza surveillance.	The CFC recommends that the USFWS prohibit lethal collection of certain shorebird species during avian influenza surveillance activities. Samples from highly imperiled species should be taken by nonlethal means.
March 20, 2007	11	Comment period during proposed rule stage.	The CFC recommends that the USFWS allows for comment periods for all nongame migratory bird regulations to be 90 days, but no less than 60 days, and considers the option of establishing nongame migratory bird regulatory cycles similar to that which exists for the Waterfowl, Webless, and Central Management Unit-Dove TC.
March 20, 2007	12	Finalization of MOU for the Cooperative Exchange, Interpretation, and Evaluation of Data and Information Used for Developing Migratory Bird Regulations.	The CFC recommends that the MOU listed above be finalized and signed by the Director of the USFWS and the Chairperson of the CFC.
March 17, 2009	14	Allocation of passage Peregrine Falcon take for falconry purposes in the United States east of 100° W longitude.	The CFC recommends an equitable distribution of 36 first-year migrant peregrine falcon take permits among the CF, MF, AF, for the 20 September to 20 October 2009 trapping season; 12 permits each for the CF, MF, and AF. Of the Central Flyway's allocation, the CFC recommends 10 first-year migrant peregrine falcons for Texas and 2 first-year migrant peregrine falcons for Oklahoma for the 20 September to 20 October 2009 trapping season only.

Table 1. Continued.

Date	Recommendation #	Pertaining to	Recommendation
March 17, 2009	15	Allocation of nestling/post-fledgling first-year Peregrine Falcon take for falconry purposes in the United States west of 100° W longitude.	The CFC recommends allocating 5 nestling per post-fledgling first-year Peregrine Falcons to Montana, 5 to Wyoming, 4 to Colorado, and 2 to New Mexico for take during the nesting period through 31 August 2009 only.
March 23, 2010	14	Allocation of the take of passage immature Peregrine Falcons for falconry purposes in the United States east of 100° W longitude.	The CFC recommends that 12 of the 36 first-year migrant Peregrine Falcon take permits be allocated to the CF for the fall of 2010 trapping season, with 11 of the 12 permits designated for Texas and 1 of the 12 permits designated for Oklahoma for the fall 2010 trapping season only.
March 15, 2011	14	Participation in the USFWS Eagle Technical Assessment Group.	The CFC recommends that a Central Flyway Nongame Migratory Bird TC representative is included on the USFWS's Eagle Technical Assessment Group.
March 15, 2011	15	Peregrine Falcon allocation for falconry purposes.	The CFC recommends adoption of Alternative A (allocation of 12-12-12) for allocation of permits for the take of passage immature Peregrine Falcons for falconry, and that states consider the use of a quota system to provide additional opportunity where the probability of take is expected to be less than 1 permit:1 falcon captured.
March 15, 2012	16	Peregrine Falcon allocation for falconry purposes.	The CFC recommends a continuation of the alternative outlined above (Recommendation #15).

Table 2. Summary of correspondence submitted by the Central Flyway Nongame Migratory Bird Technical Committee, 2006-2013. Central Flyway (CF); Central Flyway Council (CFC); Technical Committee (TC).

Date	Recipient	Issue(s)	CF Key Remark(s)
June 9, 2006 -and- June 12, 2006	Michelle Morgan, Chief, Branch of Recovery and Delisting, USFWS, -and- Brian Millsap, Chief, Division of Migratory Bird Management, USFWS	• Proposed Rule to delist the Bald Eagle • Definition of "disturb" • Review of Draft National Bald Eagle Management Guidelines	• Support the delisting, but "recommend the post-delisting monitoring plan be finalized to coincide with the final delisting". • Definition too narrowly focused on nest sites; "recommend that the term "nest abandonment" be replaced with "nest site or communal roost abandonment". • "Recommend that voluntary habitat protection and management activities be maintained and enhanced in the Guidelines, and that a positive, voluntary, non-regulatory tone be maintained"; represent the most liberal estimates of acceptable disturbance; and "recommend the guidelines be reviewed after 5 years for efficiency and accuracy."
November 3, 2006	Paul Schmidt, USFWS, -and- Dr. Bea Van Horne, USFS	• Review of "Opportunities for Improving North American Avian Monitoring"	• Support the four goals proposed, but believe the report needs to provide more recognition of the realities of personnel, budgets, and time restraints to reach these goals.
November 15, 2006	Robert Blohm, Acting Chief, Division of Migratory Bird Management, USFWS	• Draft EA on Take of Raptors from the Wild under the Falconry Regulations and the Raptor Propagation Regulations	• "Substantially more detail is required regarding the population model, reporting and data management, oversight and communication, and enforcement." • "Concerned that other proposed changes to the regulations governing falconry have not been adequately addressed to date."

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
January 11, 2007	Robert Blohm, Acting Chief, Division of Migratory Bird Management, USFWS	• Reopening of comment period: Protection of Bald Eagles; Definition of ''Disturb''	• Reinforced our June 9th and 12th 2006 comments. • Suggested this definition, with our additions in italics: "Disturb means to agitate or bother a bald or golden eagle to the degree that causes *or is likely or predicted to cause* (i) *repeated displacement*, injury, or death to an eagle (including chicks and eggs) due to interference with breeding, feeding, or sheltering behavior, or (ii) nest *site or communal roost* abandonment or *likely or predictable abandonment of nest site or communal roost*."
March 6, 2007	Central Flyway Council	• Participation of Canadian provinces in Central Flyway NMBTC activities	• "Our Committee suggests that an invitation be extended to Northwest Territories, Alberta, and Saskatchewan to nominate an individual to serve on the Central Flyway Nongame Migratory Bird TC for input on issues that affect bird species or populations that are common to provinces and states within the CF."
March 6, 2007	Dr. Thomas DeLiberto, USDA APHIS-Wildlife Services, -and- Dr. Thomas J. Roffe, USFWS	• Avian influenza surveillance in 2007	• Samples from Buff-breasted Sandpiper and other highly imperiled species should be taken by nonlethal methods.

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
August 31, 2007	Jody Millar, Bald Eagle Monitoring Coordinator, USFWS	• Draft Post-delisting Monitoring Plan for Bald Eagles	• The plan is generally well developed, but "we are disappointed that the sampling plan was not completed, approved, and ready for implementation prior to delisting of the Bald Eagle." • "Troubled at the apparent lack of dedicated funding to support the monitoring effort." • Unclear as to what exactly is expected of the states.
August 31, 2007	Division of Migratory Bird Management, USFWS	• Proposed Rule: Authorizations Under the Bald and Golden Eagle Protection Act for Take of Eagles	• Recommend the Service "include state agency expertise in defining regions that may be used to assess the impact of take..." • "It has been our understanding that take permits will not be issued and take resulting from disturbance of Bald Eagles will not be prosecuted as long as the national guidelines have been followed." • "Take" should be based on state guidelines when they differ from federal guidelines." • Lacks specific information relating to Golden Eagles. Recommend a document similar to Bald Eagles Management Guidelines be developed for Golden Eagles. • Recommend the Service consider development of monitoring strategy for Golden Eagles. Lacking "defensible information on the status and trends of Golden Eagle populations."

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
January 21, 2008	Robert Blohm, Chief, Division of Migratory Bird Management, USFWS	• Draft Environmental Assessment and Management Plan for the take of migrant Peregrine Falcons in the U.S. for use in falconry	• The DEA asserts that Canadian provinces will be involved in the allocation through the Flyways; however, the Canadian Provinces have not accepted our offer to provide representation on the Central Flyway Nongame Migratory Bird TC.
August 14, 2008	H. Dale Hall, Director USFWS	• Eagle Take Permit comment period	• Extend comment period from 30 to 60 days.
September 15, 2008	Diana Whittington, Division of Policy and Directives Management, USFWS	• Draft Environmental Assessment for the Proposal to Permit Take Provided Under the Bald and Golden Eagle Protection Act	• "Based on this review the CFC does not support any of the proposed alternatives in the Draft Environmental Assessment." • We request that Golden Eagles be removed from consideration for take permits until such time that sufficient supporting information can be collected and presented. We also recommend that the Service develop an Alternative 4 in the Draft Environmental Assessment to address a proposed take permitting system that includes Bald Eagles only." • "We continue to be concerned at the very short public comment periods provided by the Service for significant issues."
October 1, 2008	Alan Peoples (OK)	• Participation of Oklahoma in Central Flyway NMBTC activities	• Request they identify a representative ASAP, or contact the current Council chair if and when they decide to do so.

