THREATENED, ENDANGERED, AND NONGAME BIRD AND MAMMAL INVESTIGATIONS

Wyoming Game and Fish Department Nongame Program
Statewide Wildlife and Habitat Management Section
Wildlife Division

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United States Army Corp of Engineers (USACE)
United States Fish and Wildlife Service Cooperative Agreement (USFWS CA)
United States Fish and Wildlife Service State Wildlife Grants (USFWS SWG)
United States Forest Service Cooperative Agreement (USFS CA)
United States Forest Service Rocky Mountain Research Station (USFS RMRS)
Western Association of Fish and Wildlife Agencies (WAFWA)
Wyoming Game and Fish Department (WGFD)
Wyoming Governor's Endangered Species Account Funds (WGESAF)
Wyoming State Legislature General Fund Appropriations (WSLGFA)

OVERVIEW OF NONGAME PROGRAM PROJECTS AND FUNDING SOURCES

Species/Project	BLM CA	BOR CA	MBRWF	NPS CA	RCF	USACE	USFWS CA	USFWS SWG	USFS CA	USFS RMRS	WAFWA	WGFD	WG ESAF	WSL GFA
Preble's Meadow Jumping Mouse													X	X
Trumpeter Swan	X						X							X
Common Loon					X									
Secretive Marsh Birds													X	X
Bald Eagle monitoring						X								X
Mountain Plover													X	X
Upland Sandpiper													X	X
Long-billed Curlew													X	X
Burrowing Owl													X	X
Great Gray Owl								X						X
Black-backed Woodpecker density													X	X
Black-backed Woodpecker population										X			X	
Peregrine Falcon							X	X						X
Bat inventory								X						X
Bat hibernacula and surveillance								X						X

Species/Project	BLM CA	BOR CA	MBRWF	NPS CA	RCF	USACE	USFWS CA	USFWS SWG	USFS CA	USFS RMRS	WAFWA	WGFD	WG ESAF	WSL GFA
Northern Flying Squirrel – Jackson			X											X
Northern Flying Squirrel – BHNF								X						X
Water Vole								X						X
Fisher								X						X
Falconry	X											X		
Breeding Bird Survey	X	X		X			X		X					X
WYPIF/IMBCR	X			X				X	X				X	X
White-tailed Prairie Dog								X			X			X
Spotted Skunks													X	X
Central Flyway NMBTC												X		X

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, Sagebrush Sparrow, and Sage Thrasher. Recent SWG projects also included 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, Bird Conservancy of the Rockies (formerly 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 difficult 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 2014 to 14 April 2015 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 most recent Revised Checklist of North American Mammals North of Mexico.

THREATENED AND ENDANGERED SPECIES

DISTRIBUTION AND ECOLOGY OF JUMPING MICE (*ZAPUS SPP.*) IN 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 Fund Appropriations

PROJECT DURATION: 1 July 2012 – 30 September 2014

PERIOD COVERED: 15 April 2014 – 30 September 2014

PREPARED BY: Nichole Cudworth, Nongame Biologist

ABSTRACT

The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is listed as Threatened by the US Fish and Wildlife Service throughout its range in Wyoming and Colorado. Despite initial controversy over taxonomy, the Preble's meadow jumping mouse was given subspecific status in 2006. As a result, the Wyoming Game and Fish Department began funding annual surveys in 2009 to document presence and distribution. In 2014, we used live-capture surveys to further refine distribution and investigate the effects of wildfire and sympatry with western jumping mice (*Z. princeps*) on Preble's meadow jumping mouse populations. Overall, we captured 51 unique individuals at 5 sites; genetic results are pending. We documented jumping mice at two of four drainages that were not previously surveyed. We were also able to document recolonization of jumping mice within 2 years following low-severity fires. Finally, we captured 41 individuals at Friend Creek, a site where we documented sympatric populations of western and Preble's meadow jumping mice in 2013. We hope to further evaluate the impacts of sympatry on movements, reproduction, and capture rates once genetic results are available for these individuals. This year concludes a 6-year effort to refine distribution and ecology of jumping mice. Future surveys should continue to monitor both disturbed and undisturbed sites to elucidate persistence, survival, and abundance in order to ensure the continued presence of Preble's meadow jumping mice in Wyoming.

INTRODUCTION

The Preble's meadow jumping mouse (Preble's; *Zapus hudsonius preblei*) is listed as Threatened by the US Fish and Wildlife Service throughout its range in Wyoming and Colorado. The Preble's is dependent on riparian habitat with relatively undisturbed grassland vegetation interspersed with shrubs (USFWS 2003*a*, 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 are recognized as the critical limiting factors 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; Cudworth and Grenier 2013, 2014). Our objectives in 2014 were four-fold: continue to evaluate distribution; assess the impacts of recent wildfire outbreaks; determine within-site survival, population dynamics, and demographics; and investigate the impacts of sympatry with western jumping mice (*Z. princeps*).

METHODS

We conducted surveys from 2 June through 21 August 2014 throughout the distribution of Preble's in Wyoming. In order to evaluate distribution, we surveyed sites within four hydrologic unit codes (HUCs) that had not previously been surveyed. To evaluate the response of Preble's to wildfire, we also conducted repeated surveys once per month along North Cottonwood Creek, which burned at low severity in 2012 (USFS 2012). North Cottonwood Creek contained a confirmed breeding population of Preble's in 2011, the year immediately preceding wildfire outbreaks (Thompson et al. 2012). To estimate within-site survival, population dynamics, and demographics, we conducted surveys periodically along 2 sites on the North Laramie River, one of which had a known population of jumping mice in 2009 (Thompson and Grenier 2010). Finally, to evaluate the effects of sympatry with western jumping mice, we conducted repeated surveys every 3 weeks along Friend Creek, where both species were confirmed in 2013 (Table 1, Fig. 1).

We followed protocols established by the USFWS (2004) to capture jumping mice. We used live traps (Model 339A non-folding traps; H.B. Sherman Traps, Inc., Tallahassee, FL) baited with 3-way grain mix with molasses (Ranch-Way Feeds, Inc., Fort Collins, CO) 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 on the same side of the stream. We opened traps within 3 hrs of sunset and checked within 3 hrs of sunrise for 3 consecutive nights for a total of ≥750 trap nights per site. We used a GPS to document location 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.

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, identification in the field is impossible, and genetic analyses are required to distinguish between species. Consequently, we also collected biological samples, 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 sites throughout the predicted range of the Preble's in Wyoming; we surveyed Friend Creek four times, Laramie River (Tunnel Road) three times, Laramie River (Wheatland) two times, and North Cottonwood Creek three times throughout the season. Sites averaged 869.0 (±25.4) trap nights per trapping session (range: 795.5 to 1194.5). We captured 51 jumping mice at 5 sites, including two HUCs that had not been surveyed previously: Rock Creek and Cooper Creek (Table 1; Fig. 1). We failed to detect jumping mice at the other distribution sites. We captured three jumping mice at Cottonwood Creek, the site of the 2012 fire, including two reproductively active females (Table 2). We captured one jumping mouse along the upper Laramie River (Tunnel Road), but failed to capture any jumping mice lower near Wheatland. Finally, we captured 41 jumping mice at Friend Creek, 4 of which were recaptures from 2013 (Table 2). Two individuals were female Preble's (ID#: 00313 and 20714), one was a male western jumping mouse (ID#: 21214), and the fourth was a female, although the ear tag was lost and did not allow for positive identification (ID#: 20114).

We captured 2,759 nontarget individuals, which included 11 different species. Nontarget captures, in order of number of captures, included: deer mouse (*Peromyscus maniculatus*), voles (montane vole [*Microtus montanus*], prairie vole [*M. ochrogaster*], and long-tailed vole [*M. longicaudus*]), western harvest mouse (*Reithrodontomys megalotis*), shrews (dusky shrew [*Sorex monticolus*] and dwarf shrew [*S. nanus*]), least chipmunk (*Neotamias minimus*), short-tailed weasel (*Mustela erminea*), bushy-tailed woodrat (*Neotoma cinerea*), and house mouse (*Mus*

musculus). Nontarget captures and known Preble's recaptures resulted in five 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

The predicted distribution of Preble's in Wyoming includes all or portions of seven counties in the southeastern corner of the state. Although several 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 (Table 1, Fig. 1). Consistent with observations thus far, we captured no jumping mice east of Interstate 25. Additionally, the three sites where we did not capture jumping mice were at the lowest elevations (Table 1). Preble's are typically found at elevations ranging from approximately 1,420 to 2,300 m; the lowest Preble's observation was recorded at 1,218 m in Colorado (USFWS 2003*b*, 2008). Our lowest sites ranged from 1,232 m to 1,573 m, which were near the lower elevation limit reported for the Preble's. We did, however, capture jumping mice at previously unsurveyed locations within the Laramie Plains and the northeastern edge of the Snowy Range. Based on captures in adjacent drainages, we suspect these individuals are western jumping mice, although genetic results are pending. Despite numerous survey efforts throughout the range of Preble's in Wyoming, the current range of the Preble's appears to be restricted to higher-elevation drainages along the eastern front of the Laramie Mountains (Fig. 2; Bowe and Beauvais 2012). Consequently, it appears likely that the predicted range of the Preble's in Wyoming may have been overestimated and re-evaluation of the distribution is likely warranted.

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. Although we did not capture any jumping mice along North Cottonwood Creek the year immediately following wildfire outbreaks (Cudworth and Grenier 2014), we did capture 3 individuals this summer, including 2 reproductively active females, indicating that jumping mice are capable of establishing a breeding population within 2 years of low-severity fires.

Although we had hoped to evaluate within-site survival, population dynamics, and demographics, low jumping mouse captures prevented us from doing so. One site failed to produce any jumping mice, and the other only resulted in a single individual, despite a known population of Preble's occurring at the site in 2009 (Thompson and Grenier 2010). However, overall captures of small mammals were high this year, with an average of 0.204 captures per trap night in 2014 compared to 0.039 captures per trap night in 2013 (Cudworth and Grenier 2014). Small mammals may demonstrate large annual variation in abundance regardless of

disturbance (Converse et al. 2006), and it is possible that populations may fluctuate, influencing presence and capture rates. Therefore, annual surveys are important to elucidate the effects of disturbance and variation in abundance and presence of jumping mice.

In 2013, surveys along Friend Creek resulted in confirmed Preble's and western jumping mice (Cudworth and Grenier 2014). Both species have been confirmed at this site in the past, including 1998, when both species were documented sympatrically (WYNDD download from 15 May 2013 with taxonomic identification following Bowe and Beauvais 2012); however, this remains one of only a few sites that has documented temporal and spatial sympatry of Preble's and western jumping mice in Wyoming. We captured 41 individuals at this site in 2014, including 4 recaptured individuals from 2013, representing both species. Although genetic results were pending when this report went to press, we will evaluate the impacts of sympatry on movements, reproduction, and capture rates once results are available.

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. In order to ensure the continued presence of Preble's in Wyoming, future surveys should continue to monitor both disturbed and undisturbed sites to elucidate persistence, survival, and abundance of populations in addition to surveys designed to update distributional boundaries and increase occurrence records.