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 6, 2009	George Allen Division of Policy and Directives Management	• Proposed Rule for Removal of Rusty Blackbird and Tamaulipas (Mexican) Crow From the Depredation Order and other changes	• We do not believe rusty blackbird is a nuisance species warranting depredation measures. Agree to remove it from the depredation order. • Agree to remove the Tamaulipas Crow from the order.
March 9, 2009	Central Flyway Council	• Allocation of nestling/post-fledgling first-year Peregrine Falcons between the Central and Pacific Flyways	• Nongame technical committee members of the Central Flyway whose state is split with the Pacific Flyway provided recommendations on the level at which take should be authorized.
March 15, 2010	CFNMBTC	• Developed a flyway-wide list of Species of Greatest Conservation Need	• Illustrated the diversity of the species with which we work and demonstrated the Central Flyway Nongame Migratory Bird TC's interest in all native habitat types.
March 23, 2010	U.S. Senators Feinstein and Alexander, -and- U.S. Representatives Dicks and Simpson	• State Wildlife Grants program appropriation	• Requests funding for the State Wildlife Grants program at a level of $90 million during FY2011 and retention of the 65:35 cost-share ratio, which Congress enacted during FY2010.
March 23, 2010	George Allen, Chief Branch of Permits and Regulations, USFWS	• Bird Banding Lab letter	• The CFC requested that each of the four flyways be allowed a 120-day review period in order to evaluate and prepare a coordinated response among our TC.
March 4, 2011 (original) August 10, 2011 (signed)	USFWS	• Double-crested Cormorant letter	• The CFC had several questions about the USFWS's long-term vision to manage Double-crested Cormorants before we develop a flyway management plan.

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 23, 2011	USFWS	• Eagle Technical Assessment letter	• We requested the USFWS to include the CFNMBTC in inaugural and on-going efforts to address Bald and Golden Eagle issues.
October 3, 2011	USFWS	• Bald and Golden Eagle captive propagation letter	• In general, we do not see the need and, therefore, do not support captive propagation of Bald and Golden Eagles.
October 3, 2011	Senators Reed and Murkowski, and Representatives Simpson and Moran	• State Wildlife Grants support letter	• Support the continuation of State Wildlife Grants funding at $90 million for FY2012 and retention of the 65:35 cost-share ratio.
December 20, 2011	USFWS	• Double-crested Cormorant management	• Request 60-day comment period extension for Federal Register Notice of Intent regarding Double-crested Cormorant management.
March 13, 2012	USFWS	• Double-crested Cormorant management	• Comments to Federal Register Notice of Intent regarding Double-crested Cormorant management.
October 5, 2012	George Allen, USFWS	• Blackbird depredation	• Informal comments regarding a Pre-publication Draft Proposed Rule Regarding Amendments to the Migratory Bird Treaty Act.
October 9, 2012	Central Flyway Webless and Waterfowl Technical Committees	• Technical Committees' species responsibility	• Request for dialogue to improve how the different TCs address issues related to species based current Flyway structure. Non-hunted species currently fall under the responsibility of the TCs that traditional focus on game species.
January 29, 2013	Central Flyway Council	• 2013 meeting schedule	• Inform Council of the CFNMBTC plan to meet in July rather than March.

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
November 26, 2013	USFWS	• Proposed rule to list the *rufa* Red Knot as a threatened species	• USFWS needs to evaluate the Red Knot's life history and migration strategy, and identify a network of key Red Knot habitats or sites. • Geographic range should only include areas where the Red Knot occurs regularly (annually or near annually). • USFWS needs to evaluate different populations of the *rufa* Red Knot as Distinct Population Segments.

WYOMING BIRD RECORDS COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Rare and Unusual Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2013 – 31 December 2013

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Courtney Rudd, Nongame Biologist

SUMMARY

The Wyoming Bird Records Committee (WBRC) was established in 1989 to accomplish the following goals:

1) To solicit, organize, and maintain records, documentation, photographs, tape recordings, and any other material relative to the birds of Wyoming.
2) To review records of new or rare species or species difficult to identify and offer an intelligent, unbiased opinion of the validity or thoroughness of these reports. From these reviews, the WBRC will develop and maintain an Official State List of Birds in Wyoming.
3) To disseminate useful and pertinent material concerning the field identification of Wyoming birds in order to assist Wyoming birders in increasing their knowledge and skill.

The WBRC is interested in promoting and maintaining quality and integrity in the reporting of Wyoming bird observations, and it treats all bird records as significant historical documents. The Wyoming Bird Records Committee operates under a set of bylaws approved in 1991 and updated in 1992 and 1998.

As of 31 December 2013, the WBRC has reviewed 1,325 reports of rare and unusual birds in Wyoming. A total of 1,079 (81%) have been accepted and 246 (19%) have not been accepted. Nine reports have been submitted thus far in 2014 and are awaiting review.

The Wyoming Bird Records Committee Database is a dynamic document, updated once or twice a year following the WBRC meetings. All WBRC reports for 2013, as well as Rare and

Unusual Bird Forms, are available from the Nongame Bird Biologist in the Lander Regional Office.

ACKNOWLEDGEMENTS

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APPENDIX I

THE OFFICIAL STATE LIST OF THE COMMON AND SCIENTIFIC NAMES OF THE BIRDS, MAMMALS, AMPHIBIANS, AND REPTILES IN WYOMING

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
		BIRDS [c, d]		
Waterfowl **Order: Anseriformes** **Family: Anatidae**				
171.0	Greater White-fronted Goose *	*Anser albifrons*	(FL)	M
169.0	Snow Goose *	*Chen caerulescens*		M
170.0	Ross's Goose *	*Chen rossii*	(FL)	M
173.0	Brant	*Branta bernicla*	(AS)	A, Includes Black Brant (174.0)
172.2	Cackling Goose	*Branta hutchinsii*	(FL)	A
172.0	Canada Goose *	*Branta canadensis*		R
181.0	Trumpeter Swan *	*Cygnus buccinator*	(FL)	R, No season, NSS2/II
180.0	Tundra Swan *	*Cygnus columbianus*		W, No season
179.0	Whooper Swan	*Cygnus cygnus*	(AS)	A
144.0	Wood Duck *	*Aix sponsa*		S
135.0	Gadwall *	*Anas strepera*		R
136.0	Eurasian Wigeon	*Anas penelope*	(AS)	A
137.0	American Wigeon *	*Anas americana*		R
133.0	American Black Duck	*Anas rubripes*	(AS)	A
132.0	Mallard *	*Anas platyrhynchos*		R
134.0	Mottled Duck	*Anas fulvigula*	(AS)	A
140.0	Blue-winged Teal *	*Anas discors*		S
141.0	Cinnamon Teal *	*Anas cyanoptera*		S
142.0	Northern Shoveler *	*Anas clypeata*		S
143.0	Northern Pintail *	*Anas acuta*		R, NSS3/II
139.2	Garganey	*Anas querquedula*	(AS)	A
139.0	Green-winged Teal *	*Anas crecca*		R
147.0	Canvasback *	*Aythya valisineria*		S, NSS3/II
146.0	Redhead *	*Aythya americana*		S, NSS3/II
150.0	Ring-necked Duck *	*Aythya collaris*		S
149.1	Tufted Duck	*Aythya fuligula*	(AS)	A
148.0	Greater Scaup *	*Aythya marila*	(FL)	M
149.0	Lesser Scaup *	*Aythya affinis*		S, NSS3/II
155.0	Harlequin Duck *	*Histrionicus histrionicus*		S, NSS3/II
166.0	Surf Scoter *	*Melanitta perspicillata*	(FL)	M
165.0	White-winged Scoter *	*Melanitta fusca*	(FL)	M
163.0	Black Scoter	*Melanitta americana*	(AS)	A
154.0	Long-tailed Duck *	*Clangula hyemalis*	(FL)	M
153.0	Bufflehead *	*Bucephala albeola*		R
151.0	Common Goldeneye *	*Bucephala clangula*		R
152.0	Barrow's Goldeneye *	*Bucephala islandica*		R, NSS3/II
131.0	Hooded Merganser *	*Lophodytes cucullatus*		R
129.0	Common Merganser *	*Mergus merganser*		R
130.0	Red-breasted Merganser *	*Mergus serrator*		S
167.0	Ruddy Duck *	*Oxyura jamaicensis*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Gallinaceous Birds **Order: Galliformes** **Family: Odontophoridae**				
289.0	Northern Bobwhite *	*Colinus virginianus*	(AS)	R
Family: Phasianidae				
288.2	Chukar *	*Alectoris chukar*		R
288.1	Gray Partridge *	*Perdix perdix*		R
309.1	Ring-necked Pheasant *	*Phasianus colchicus*		R
300.0	Ruffed Grouse *	*Bonasa umbellus*		R
309.0	Greater Sage-Grouse *	*Centrocercus urophasianus*		R, NSS2/I
304.0	White-tailed Ptarmigan *	*Lagopus leucura*	(AS)	R, No season
297.0	Dusky Grouse *	*Dendragapus obscurus*		R
308.0	Sharp-tailed Grouse *	*Tympanuchus phasianellus*		R, NSS4/II, Includes Columbian subspecies
305.0	Greater Prairie-Chicken	*Tympanuchus cupido*	(AS)	A
310.0	Wild Turkey *	*Meleagris gallopavo*		R
Loons **Order: Gaviiformes** **Family: Gaviidae**				
011.0	Red-throated Loon	*Gavia stellata*	(AS)	M
010.0	Pacific Loon	*Gavia pacifica*	(FL)	M
007.0	Common Loon	*Gavia immer*		S, NSS1/I
008.0	Yellow-billed Loon	*Gavia adamsii*	(AS)	A
Grebes **Order: Podicipediformes** **Family: Podicipedidae**				
006.0	Pied-billed Grebe	*Podilymbus podiceps*		S
003.0	Horned Grebe	*Podiceps auritus*		S
002.0	Red-necked Grebe	*Podiceps grisegena*	(AS)	S
004.0	Eared Grebe	*Podiceps nigricollis*		S
001.0	Western Grebe	*Aechmophorus occidentalis*		S
001.1	Clark's Grebe	*Aechmophorus clarkii*		S, NSSU/II
Shearwaters **Order: Procellariiformes** **Family: Procellariidae**				
088.1	Streaked Shearwater	*Calonectris leucomelas*	(AS)	A
Storks **Order: Ciconiiformes** **Family: Ciconiidae**				
188.0	Wood Stork	*Mycteria americana*	(AS)	A, Endangered
Cormorants and Frigatebirds **Order: Suliformes** **Family: Fregatidae**				
128.2	Lesser Frigatebird	*Fregata ariel*	(AS)	A
Family: Phalacrocoracidae				
120.0	Double-crested Cormorant	*Phalacrocorax auritus*		S
Pelicans and Wading Birds **Order: Pelecaniformes** **Family: Pelecanidae**				
125.0	American White Pelican	*Pelecanus erythrorhynchos*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
126.0	Brown Pelican	*Pelecanus occidentalis*	(AS)	A
Family: Ardeidae				
190.0	American Bittern	*Botaurus lentiginosus*	(FL)	S, NSS3/II
191.0	Least Bittern	*Ixobrychus exilis*	(AS)	A
194.0	Great Blue Heron	*Ardea herodias*		S
196.0	Great Egret	*Ardea alba*	(AS)	A
197.0	Snowy Egret	*Egretta thula*		S, NSS3/II
200.0	Little Blue Heron	*Egretta caerulea*	(AS)	A
199.0	Tricolored Heron	*Egretta tricolor*	(AS)	A
200.1	Cattle Egret	*Bubulcus ibis*	(FL)	S
201.0	Green Heron	*Butorides virescens*	(AS)	M
202.0	Black-crowned Night-Heron	*Nycticorax nycticorax*		S, NSS3/II
203.0	Yellow-crowned Night-Heron	*Nyctanassa violacea*	(AS)	A
Family: Threskiornithidae				
184.0	White Ibis	*Eudocimus albus*	(AS)	A
186.0	Glossy Ibis	*Plegadis falcinellus*	(AS)	A
187.0	White-faced Ibis	*Plegadis chihi*		S, NSS3/II
Diurnal Birds of Prey **Order: Accipitriformes** **Family: Cathartidae**				
326.0	Black Vulture	*Coragyps atratus*	(AS)	A
325.0	Turkey Vulture	*Cathartes aura*		S
Family: Pandionidae				
364.0	Osprey	*Pandion haliaetus*		S
Family: Accipitridae				
328.0	White-tailed Kite	*Elanus leucurus*	(AS)	A
329.0	Mississippi Kite	*Ictinia mississippiensis*	(AS)	A
352.0	Bald Eagle	*Haliaeetus leucocephalus*		R, NSS2/I
331.0	Northern Harrier	*Circus cyaneus*		S
332.0	Sharp-shinned Hawk	*Accipiter striatus*		S
333.0	Cooper's Hawk	*Accipiter cooperii*		S
334.0	Northern Goshawk	*Accipiter gentilis*		R, NSSU/I
335.0	Harris's Hawk	*Parabuteo unicinctus*	(AS)	A
339.0	Red-shouldered Hawk	*Buteo lineatus*	(AS)	A
343.0	Broad-winged Hawk	*Buteo platypterus*	(FL)	S
342.0	Swainson's Hawk	*Buteo swainsoni*		S, NSSU/II
337.0	Red-tailed Hawk	*Buteo jamaicensis*		R, Includes Harlan's Hawk (338.0)
348.0	Ferruginous Hawk	*Buteo regalis*		R, NSSU/I
347.0	Rough-legged Hawk	*Buteo lagopus*		W
349.0	Golden Eagle	*Aquila chrysaetos*		R
Marshbirds **Order: Gruiformes** **Family: Rallidae**				
215.0	Yellow Rail	*Coturnicops noveboracensis*	(AS)	A
216.0	Black Rail	*Laterallus jamaicensis*	(AS)	A
212.0	Virginia Rail *	*Rallus limicola*		S, NSS3/II
214.0	Sora *	*Porzana carolina*		S
218.0	Purple Gallinule	*Porphyrio martinicus*	(AS)	A
219.0	Common Gallinule	*Gallinula chloropus*	(AS)	A

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
221.0	American Coot *	*Fulica americana*		S
Family: Gruidae				
206.0	Sandhill Crane *	*Grus canadensis*		S, NSS4/III, Includes Greater Sandhill Crane subspecies
204.0	Whooping Crane	*Grus americana*	(AS)	S, Endangered
Shorebirds **Order: Charadriiformes** **Family: Recurvirostridae**				
226.0	Black-necked Stilt	*Himantopus mexicanus*		S
225.0	American Avocet	*Recurvirostra americana*		S
Family: Charadriidae				
270.0	Black-bellied Plover	*Pluvialis squatarola*		M
272.0	American Golden-Plover	*Pluvialis dominica*	(FL)	M
278.0	Snowy Plover	*Charadrius nivosus*	(AS)	S
274.0	Semipalmated Plover	*Charadrius semipalmatus*		M
277.0	Piping Plover	*Charadrius melodus*	(AS)	M, Threatened
273.0	Killdeer	*Charadrius vociferus*		S
281.0	Mountain Plover	*Charadrius montanus*		S, NSSU/I
Family: Scolopacidae				
263.0	Spotted Sandpiper	*Actitis macularius*		S
256.0	Solitary Sandpiper	*Tringa solitaria*		M
254.0	Greater Yellowlegs	*Tringa melanoleuca*		M
258.0	Willet	*Tringa semipalmata*		S
255.0	Lesser Yellowlegs	*Tringa flavipes*		M
261.0	Upland Sandpiper	*Bartramia longicauda*	(FL)	S, NSSU/II
265.0	Whimbrel	*Numenius phaeopus*	(FL)	M
264.0	Long-billed Curlew	*Numenius americanus*		S, NSS3/II
251.0	Hudsonian Godwit	*Limosa haemastica*	(AS)	M
249.0	Marbled Godwit	*Limosa fedoa*		M
283.0	Ruddy Turnstone	*Arenaria interpres*	(FL)	M
234.0	Red Knot	*Calidris canutus*	(AS)	M
233.0	Stilt Sandpiper	*Calidris himantopus*		M
248.0	Sanderling	*Calidris alba*		M
243.0	Dunlin	*Calidris alpina*	(FL)	M
241.0	Baird's Sandpiper	*Calidris bairdii*		M
242.0	Least Sandpiper	*Calidris minutilla*		M
240.0	White-rumped Sandpiper	*Calidris fuscicollis*	(FL)	M
262.0	Buff-breasted Sandpiper	*Calidris subruficollis*	(AS)	M
239.0	Pectoral Sandpiper	*Calidris melanotos*		M
246.0	Semipalmated Sandpiper	*Calidris pusilla*		M
247.0	Western Sandpiper	*Calidris mauri*		M
231.0	Short-billed Dowitcher	*Limnodromus griseus*	(AS)	M
232.0	Long-billed Dowitcher	*Limnodromus scolopaceus*		M
230.0	Wilson's Snipe	*Gallinago delicata*		S
228.0	American Woodcock	*Scolopax minor*	(AS)	A
224.0	Wilson's Phalarope	*Phalaropus tricolor*		S
223.0	Red-necked Phalarope	*Phalaropus lobatus*		M
222.0	Red Phalarope	*Phalaropus fulicarius*	(AS)	A