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Table 1. Sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) from 2 June through 21 August 2014 in southeastern Wyoming. For each site, we list elevation and whether Preble's meadow or western jumping mice (*Z. princeps*) were previously detected and the most recent survey year. Confirmed indicates species assignment was completed via genetic analysis. Sites where jumping mice were captured in 2014 are shown in bold. Taxonomic identification from Bowe and Beauvais (2012).

Site	Elevation (m)	*Z. hudsonius preblei*		*Z. princeps*	
		Detection	Year	Detection	Year
Cooper Creek	**2,468**	**None**	**N/A**	**None**	**N/A**
Friend Creek	**2,292**	**Confirmed**	**2013**	**Confirmed**	**2013**
Horse Creek	1,573	None	N/A	None	N/A
Hughes Ditch (Torrington)	1,232	None	N/A	None	N/A
Laramie River (Tunnel Rd)	**1,968**	**Confirmed**	**2009**	**None**	**N/A**
Laramie River (Wheatland)	1,421	None	N/A	None	N/A
North Cottonwood Creek	**1,869**	**Confirmed**	**2011**	**None**	**N/A**
Rock Creek	**2,050**	**None**	**N/A**	**None**	**N/A**

Table 2. Identification number, age, sex, reproductive condition, and morphometric measurements for all jumping mice (*Zapus spp.*) captured in southeastern Wyoming, June-August 2014. If an individual was captured multiple times, we show heaviest weight and average morphometric measurements. * indicates a recapture from 2013.

ID number	Age	Sex	Reproductive condition	Weight (g)	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)
Cooper Creek								
00814	Adult	Female	Nonreproductive	27	217	136	28	13
00914	Adult	Male	Nonreproductive	24	223	138	29	12
Friend Creek								
00313 *	Adult	Female	Past-lactating	27	207	125	27	11
00414	Juvenile	Male	Nonreproductive	8	138	85	24	5
00514	Adult	Male	Scrotal	24	196	118	27	10
00614	Adult	Male	Scrotal	21	175	110	27	9
00714	Juvenile	Female	Nonreproductive	8	170	115	25	8
20014	Adult	Male	Scrotal	11	119	127	21	9
20114 *	Adult	Female	Past-lactating	26	186	109	28	10
20214	Adult	Female	Nonreproductive	19	220	139	29	11
20314	Adult	Male	Nonreproductive	17	204	127	28	11
20414	Adult	Female	Nonreproductive	32	206	127	29	10
20514	Adult	Female	Pregnant	25	196	124	29	10
20614	Adult	Male	Scrotal	17	176	89	25	9
20714 *	Adult	Female	Nonreproductive	13	167	102	26	8
20814	Adult	Male	Scrotal	26	199	119	27	10
20914	Unk	Unk	Unk					
21014	Unk	Unk	Unk					
21114	Adult	Female	Pregnant	25	209	128	29	9
21214 *	Adult	Male	Scrotal	16	179	111	25	9
21314	Adult	Male	Scrotal	19	197	123	28	12
21414	Adult	Male	Scrotal	24	186	113	27	10

Table 2. Continued.

ID number	Age	Sex	Reproductive condition	Weight (g)	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)
Friend Creek (cont.)								
21514	Adult	Male	Scrotal	23	194	114	29	9
21614	Unk	Unk	Unk					
21714	Adult	Female	Past-lactating	26	196	121	28	11
21814	Adult	Female	Nonreproductive	25	216	127	31	12
21914	Adult	Female	Pregnant	24	201	129	29	11
22114	Adult	Male	Scrotal	20	202	119	29	10
22214	Adult	Male	Scrotal	28	213	131	30	14
22314	Adult	Male	Scrotal	25				
22914	Adult	Male	Scrotal	28	207	127	25	11
23014	Adult	Female	Nonreproductive	13	178	114	24	11
23114	Adult	Female	Nonreproductive	19	200	125	28	10
23214	Adult	Male	Scrotal	17	208	128	29	11
23314	Adult	Female	Nonreproductive	23	207	127	27	11
23414	Adult	Female	Nonreproductive	23	202	127	28	12
23514	Adult	Male	Nonreproductive	25	214	130	26	12
23614	Adult	Male	Scrotal	26	203	123	27	10
23714	Adult	Female	Past-lactating	33	152	64	29	11
23814	Adult	Male	Scrotal	22	205	127	29	11
23914	Adult	Female	Nonreproductive	19	194	123	28	10
24014	Adult	Female	Nonreproductive	17	194	116	27	11
24114	Adult	Female	Nonreproductive	18	173	111	26	9
Laramie River (Tunnel Rd)								
00314	Adult	Female	Nonreproductive	32	211	129	28	11

Table 2. Continued.

ID number	Age	Sex	Reproductive condition	Weight (g)	Total length (mm)	Tail length (mm)	Hindfoot length (mm)	Ear length (mm)
North Cottonwood Creek								
00114	Adult	Male	Scrotal	18	197	124	29	11
00214	Adult	Female	Pregnant	33				
22814	Adult	Female	Lactating		202	122	29	12
Rock Creek								
22414	Adult	Female	Nonreproductive	24	209	139	28	10
22514	Adult	Male	Scrotal	36	226	148	31	10
22614	Adult	Female	Nonreproductive	21	209	138	30	11
22714	Adult	Male	Scrotal	31	212	129	25	11

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 2014. 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; _ = no verified records (Orabona et al. 2012).

Species	Latilong	Current status	Updated status
Microtus montanus	20	h	B
Microtus ochrogaster	26	b	B
Mus musculus	20	_	b
Neotoma cinerea	20	b	B
Zapus hudsonius preblei	20	b	B

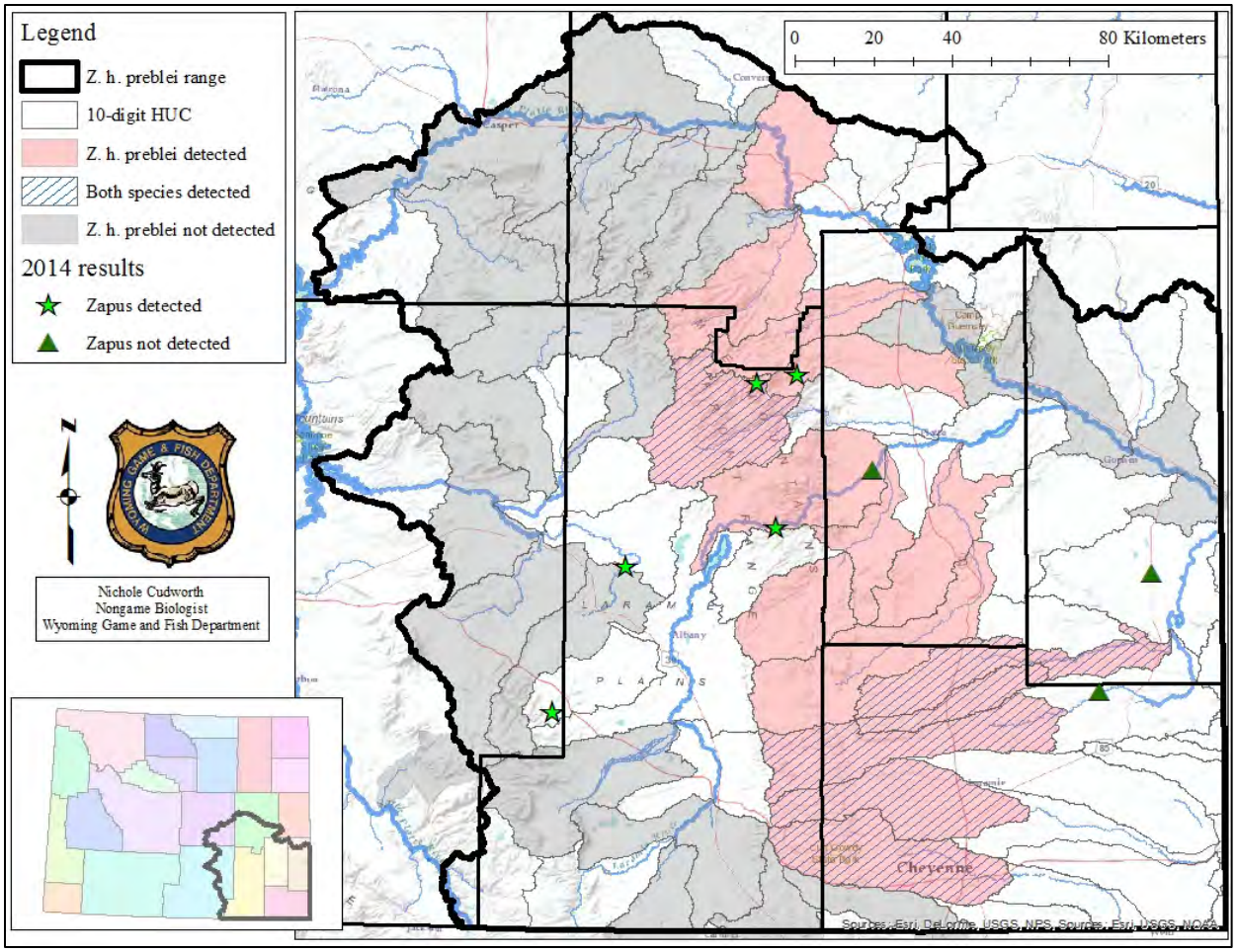

Figure 1. 10-digit Hydrologic Unit Code (HUC) watershed boundaries for all sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming through 2013. HUCs where captures of *Z. h. preblei* were possible or confirmed are shown in red; HUCs where both *Z. h. preblei* and western jumping mice (*Z. princeps*) have been detected are designated by hash marks; and HUCs that have been surveyed but where only *Z. princeps* were detected, no jumping mice were detected, or species could not be confirmed are shown in gray. Taxonomic identification and location information are from Bowe and Beauvais (2012). We also show capture results from 2014 with sites where jumping mice were detected designated by bright green stars and sites where no jumping mice were detected designated by dark green triangles. Genetic results are pending.