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Seabirds, Gulls, and Terns **Order: Charadriiformes** **Family: Stercorariidae**				
036.0	Pomarine Jaeger	*Stercorarius pomarinus*	(AS)	A
037.0	Parasitic Jaeger	*Stercorarius parasiticus*	(AS)	A
038.0	Long-tailed Jaeger	*Stercorarius longicaudus*	(AS)	A
Family: Alcidae				
023.0	Long-billed Murrelet	*Brachyramphus perdix*	(AS)	A
021.0	Ancient Murrelet	*Synthliboramphus antiquus*	(AS)	A
Family: Laridae				
040.0	Black-legged Kittiwake	*Rissa tridactyla*	(AS)	A
062.0	Sabine's Gull	*Xema sabini*	(FL)	M
060.0	Bonaparte's Gull	*Chroicocephalus philadelphia*		M
055.1	Black-headed Gull	*Chroicocephalus ridibundus*	(AS)	A
060.1	Little Gull	*Hydrocoloeus minutus*	(AS)	A
061.0	Ross's Gull	*Rhodostethia rosea*	(AS)	A
058.0	Laughing Gull	*Larus atricilla*	(AS)	A
059.0	Franklin's Gull	*Larus pipixcan*		S, NSS3/II
057.0	Heermann's Gull	*Larus heermanni*	(AS)	A
055.0	Mew Gull	*Larus canus*	(AS)	A
054.0	Ring-billed Gull	*Larus delawarensis*		S
053.0	California Gull	*Larus californicus*		S
051.0	Herring Gull	*Larus argentatus*		M
043.1	Thayer's Gull	*Larus thayeri*	(AS)	A
043.0	Iceland Gull	*Larus glaucoides*	(AS)	A
050.0	Lesser Black-backed Gull	*Larus fuscus*	(AS)	A
044.0	Glaucous-winged Gull	*Larus glaucescens*	(AS)	A
042.0	Glaucous Gull	*Larus hyperboreus*	(AS)	A
047.0	Great Black-backed Gull	*Larus marinus*	(AS)	A
074.0	Least Tern	*Sternula antillarum*	(AS)	A, Endangered
064.0	Caspian Tern	*Hydroprogne caspia*		S, NSS3/II
077.0	Black Tern	*Chlidonias niger*		S, NSS3/II
070.0	Common Tern	*Sterna hirundo*	(FL)	M
071.0	Arctic Tern	*Sterna paradisaea*	(AS)	A
069.0	Forster's Tern	*Sterna forsteri*		S, NSS3/II
Doves and Pigeons **Order: Columbiformes** **Family: Columbidae**				
313.1	Rock Pigeon	*Columba livia*		R
312.0	Band-tailed Pigeon	*Patagioenas fasciata*	(AS)	M
315.4	Eurasian Collared-Dove	*Streptopelia decaocto*		R
319.0	White-winged Dove	*Zenaida asiatica*	(AS)	A
316.0	Mourning Dove *	*Zenaida macroura*		S
315.0	Passenger Pigeon	*Ectopistes migratorius*		Extinct
Cuckoos **Order: Cuculiformes** **Family: Cuculidae**				
387.0	Yellow-billed Cuckoo	*Coccyzus americanus*	(FL)	S, NSSU/III
388.0	Black-billed Cuckoo	*Coccyzus erythropthalmus*	(FL)	S

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<u>Owls</u> **Order: Strigiformes** **Family: Tytonidae**				
365.0	Barn Owl	*Tyto alba*	(AS)	S,
Family: Strigidae				
374.0	Flammulated Owl	*Psiloscops flammeolus*	(AS)	S
373.2	Western Screech-Owl	*Megascops kennicottii*	(AS)	R
373.0	Eastern Screech-Owl	*Megascops asio*	(FL)	R
375.0	Great Horned Owl	*Bubo virginianus*		R
376.0	Snowy Owl	*Bubo scandiacus*	(AS)	W
377.0	Northern Hawk Owl	*Surnia ulula*	(AS)	A
379.0	Northern Pygmy-Owl	*Glaucidium gnoma*	(FL)	R, NSSU/II
378.0	Burrowing Owl	*Athene cunicularia*		S, NSSU/I
368.0	Barred Owl	*Strix varia*	(AS)	A
370.0	Great Gray Owl	*Strix nebulosa*		R, NSSU/I
366.0	Long-eared Owl	*Asio otus*		R
367.0	Short-eared Owl	*Asio flammeus*		R, NSS4/II
371.0	Boreal Owl	*Aegolius funereus*	(FL)	R, NSS3/II
372.0	Northern Saw-whet Owl	*Aegolius acadicus*	(FL)	R
<u>Goatsuckers</u> **Order: Caprimulgiformes** **Family: Caprimulgidae**				
421.0	Lesser Nighthawk	*Chordeiles acutipennis*	(AS)	A
420.0	Common Nighthawk	*Chordeiles minor*		S
418.0	Common Poorwill	*Phalaenoptilus nuttallii*		S
<u>Swifts</u> **Order: Apodiformes** **Family: Apodidae**				
423.0	Chimney Swift	*Chaetura pelagica*	(FL)	S
424.0	Vaux's Swift	*Chaetura vauxi*	(AS)	A
425.0	White-throated Swift	*Aeronautes saxatalis*		S
<u>Hummingbirds</u> **Order: Apodiformes** **Family: Trochilidae**				
426.0	Magnificent Hummingbird	*Eugenes fulgens*	(AS)	A
428.0	Ruby-throated Hummingbird	*Archilochus colubris*	(AS)	A
429.0	Black-chinned Hummingbird	*Archilochus alexandri*	(FL)	S
431.0	Anna's Hummingbird	*Calypte anna*	(AS)	A
432.0	Broad-tailed Hummingbird	*Selasphorus platycercus*		S
433.0	Rufous Hummingbird	*Selasphorus rufus*		S
436.0	Calliope Hummingbird	*Selasphorus calliope*		S
<u>Kingfishers</u> **Order: Coraciiformes** **Family: Alcedinidae**				
390.0	Belted Kingfisher	*Megaceryle alcyon*		R
<u>Woodpeckers</u> **Order: Piciformes** **Family: Picidae**				
408.0	Lewis's Woodpecker	*Melanerpes lewis*		S, NSSU/II
406.0	Red-headed Woodpecker	*Melanerpes erythrocephalus*	(FL)	S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
407.0	Acorn Woodpecker	*Melanerpes formicivorus*	(AS)	A
409.0	Red-bellied Woodpecker	*Melanerpes carolinus*	(AS)	A
404.0	Williamson's Sapsucker	*Sphyrapicus thyroideus*		S
402.0	Yellow-bellied Sapsucker	*Sphyrapicus varius*	(AS)	A
402.1	Red-naped Sapsucker	*Sphyrapicus nuchalis*		S
394.0	Downy Woodpecker	*Picoides pubescens*		R
393.0	Hairy Woodpecker	*Picoides villosus*		R
399.0	White-headed Woodpecker	*Picoides albolarvatus*	(AS)	A
401.0	American Three-toed Woodpecker	*Picoides dorsalis*		R, NSSU/II
400.0	Black-backed Woodpecker	*Picoides arcticus*	(FL)	R, NSSU/II
412.0	Northern Flicker	*Colaptes auratus*		R, Includes Red-shafted and Yellow-shafted
405.0	Pileated Woodpecker	*Dryocopus pileatus*	(AS)	A
Falcons **Order: Falconiformes** **Family: Falconidae**				
362.0	Crested Caracara	*Caracara cheriway*	(AS)	A
360.0	American Kestrel	*Falco sparverius*		S
357.0	Merlin	*Falco columbarius*		R, NSSU/III
354.0	Gyrfalcon	*Falco rusticolus*	(AS)	W
356.0	Peregrine Falcon	*Falco peregrinus*	(FL)	R, NSS3/II
355.0	Prairie Falcon	*Falco mexicanus*		R
Passerines **Order: Passeriformes** **Family: Tyrannidae**				
459.0	Olive-sided Flycatcher	*Contopus cooperi*		S
462.0	Western Wood-Pewee	*Contopus sordidulus*		S
461.0	Eastern Wood-Pewee	*Contopus virens*	(AS)	A
466.0	Willow Flycatcher	*Empidonax traillii*		S, NSS4/III
467.0	Least Flycatcher	*Empidonax minimus*	(FL)	S
468.0	Hammond's Flycatcher	*Empidonax hammondii*	(FL)	S
469.1	Gray Flycatcher	*Empidonax wrightii*	(FL)	S
469.0	Dusky Flycatcher	*Empidonax oberholseri*		S
464.0	Cordilleran Flycatcher	*Empidonax occidentalis*		S
456.0	Eastern Phoebe	*Sayornis phoebe*	(AS)	S
457.0	Say's Phoebe	*Sayornis saya*		S
471.0	Vermilion Flycatcher	*Pyrocephalus rubinus*	(AS)	A
454.0	Ash-throated Flycatcher	*Myiarchus cinerascens*	(FL)	S, NSS3/II
452.0	Great Crested Flycatcher	*Myiarchus crinitus*	(AS)	A
448.0	Cassin's Kingbird	*Tyrannus vociferans*	(FL)	S
447.0	Western Kingbird	*Tyrannus verticalis*		S
444.0	Eastern Kingbird	*Tyrannus tyrannus*		S
443.0	Scissor-tailed Flycatcher	*Tyrannus forficatus*	(AS)	A
Family: Laniidae				
622.0	Loggerhead Shrike	*Lanius ludovicianus*		S
621.0	Northern Shrike	*Lanius excubitor*		W
Family: Vireonidae				
631.0	White-eyed Vireo	*Vireo griseus*	(AS)	A
634.0	Gray Vireo	*Vireo vicinior*	(AS)	S
628.0	Yellow-throated Vireo	*Vireo flavifrons*	(AS)	A

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629.1	Plumbeous Vireo	*Vireo plumbeus*		S
629.2	Cassin's Vireo	*Vireo cassinii*	(AS)	M
629.3	Blue-headed Vireo	*Vireo solitarius*	(AS)	M
627.0	Warbling Vireo	*Vireo gilvus*		S
626.0	Philadelphia Vireo	*Vireo philadelphicus*	(AS)	M
624.0	Red-eyed Vireo	*Vireo olivaceus*		S
Family: Corvidae				
484.0	Gray Jay	*Perisoreus canadensis*		R
492.0	Pinyon Jay	*Gymnorhinus cyanocephalus*		R
478.0	Steller's Jay	*Cyanocitta stelleri*		R
477.0	Blue Jay	*Cyanocitta cristata*		R
481.0	Western Scrub-Jay	*Aphelocoma californica*	(FL)	R, NSS3/II
491.0	Clark's Nutcracker	*Nucifraga columbiana*		R
475.0	Black-billed Magpie	*Pica hudsonia*		R
488.0	American Crow	*Corvus brachyrhynchos*		R
486.0	Common Raven	*Corvus corax*		R
Family: Alaudidae				
474.0	Horned Lark	*Eremophila alpestris*		R
Family: Hirundinidae				
611.0	Purple Martin	*Progne subis*	(AS)	S
614.0	Tree Swallow	*Tachycineta bicolor*		S
615.0	Violet-green Swallow	*Tachycineta thalassina*		S
617.0	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*		S
616.0	Bank Swallow	*Riparia riparia*		S
612.0	Cliff Swallow	*Petrochelidon pyrrhonota*		S
613.0	Barn Swallow	*Hirundo rustica*		S
Family: Paridae				
735.0	Black-capped Chickadee	*Poecile atricapillus*		R
738.0	Mountain Chickadee	*Poecile gambeli*		R
733.0	Juniper Titmouse	*Baeolophus ridgwayi*	(FL)	R, NSS3/II
Family: Aegithalidae				
743.0	Bushtit	*Psaltriparus minimus*	(FL)	S, NSS3/II
Family: Sittidae				
728.0	Red-breasted Nuthatch	*Sitta canadensis*		R
727.0	White-breasted Nuthatch	*Sitta carolinensis*		R
730.0	Pygmy Nuthatch	*Sitta pygmaea*		R, NSSU/II
Family: Certhiidae				
726.0	Brown Creeper	*Certhia americana*		R
Family: Troglodytidae				
715.0	Rock Wren	*Salpinctes obsoletus*		S
717.0	Canyon Wren	*Catherpes mexicanus*		R
721.0	House Wren	*Troglodytes aedon*		S
722.1	Pacific Wren	*Troglodytes pacificus*	(AS)	M
722.0	Winter Wren	*Troglodytes troglodytes*	(AS)	M
724.0	Sedge Wren	*Cistothorus platensis*	(AS)	A
725.0	Marsh Wren	*Cistothorus palustris*		S
718.0	Carolina Wren	*Thryothorus ludovicianus*	(AS)	A
719.0	Bewick's Wren	*Thryomanes bewickii*	(FL)	S

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Family: Polioptilidae				
751.0	Blue-gray Gnatcatcher	*Polioptila caerulea*		S
Family: Cinclidae				
701.0	American Dipper	*Cinclus mexicanus*		R
Family: Regulidae				
748.0	Golden-crowned Kinglet	*Regulus satrapa*		R
749.0	Ruby-crowned Kinglet	*Regulus calendula*		S
Family: Turdidae				
766.0	Eastern Bluebird	*Sialia sialis*	(FL)	S
767.0	Western Bluebird	*Sialia mexicana*	(AS)	S
768.0	Mountain Bluebird	*Sialia currucoides*		S
754.0	Townsend's Solitaire	*Myadestes townsendi*		R
756.0	Veery	*Catharus fuscescens*		S
757.0	Gray-cheeked Thrush	*Catharus minimus*	(AS)	M
758.0	Swainson's Thrush	*Catharus ustulatus*		S
759.0	Hermit Thrush	*Catharus guttatus*		S
755.0	Wood Thrush	*Hylocichla mustelina*	(AS)	M
761.0	American Robin	*Turdus migratorius*		R
763.0	Varied Thrush	*Ixoreus naevius*	(AS)	M
Family: Mimidae				
704.0	Gray Catbird	*Dumetella carolinensis*		S
705.0	Brown Thrasher	*Toxostoma rufum*		S
702.0	Sage Thrasher	*Oreoscoptes montanus*		S, NSS4/II
703.0	Northern Mockingbird	*Mimus polyglottos*		S
Family: Sturnidae				
493.0	European Starling	*Sturnus vulgaris*		R
Family: Motacillidae				
697.0	American Pipit	*Anthus rubescens*		S
700.0	Sprague's Pipit	*Anthus spragueii*	(AS)	M
Family: Bombycillidae				
618.0	Bohemian Waxwing	*Bombycilla garrulus*		W
619.0	Cedar Waxwing	*Bombycilla cedrorum*		R
Family: Calcariidae				
536.0	Lapland Longspur	*Calcarius lapponicus*		W
538.0	Chestnut-collared Longspur	*Calcarius ornatus*	(FL)	S, NSS4/II
537.0	Smith's Longspur	*Calcarius pictus*	(AS)	A
539.0	McCown's Longspur	*Rhynchophanes mccownii*		S, NSS4/II
534.0	Snow Bunting	*Plectrophenax nivalis*		W
Family: Parulidae				
674.0	Ovenbird	*Seiurus aurocapilla*		S
639.0	Worm-eating Warbler	*Helmitheros vermivorum*	(AS)	A
675.0	Northern Waterthrush	*Seiurus noveboracensis*		M
642.0	Golden-winged Warbler	*Vermivora chrysoptera*	(AS)	A
641.0	Blue-winged Warbler	*Vermivora cyanoptera*	(AS)	A
636.0	Black-and-white Warbler	*Mniotilta varia*	(FL)	M
637.0	Prothonotary Warbler	*Protonotaria citrea*	(AS)	A
647.0	Tennessee Warbler	*Oreothlypis peregrina*	(FL)	M
646.0	Orange-crowned Warbler	*Oreothlypis celata*		S
645.0	Nashville Warbler	*Oreothlypis ruficapilla*	(FL)	M
644.0	Virginia's Warbler	*Oreothlypis virginiae*	(FL)	S