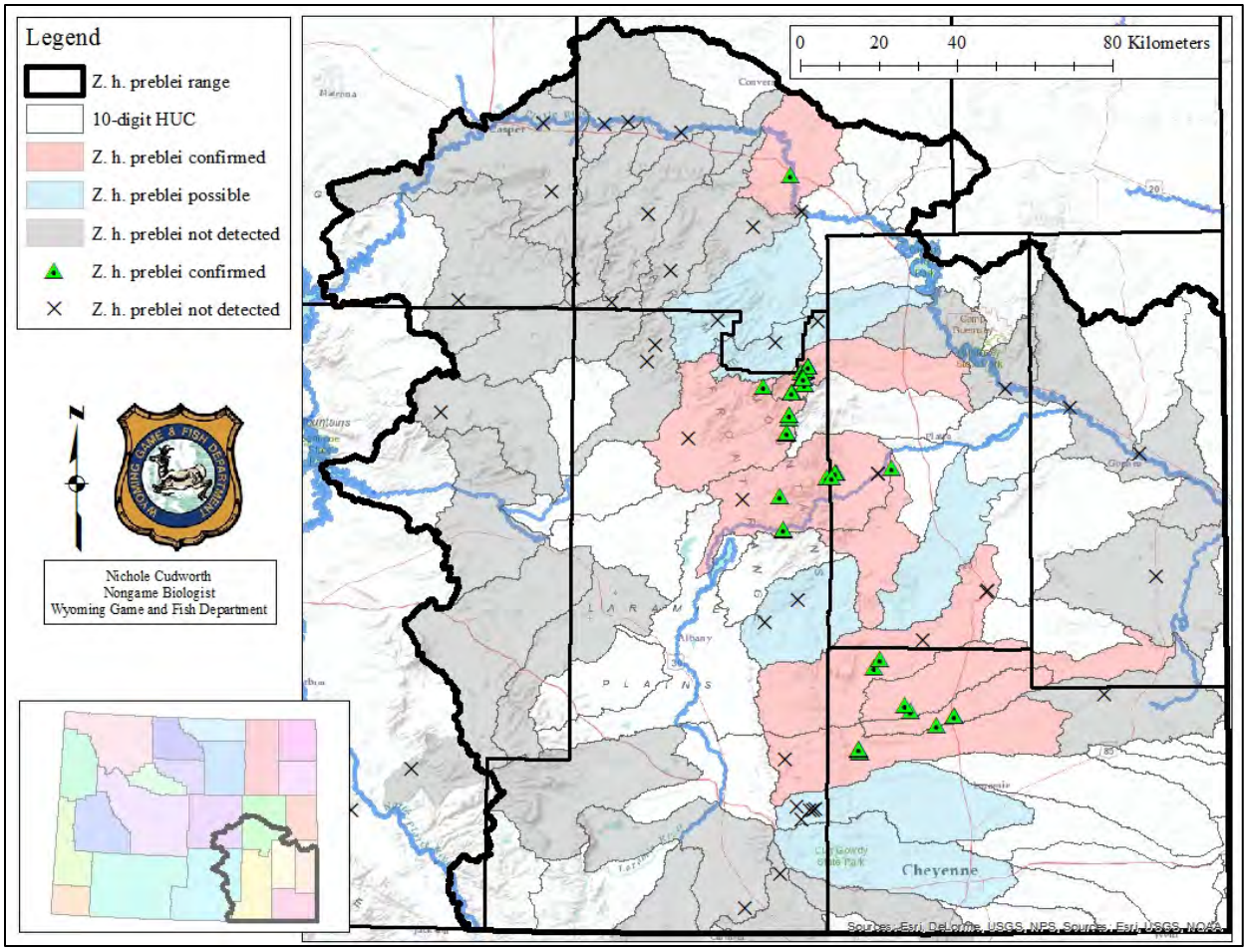

Figure 2. 10-digit Hydrologic Unit Code (HUC) watershed boundaries for all sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming through 2014. Sites where genetic analyses were pending are not included. HUCs where captures of *Z. h. preblei* were confirmed via genetic analyses are shown in red; actual capture locations are designated by green triangles. HUCs where identification of *Z. h. preblei* was based on morphometric measurements are shown in blue. HUCs where only *Z. princeps* were detected, no jumping mice were detected, or species could not be confirmed are shown in gray. All trapping locations sampled within the 6-year survey effort (2009-2014) where we failed to capture *Z. h. preblei* are designated by a black X. These locations either resulted in no captures or only confirmed *Z. princeps*. Taxonomic identification and location information from non-Departmental surveys are from Bowe and Beauvais (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
Bureau of Land Management Cooperative Agreement
United States Fish and Wildlife Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

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 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 2014 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 = 167 adults, 56 cygnets), which is a record high for the State. We also documented a record high number of occupied nest sites (n =53), which is the largest number since we initiated surveys in the 1980s. In February 2015, we counted a total of 1,075 swans in the Pacific Flyway area of Wyoming and 47 in the Central Flyway. This was a 13% increase compared to the previous winter. Fifty-one 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 in number and productivity of swan nest sites 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 five 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 (WLCI), Wyoming Wildlife and Natural Resource Trust (WWNRT), Natural Resources Conservation Service (NRCS), and the US Fish and Wildlife Service Partners Program. The success of this swan-focused wetland program has helped to stimulate other wetland-related projects in the Green River area. The Wyoming Game and Fish Department is currently administrating a standard North American Wetlands Conservation Act grant proposal developed with The Conservation Fund and other partners to obtain $1 million 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 2014). 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 to review and discuss productivity trends

and 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 2014 nesting season and the 2014-2015 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 subadults) and gray cygnets. We surveyed nest sites on 20 May (Snake River) and 9 June (Green and Salt River drainages) to determine occupancy and again on 8 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 16 and 17 September 2014 and the winter survey on 11 and 12 February 2015. 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 Greater Yellowstone Trumpeter Swan Working Group meeting from 14-16 October 2014 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 2014, 2015).

RESULTS

During February 2015, we counted a total of 1,075 swans wintering in the Pacific Flyway portion of Wyoming outside of Yellowstone National Park (YNP), which represents a 13% increase over the previous year (Table 1, Fig. 1). The largest percentage of wintering swans in the Pacific Flyway area occurred in the Snake River (52%) and the Green River (23%) 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 6.5% per year between 1972 and 2014 (Olson 2015). Increase in wintering birds is largely the result of continued growth of the migrant interior Canada population.

In fall 2014, we counted a record high number of white swans (adults and subadults) in Wyoming outside of YNP (n = 167; Table 2). This represents a 9% increase in adults from the previous survey year. The rate of growth in Wyoming (1993-2013) has increased by 2.4% per year ($P < 0.01$) for white birds and 7.5% ($P < 0.001$) for cygnets (Olson 2014). However, the long-term trend for total number of swans in the traditional Snake River core area (1999-2014) showed no increase during this period (p=0.88; Olson 2014). Conversely, in the Green River expansion area the number of swans has increased by 10% ($P < 0.001$) over the past 14 years (Olson 2014). Overall, the total TSAF fall count of white birds was similar to the previous year (452 vs. 455). Number of cygnets, however, increased to137 from 110. The TSAF have shown

a slight annual increase of 2.0% for white birds ($P < 0.01$) and a slight increase in cygnets (+3.4%, $P = 0.02$) between 1993 and 2013 (Olson 2014).

The number of nest sites occupied in 2014 in Wyoming outside of YNP ($n = 53$) represented a new record for Wyoming and greatly exceeded the 10-year mean (Table 3, Fig. 2). The number of nesting pairs in 2014 decreased from 34 to 29 (15%). The number of young hatched in Wyoming outside YNP in 2014 showed a large decline of 37%, but number of fledged young was similar ($n = 54$). Of the 53sites occupied in 2014, 55% of pairs initiated nesting, 40% hatched young, and 36% fledged at least one young. Overall, swans in the Green River Basin accounted for 72% of occupied sites and 65% of fledged young (Table 4). In the Snake River core area, 30% of cygnets that hatched did not fledge, compared to 3% 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 7 out of the last 8 years.

Site-specific occupancy and productivity results for all known swan nest sites surveyed in Wyoming outside of YNP are presented in Appendix I. An analysis of site specific productivity data from 29 nest sites in the Snake River core area that had been occupied at least once during the 11-year period (2004-2014) showed that only three territories produced young more than half of the years during this period (SP, unpubl. data). Twenty-seven percent of the sites (8) produced no young and another 37% (10) produced only 1 or 2 young over the same time period.

Summary of mortality data from 1991-2015 are presented in Table 5. We documented 11 mortalities in Wyoming, which was similar to the previous year. Necropsy results from the Wyoming State Veterinary Laboratory for 6 carcasses submitted this past spring and summer found that most of the necropsied swans died from heavy internal parasite loads, including acanthocephalan and coccidian. Overall since 1998, the Department has documented a total of 336 swan mortalities. The cause of mortality could be identified in 104 cases (31%) with collisions (45%) the leading cause (Table 5). Many swan carcasses found during winter and early spring are in emaciated condition and have been scavenged or decayed to the degree that necropsies are not possible. Crowded conditions in some wetlands may be resulting in a build-up of parasite populations.

DISCUSSION

The 2014 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 loss of nest sites and low productivity of many nest sites in the Snake River core area. A total of five sites have produced over half of the total number of cygnets fledged in the Snake River core area from 2004-2014 (SP, unpubl. data). During this same period, 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 in 2014, 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. 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. 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, 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 over 35% 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 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 2014, YNP released two captive-raised yearlings and four cygnets obtained from the Wyoming Wetlands Society (WWS) in the Park to supplement their meager wild population (n = 18 in fall 2014; Olson 2014). Monitoring the fate of these additional birds will hopefully determine what factors may be affecting swan survivorship and productivity in the Park and in northwestern Wyoming (D. Smith, YNP wildlife biologist, pers. comm.). 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 continues to be a leader in habitat improvement projects for swans and other wildlife associated with shallow water wetland habitat. In 2014, 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 WLCI, WWNRT, NRCS programs, and USFWS Partners Program. Construction is currently underway for two additional ponds on a ranch near Boulder, Wyoming. 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, the USFWS, 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 WLCI 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 the number and distribution of swans in the state, and have also increased the amount of wetland habitat important for swans and many other species of waterfowl and other 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 2014 and 2015. 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 Olson (2015).

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
2004	Adult	149	307	61	94	0	611
	Cygnet	33	18	17	23	0	91
	Total	182	325	78	117	0	702
2005	Adult	124	367	61	102	31	685
	Cygnet	30	109	20	35	2	196
	Total	154	476	81	137	33	881
2006	Adult	121	413	100	124	18	776
	Cygnet	14	58	13	37	3	125
	Total	135	471	113	161	21	901
2007	Adult	144	420	116	158	6	844
	Cygnet	25	84	30	35	6	180
	Total	169	504	146	193	12	1024
2008	Adult	65	316	109	174	4	668
	Cygnet	7	63	30	43	6	149
	Total	72	379	139	217	10	817
2009	Adult	88	321	160	133	24	726
	Cygnet	2	63	27	8	12	112
	Total	90	384	187	141	36	838

Table 1. Continued.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
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
2012	Adult	51	488	210	109	27	885
	Cygnet	4	99	20	29	24	176
	Total	55	587	230	138	51	1061
2013	Adult	2	548	212	120	15	897
	Cygnet	0	120	30	20	8	178
	Total	2	668	242	140	23	1075
2014	Adult	24	411	261	123	41	860
	Cygnet	7	50	45	21	6	129
	Total	31	461	306	144	47	989
2015	Adult	111	472	211	93	39	926
	Cygnet	33	96	33	26	8	196
	Total	144	568	244	119	47	1122

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 the states of Idaho, Montana, and Wyoming, 2006-2014 (Olson 2014). YNP represents Yellowstone National Park. On 17 September 2014, YNP released four captive-raised swan cygnets on the Yellowstone River (Otter Creek); these are included in the totals below.