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678.0	Connecticut Warbler	*Oporornis agilis*	(AS)	A
680.0	MacGillivray's Warbler	*Geothlypis tolmiei*		S
679.0	Mourning Warbler	*Geothlypis philadelphia*	(AS)	A
677.0	Kentucky Warbler	*Geothlypis formosus*	(AS)	A
681.0	Common Yellowthroat	*Geothlypis trichas*		S
684.0	Hooded Warbler	*Setophaga citrina*	(AS)	A
687.0	American Redstart	*Setophaga ruticilla*		S
650.0	Cape May Warbler	*Setophaga tigrina*	(AS)	A
648.0	Northern Parula	*Setophaga americana*	(FL)	M
657.0	Magnolia Warbler	*Setophaga magnolia*	(FL)	M
660.0	Bay-breasted Warbler	*Setophaga castanea*	(AS)	M
662.0	Blackburnian Warbler	*Setophaga fusca*	(AS)	M
652.0	Yellow Warbler	*Dendroica petechia*		S
659.0	Chestnut-sided Warbler	*Setophaga pensylvanica*	(FL)	M
661.0	Blackpoll Warbler	*Setophaga striata*	(FL)	M
654.0	Black-throated Blue Warbler	*Setophaga caerulescens*	(FL)	M
672.0	Palm Warbler	*Setophaga palmarum*	(AS)	M
671.0	Pine Warbler	*Setophaga pinus*	(AS)	A
655.0	Yellow-rumped Warbler	*Setophaga coronata*		S
663.0	Yellow-throated Warbler	*Setophaga dominica*	(AS)	A
673.0	Prairie Warbler	*Setophaga discolor*	(AS)	A
665.0	Black-throated Gray Warbler	*Setophaga nigrescens*	(FL)	S
668.0	Townsend's Warbler	*Setophaga townsendi*		S
669.0	Hermit Warbler	*Setophaga occidentalis*	(AS)	A
667.0	Black-throated Green Warbler	*Setophaga virens*	(AS)	A
686.0	Canada Warbler	*Cardellina canadensis*	(AS)	A
685.0	Wilson's Warbler	*Cardellina pusilla*		S
690.0	Red-faced Warbler	*Cardellina rubrifrons*	(AS)	A
683.0	Yellow-breasted Chat	*Icteria virens*		S
Family: Emberizidae				
590.0	Green-tailed Towhee	*Pipilo chlorurus*		S
587.0	Spotted Towhee	*Pipilo maculatus*		S
591.0	Canyon Towhee	*Pipilo fuscus*	(AS)	A
578.0	Cassin's Sparrow	*Peucaea cassinii*	(AS)	A, (AS) except confirmed breeding in Torrington area
559.0	American Tree Sparrow	*Spizella arborea*		W
560.0	Chipping Sparrow	*Spizella passerina*		S
561.0	Clay-colored Sparrow	*Spizella pallida*		S
562.0	Brewer's Sparrow	*Spizella breweri*		S, NSS4/II
563.0	Field Sparrow	*Spizella pusilla*	(AS)	S
540.0	Vesper Sparrow	*Pooecetes gramineus*		S
552.0	Lark Sparrow	*Chondestes grammacus*		S
573.0	Black-throated Sparrow	*Amphispiza bilineata*	(AS)	S
574.0	Sagebrush Sparrow	*Artemisiospiza nevadensis*		S, NSS4/II
605.0	Lark Bunting	*Calamospiza melanocorys*		S, NSS4/II
542.0	Savannah Sparrow	*Passerculus sandwichensis*		S
546.0	Grasshopper Sparrow	*Ammodramus savannarum*		S, NSS4/II
545.0	Baird's Sparrow	*Ammodramus bairdii*	(AS)	S
548.0	Le Conte's Sparrow	*Ammodramus leconteii*	(AS)	M

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549.1	Nelson's Sparrow	*Ammodramus nelsoni*	(AS)	A
585.0	Fox Sparrow	*Passerella iliaca*		R
581.0	Song Sparrow	*Melospiza melodia*		R
583.0	Lincoln's Sparrow	*Melospiza lincolnii*		S
584.0	Swamp Sparrow	*Melospiza georgiana*	(FL)	M
558.0	White-throated Sparrow	*Zonotrichia albicollis*		M
553.0	Harris's Sparrow	*Zonotrichia querula*		W
554.0	White-crowned Sparrow	*Zonotrichia leucophrys*		S
557.0	Golden-crowned Sparrow	*Zonotrichia atricapilla*	(AS)	A
567.0	Dark-eyed Junco	*Junco hyemalis*		R, Includes White-winged (566.0), Slate-colored (567.0), Oregon (567.1), Pink-sided (568.0), and Gray-headed (569.0)
Family: Cardinalidae				
609.0	Hepatic Tanager	*Piranga flava*	(AS)	A
610.0	Summer Tanager	*Piranga rubra*	(AS)	M
608.0	Scarlet Tanager	*Piranga olivacea*	(AS)	A
607.0	Western Tanager	*Piranga ludoviciana*		S
593.0	Northern Cardinal	*Cardinalis cardinalis*	(AS)	M
594.1	Yellow Grosbeak	*Pheucticus chrysopeplus*	(AS)	A
595.0	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	(FL)	S
596.0	Black-headed Grosbeak	*Pheucticus melanocephalus*		S
597.0	Blue Grosbeak	*Passerina caerulea*		S
599.0	Lazuli Bunting	*Passerina amoena*		S
598.0	Indigo Bunting	*Passerina cyanea*	(FL)	S
601.0	Painted Bunting	*Passerina ciris*	(AS)	A
604.0	Dickcissel	*Spiza americana*	(FL)	S, NSS4/II
Family: Icteridae				
494.0	Bobolink	*Dolichonyx oryzivorus*	(FL)	S, NSS4/II
498.0	Red-winged Blackbird	*Agelaius phoeniceus*		S
501.0	Eastern Meadowlark	*Sturnella magna*	(AS)	A
501.1	Western Meadowlark	*Sturnella neglecta*		S
497.0	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		S
509.0	Rusty Blackbird	*Euphagus carolinus*	(AS)	M
510.0	Brewer's Blackbird	*Euphagus cyanocephalus*		S
511.0	Common Grackle	*Quiscalus quiscula*		S
512.0	Great-tailed Grackle	*Quiscalus mexicanus*	(FL)	A
495.0	Brown-headed Cowbird	*Molothrus ater*		S
506.0	Orchard Oriole	*Icterus spurius*	(FL)	S
508.0	Bullock's Oriole	*Icterus bullockii*		S
507.0	Baltimore Oriole	*Icterus galbula*	(AS)	A
504.0	Scott's Oriole	*Icterus parisorum*	(AS)	S
Family: Fringillidae				
514.1	Brambling	*Fringilla montifringilla*	(AS)	A
524.0	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*		R
525.0	Black Rosy-Finch	*Leucosticte atrata*		R, NSSU/II
526.0	Brown-capped Rosy-Finch	*Leucosticte australis*	(FL)	R, NSSU/II
515.0	Pine Grosbeak	*Pinicola enucleator*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
519.0	House Finch	*Haemorhous mexicanus*		R
517.0	Purple Finch	*Haemorhous purpureus*	(AS)	W
518.0	Cassin's Finch	*Haemorhous cassini*		R
521.0	Red Crossbill	*Loxia curvirostra*		R
522.0	White-winged Crossbill	*Loxia leucoptera*	(FL)	R
528.0	Common Redpoll	*Acanthis flammea*		W
527.0	Hoary Redpoll	*Acanthis hornemanni*	(AS)	W
533.0	Pine Siskin	*Spinus pinus*		R
530.0	Lesser Goldfinch	*Spinus psaltria*	(FL)	M
531.0	Lawrence's Goldfinch	*Spinus lawrencei*	(AS)	A
529.0	American Goldfinch	*Spinus tristis*		R
514.0	Evening Grosbeak	*Coccothraustes vespertinus*		R
Family: Passeridae				
688.2	House Sparrow	*Passer domesticus*		R
Note: the following avian species have been documented in Wyoming, but these are human-assisted species and, as such, are not recognized as wild, naturally occurring species in the State.				
Controlled Species **Waterfowl** **Order: Anseriformes** **Family: Anatidae**				
178.0	Fulvous Whistling-Duck	*Dendrocygna bicolor*	(AS)	A, Controlled
178.2	Mute Swan	*Cygnus olor*	(AS)	A, Controlled
141.2	Ruddy Shelduck	*Tadorna ferruginea*		A, Controlled
141.1	Common Shelduck	*Tadorna tadorna*		A, Controlled
Pigeons and Doves **Order: Columbiformes** **Family: Columbidae**				
315.2	African Collared-Dove	*Streptopelia roseogrisea*		A, Controlled
Passerines **Order: Passeriformes** **Family: Fringillidae**				
526.1	European Goldfinch	*Carduelis carduelis*		A, Controlled