Year	Age group	Montana	Idaho	Wyoming YNP	Wyoming outside YNP	Tri-State total
	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
	Adult	198	74	13	167	452
2014	Cygnet	57	23	5	56	141
	Total	255	97	18	223	593

Table 3. Occupancy and productivity data for Trumpeter Swans (*Cygnus buccinator*) nesting in Wyoming outside of Yellowstone National Park, 1991-2014. 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 are those that have been changed to reflect corrections in historic data. [a] Production data include 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 successfully grafted to a pair 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 2004-2013.

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
2014	53	29	21	19	63	54
10-year mean (SD)	**34.8** (8.1)	**22.8** (4.6)	**16.7** (3.2)	**13.2** (3.1)	**55.3** (13.3)	**41.0** (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, 2007-2014. Expansion areas include drainages where the 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
2014	14	9	8	27	19	3.38
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
2014	38	20	13	36	35	2.77
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
2014	1	1	0	0	0	0.00

Table 5. Summary of Trumpeter Swan (*Cygnus buccinator*) annual mortalities in Wyoming, showing age class and probable cause of death, 1991 through 15 April 2015. 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 1998-2014.

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
2014-2015	11	5	1	1	2			4	5
Total[d]	336	204	49	92	47	26	13	18	232

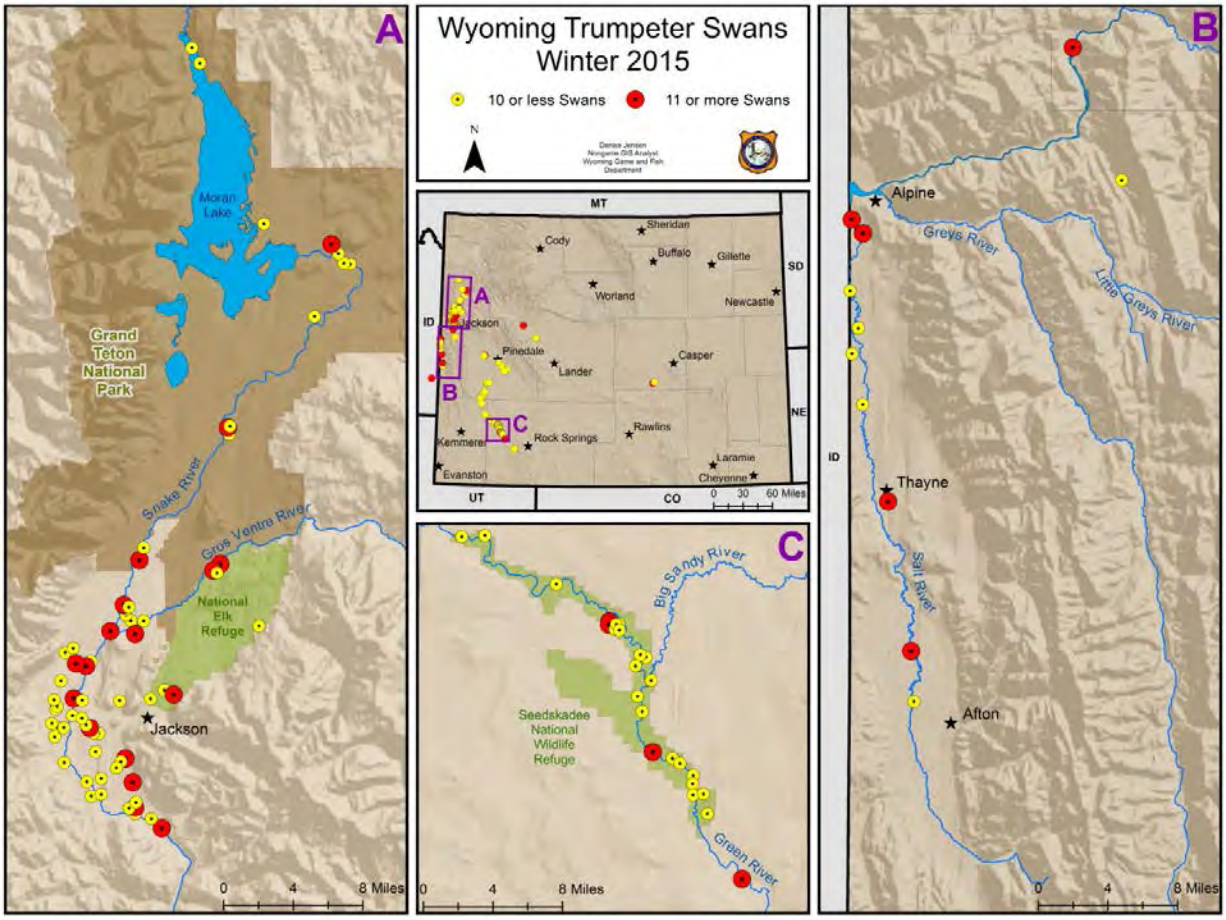

Figure 1. Locations of wintering Trumpeter Swans (*Cygnus buccinator*) in Wyoming documented during the annual winter aerial survey flown 11 February 2015 (Green River) and 12 February 2015 (Snake and Salt River drainages). Prior to management efforts beginning in the late 1980s to increase the distribution of swans in the Tri-State area, all swans wintered in the Jackson core area.