Spp. Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
		MAMMALS [d, e]		
Marsupials **Order: Marsupialia** **Family: Didelphidae**				
800.0	Virginia Opossum	Didelphis virginiana		A
Insectivores **Order: Insectivora** **Family: Soricidae**				
801.0	Masked Shrew	*Sorex cinereus*		R
801.1	Hayden's Shrew	*Sorex haydeni*		R, NSS4/III
806.0	Pygmy Shrew	*Sorex hoyi*		R, NSS2/II
805.0	Merriam's Shrew	*Sorex merriami*		R
807.0	Dusky Shrew	*Sorex monticolus*		R
803.0	Dwarf Shrew	*Sorex nanus*		R, NSS3/II
804.0	American Water Shrew	*Sorex palustris*		R
804.1	Preble's Shrew	*Sorex preblei*		R, NSS3/II
802.0	Vagrant Shrew	*Sorex vagrans*		R, NSS4/III
Family: Talpidae				
810.0	Eastern Mole	*Scalopus aquaticus*		R
Bats **Order: Chiroptera** **Family: Vespertilionidae**				
815.1	California Myotis	*Myotis californicus*		U
816.0	Western Small-footed Myotis	*Myotis ciliolabrum*		U, NSS4/II
818.0	Long-eared Myotis	*Myotis evotis*		U, NSS3/II
819.0	Northern Myotis	*Myotis septentrionalis*		U, NSS3/II
815.0	Little Brown Myotis	*Myotis lucifugus*		U, NSS4/II
826.0	Fringed Myotis	*Myotis thysanodes*		U, NSS3/II
817.0	Long-legged Myotis	*Myotis volans*		U, NSS3/II
817.1	Yuma Myotis	*Myotis yumanensis*		U
821.0	Eastern Red Bat	*Lasiurus borealis*		S, NSSU/II
822.0	Hoary Bat	*Lasiurus cinereus*		S
820.0	Silver-haired Bat	*Lasionycteris noctivagans*		U
820.1	Eastern Pipistrelle	*Pipistrellus subflavus*		U
825.0	Big Brown Bat	*Eptesicus fuscus*		U, NSS4/II
824.0	Spotted Bat	*Euderma maculatum*		S, NSS3/II
823.0	Townsend's Big-eared Bat	*Corynorhinus townsendii*		U, NSS2/I
827.0	Pallid Bat	*Antrozous pallidus*		S, NSS3/III
Family: Molossidae				
828.0	Brazilian Free-tailed Bat	*Tadarida brasiliensis*		A
829.0	Big Free-tailed Bat	*Nyctinomops macrotis*		A
Lagomorphs **Order: Lagomorpha** **Family: Ochotonidae**				
830.0	American Pika	*Ochotona princeps*		R, NSSU/II
Family: Leporidae				
837.0	Pygmy Rabbit	*Brachylagus idahoensis*		R, NSS3/II
833.0	Desert Cottontail *	*Sylvilagus audubonii*		R
834.0	Eastern Cottontail *	*Sylvilagus floridanus*		R
835.0	Mountain Cottontail *	*Sylvilagus nuttallii*		R

Spp. Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
836.0	Snowshoe Hare *	*Lepus americanus*		R
832.0	Black-tailed Jackrabbit *	*Lepus californicus*		R, Predatory animal
831.0	White-tailed Jackrabbit *	*Lepus townsendii*		R, Predatory animal
Rodents **Order: Rodentia** **Family: Sciuridae**				
841.0	Yellow-pine Chipmunk	*Neotamias amoenus*		R, NSS4/III
842.0	Cliff Chipmunk	*Neotamias dorsalis*		R, NSS3/II
840.0	Least Chipmunk	*Neotamias minimus*		R
843.0	Uinta Chipmunk	*Neotamias umbrinus*		R, NSS4/III
844.0	Yellow-bellied Marmot	*Marmota flaviventris*		R
846.0	Uinta Ground Squirrel	*Spermophilus armatus*		R
845.0	Wyoming Ground Squirrel	*Spermophilus elegans*		R
849.0	Golden-mantled Ground Squirrel	*Spermophilus lateralis*		R
847.0	Spotted Ground Squirrel	*Spermophilus spilosoma*		R, NSS4/III
848.0	Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*		R
851.0	White-tailed Prairie Dog	*Cynomys leucurus*		R
850.0	Black-tailed Prairie Dog	*Cynomys ludovicianus*		R
855.0	Abert's Squirrel	*Sciurus aberti*		R
856.0	Eastern Gray Squirrel *	*Sciurus carolinensis*		R
852.0	Eastern Fox Squirrel *	*Sciurus niger*		R
854.0	Red Squirrel *	*Tamiasciurus hudsonicus*		R
853.0	Northern Flying Squirrel	*Glaucomys sabrinus*		R, NSS4/II
Family: Geomyidae				
862.0	Wyoming Pocket Gopher	*Thomomys clusius*		R, NSS3/II
863.0	Idaho Pocket Gopher	*Thomomys idahoensis*		R, NSS3/II
860.0	Northern Pocket Gopher	*Thomomys talpoides*		R
861.0	Plains Pocket Gopher	*Geomys bursarius*		R, NSS4/II
Family: Heteromyidae				
865.0	Olive-backed Pocket Mouse	*Perognathus fasciatus*		R, NSS4/II
893.0	Plains Pocket Mouse	*Perognathus flavescens*		R, NSS3/III
866.0	Silky Pocket Mouse	*Perognathus flavus*		R, NSS3/II
867.0	Great Basin Pocket Mouse	*Perognathus parvus*		R, NSS3/II
868.0	Hispid Pocket Mouse	*Chaetodipus hispidus*		R, NSS3/II
869.0	Ord's Kanagroo Rat	*Dipodomys ordii*		R
Family: Castoridae				
875.0	Beaver *	*Castor canadensis*		R
Family: Muridae				
877.0	Western Harvest Mouse	*Reithrodontomys megalotis*		R
876.0	Plains Harvest Mouse	*Reithrodontomys montanus*		R, NSS3/II
878.0	Canyon Mouse	*Peromyscus crinitus*		R, NSS3/II
881.0	White-footed Mouse	*Peromyscus leucopus*		R
880.0	Deer Mouse	*Peromyscus maniculatus*		R
879.0	Piñon Mouse	*Peromyscus truei*		R, NSS3/II
882.0	Northern Grasshopper Mouse	*Onychomys leucogaster*		R
883.0	Bushy-tailed Woodrat	*Neotoma cinerea*		R
884.0	Southern Red-backed Vole	*Clethrionomys gapperi*		R
885.0	Western Heather Vole	*Phenacomys intermedius*		R
888.0	Long-tailed Vole	*Microtus longicaudus*		R
887.0	Montane Vole	*Microtus montanus*		R

Spp. Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
890.0	Prairie Vole	*Microtus ochrogaster*		R
886.0	Meadow Vole	*Microtus pennsylvanicus*		R
889.0	Water Vole	*Microtus richardsoni*		R, NSS3/II
891.0	Sagebrush Vole	*Lemmiscus curtatus*		R
892.0	Common Muskrat *	*Ondatra zibethicus*		R
894.2	Norway Rat	*Rattus norvegicus*		R
894.1	House Mouse	*Mus musculus*		R
Family: Zapodidae				
895.0	Meadow Jumping Mouse	*Zapus hudsonius*		R, NSS4/II
895.1	Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*		R
896.0	Western Jumping Mouse	*Zapus princeps*		R
Family: Erethizontidae				
900.0	North American Porcupine *	*Erethizon dorsatum*		R, Predatory animal
<u>Carnivores</u> **Order: Carnivora** **Family: Canidae**				
901.0	Coyote *	*Canis latrans*		R, Predatory animal
902.0	Gray Wolf *	*Canis lupus*		R
904.0	Swift Fox	*Vulpes velox*		R, NSS4/II
903.0	Red Fox *	*Vulpes vulpes*		R, Predatory animal
905.0	Common Gray Fox	*Urocyon cinereoargenteus*		R
Family: Ursidae				
940.0	Black Bear *	*Ursus americanus*		R
941.0	Grizzly Bear *	*Ursus arctos*		R, Threatened
Family: Procyonidae				
906.0	Ringtail	*Bassariscus astutus*		R
907.0	Northern Raccoon *	*Procyon lotor*		R, Predatory animal
Family: Mustelidae				
908.0	American Marten *	*Martes americana*		R, NSS4/II
909.0	Fisher	*Martes pennanti*		R, NSSU/III
910.0	Short-tailed Weasel (Ermine) *	*Mustela erminea*		R
911.0	Long-tailed Weasel *	*Mustela frenata*		R
913.0	Black-footed Ferret	*Mustela nigripes*		R, Endangered, NSS1/I
919.0	Least Weasel	*Mustela nivalis*		R, NSSU/III
912.0	American Mink *	*Mustela vison*		R
914.0	Wolverine	*Gulo gulo*		R, NSS3/II
915.0	American Badger *	*Taxidea taxus*		R
916.1	Western Spotted Skunk *	*Spilogale gracilis*		R, Predatory animal
916.0	Eastern Spotted Skunk *	*Spilogale putorius*		R, Predatory animal
917.0	Striped Skunk *	*Mephitis mephitis*		R, Predatory animal
918.0	Northern River Otter	*Lontra canadensis*		R, NSSU/II
Family: Felidae				
922.0	Mountain Lion (Puma) *	*Puma concolor*		R
920.0	Canada Lynx	*Lynx canadensis*		R, Threatened, NSS1/I
921.0	Bobcat *	*Lynx rufus*		R

Spp. Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
<u>Ungulates</u> **Order: Artiodactyla** **Family: Cervidae**				
930.0	Elk (Wapiti) *	*Cervus canadensis*		R
932.0	Mule Deer (Black-tailed Deer) *	*Odocoileus hemionus*		R
933.0	White-tailed Deer *	*Odocoileus virginianus*		R
931.0	Moose *	*Alces alces*		R, NSS4/II
Family: Antilocapridae				
935.0	Pronghorn *	*Antilocapra americana*		R
Family: Bovidae				
925.0	Bison *	*Bos bison*		R
926.0	Mountain Goat *	*Oreamnos americanus*		R
927.0	Bighorn Sheep (Mountain Sheep) *	*Ovis canadensis*		R, NSS3/II

Spp. Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
AMPHIBIANS [f]				
Salamanders **Order: Caudata** **Family: Ambystomatidae**				
950.0	Tiger Salamander	*Ambystoma mavortium*		R; includes Blotched, Western, and Arizona subspecies.
Toads and Frogs **Order: Anura** **Family: Pelobatidae**				
951.0	Plains Spadefoot	*Spea bombifrons*		R, NSSU/III
951.1	Great Basin Spadefoot	*Spea intermontana*		R, NSSU/I
Family: Bufonidae				
951.2	Western Toad (Boreal Toad)	*Anaxyrus boreas*		R, NSS1/I
951.3	Great Plains Toad	*Anaxyrus cognatus*		R, NSSU/III
951.5	Wyoming Toad	*Anaxyrus baxteri*		R, NSS1/I
951.4	Rocky Mountain Toad (Woodhouse's Toad)	*Anaxyrus woodhousii woodhousii*		R
Family: Ranidae				
952.1	American Bullfrog	*Lithobates catesbeianus*		R
952.2	Northern Leopard Frog	*Lithobates pipiens*		R, NSSU/III
952.3	Columbia Spotted Frog	*Rana luteiventris*		R, NSS3/II
952.4	Wood Frog	*Lithobates sylvaticus*		R, NSS2/II
Family: Hylidae				
952.0	Boreal Chorus Frog	*Pseudacris maculata*		R

Spp.Code	Common Name	Scientific Name	Doc. Type	Seasonal Status and Additional Information [a, b]
		REPTILES [f]		
Turtles **Order: Testudines** **Family: Trionychidae**				
953.0	Eastern Spiny Softshell	*Apalone spinifera spinifera*		R, NSS4/III
Family: Testudinidae				
953.2	Plains Box Turtle	*Terrapene ornata ornata*		R, NSSU/III
953.3	Western Painted Turtle	*Chrysemys picta bellii*		R, NSS4/III
Family: Chelydridae				
953.1	Snapping Turtle	*Chelydra serpentina*		R
Lizards **Order: Squamata** **Family: Teiidae**				
954.0	Prairie Racerunner	*Aspidoscelis sexlineata viridis*		R, NSSU/II
Family: Scincidae				
954.1	Northern Many-lined Skink	*Plestidon multivirgatus multivirgatus*		R, NSS4/U/III
954.9	Great Basin Skink	*Plestiodon skiltonianus utahensis*		R, NSSU/III
Family: Iguanidae				
954.3	Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*		R
954.4	Plateau Fence Lizard	*Sceloporus tristichus*		R
954.6	Prairie Lizard	*Sceloporus consobrinus*		R, NSSU/II
954.8	Northern Tree Lizard	*Urosaurus ornatus wrighti*		R, NSS1/II
954.2	Greater Short-horned Lizard	*Phrynosoma hernandesi*		R, NSS4/III
954.7	Great Plains Earless Lizard	*Holbrookia maculata maculata*		R, NSSU/III
Snakes **Order: Squamata** **Family: Boidae**				
955.2	Northern Rubber Boa	*Charina bottae*		R, NSS3/II
Family: Colubridae				
955.3	Plains Hog-nosed Snake	*Heterodon nasicus*		R, NSSU/II
956.2	Eastern Yellow-bellied Racer	*Coluber constrictor flaviventris*		R
956.6	Desert Striped Whipsnake	*Coluber taeniatus taeniatus*		R
956.3	Smooth Greensnake	*Opheodrys vernalis*		R, NSS3/II
955.4	Black Hills Red-bellied Snake	*Storeria occipitomaculata pahasapae*		R, NSSU/II
956.1	Pale Milksnake	*Lampropeltis triangulum multistriata*		R, NSS3/II
955.6	Great Basin Gophersnake	*Pituophis catenifer deserticola*		R, NSS2/II
955.5	Bullsnake	*Pituophis catenifer sayi*		R
956.4	Plains Black-headed Snake	*Tantilla nigriceps*		R, NSSU/II
955.8	Wandering Gartersnake	*Thamnophis elegans vagrans*		R
956.0	Valley Gartersnake	*Thamnophis sirtalis fitchi*		R, NSSU/II
955.9	Red-sided Gartersnake	*Thamnophis sirtalis parietalis*		R, NSSU/II
955.7	Plains Gartersnake	*Thamnophis radix*		R, NSSU/II
Family: Crotalidae				
955.0	Prairie Rattlesnake	*Crotalus viridis*		R
955.1	Midget Faded Rattlesnake	*Crotalus oreganus concolor*		R, NSS1/I

[a] Species seasonal status: R = year-round resident, S = summer resident, W = winter resident, M = migrant, A = accidental occurrence in Wyoming, U = residency status in Wyoming is unknown.

[b] Wyoming Game and Fish Department Species of Greatest Conservation Need with a Native Species Status (NSS) of 1, 2, 3, 4, or unknown and Conservation Tier I, II, or III (WGFD 2010) .

[c] Common and scientific names and species order are from the American Ornithologists' Union (1983, 2013). An "(AS)" indicates species for which full written documentation of all sightings is requested by the Wyoming Bird Records Committee; an "(FL)" indicates species for which documentation is only requested for the first sighting in each latilong and all nesting observations. In addition, full documentation is required for any species not listed here and for observations of breeding attempts.

[d] An asterisk following a species common name indicates those species classified as game, predacious bird, predatory animal, or furbearer by state statute or Wyoming Game and Fish Commission Regulation.

[e] Common and scientific names (except *C. townsendii*) and species order are from Baker et al. (2003).

[f] Common and scientific names and species order are from Baxter and Stone (1992) and Crother (2012).

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