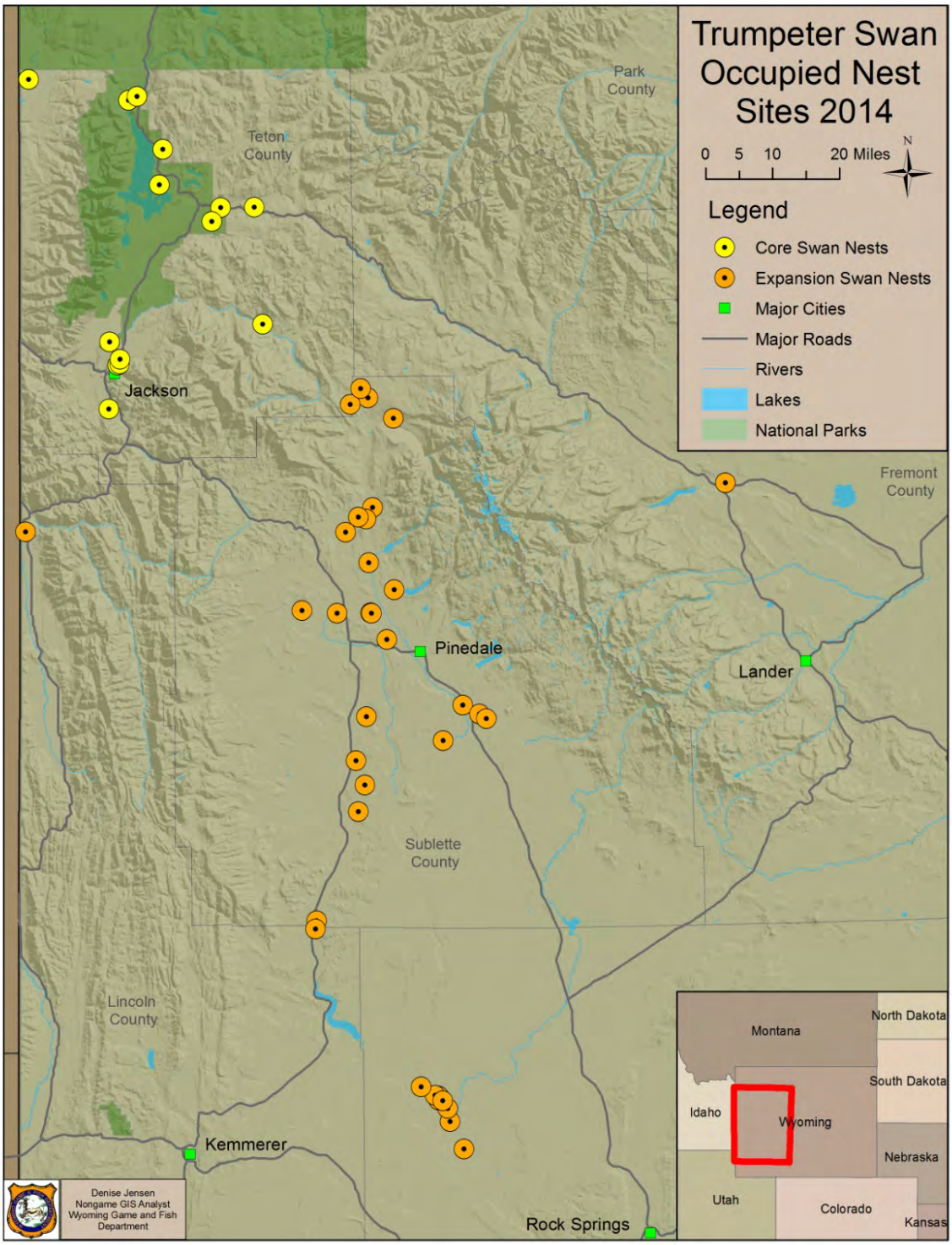

Figure 2. Locations of nest sites occupied by pairs of Trumpeter Swans (*Cygnus buccinator*) in Wyoming in the 2014 nesting season. Pairs did not lay eggs at all occupied sites. Shown are nests in the core Snake River area (yellow dots) and nests in the range expansion areas (orange dots). In a few cases, a single dot represents more than one occupied site for sites located in close proximity to each other.

Appendix I. Annual summary of occupancy and production status for all known Trumpeter Swan (*Cygnus buccinator*) nests in Wyoming outside Yellowstone National Park, 2004-2014 by area. Sites include: CTNF – Caribou Targhee National Forest; GTNP – Grand Teton National Park; NER – National Elk Refuge; and Seedskadee NWR – Seedskadee 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	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CTNF											
Ernest Lake	---	NB	---	---	---	---	---	---	---	---	---
Bergman Marsh	---	---	---	---	---	---	---	---	---	---	---
Indian Lake	N55	N00	N10	N44	O	N40	N30	N30	N41	O	OL
Widget Lake	---	---	---	---	---	---	---	---	---	---	---
Winegar Creek						N30	N20	N30	1A	N20	N40
Fall River Slough				N00	---	---	---	---	---	---	---
Loon Lake	---	---	---	---	---	---	OL	---	---	---	---
Rock Lake	OL	OM	N00	---	O	---	---	---	---	---	---
Rock Lake slough							N41	---	---	---	1A
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	O
Glade Cliff Slough		N00	N10	O	N00	O	O	O	N11	N22	N00
Glade South	N22	N00	O	O	---	---	---	---	---	O	---
Flagg gravel pit ponds								---	---	O	---
Arizona Lake	OM	N20	N40	N00	N00	N30	N20	N20	N00	---	O
Emma Matilda	---	NB	NB	---	1A	OL	OL	OL	OL	O	---
Swan Lake	N33	NB	OL	OM	N22	O	OM	N55	O	O	O

Appendix 1. Continued.

Site	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GTNP (cont.)											
Christian Pond	---	---	---	---	---	---	---	---	---	---	---
Hedrick Pond	---	NB	1A	O	---	---	---	---	---	---	---
Elk Ranch	OM	OM	OM	O	O	O	OL	OL	O	O	O
Spread Creek Ponds	---	---	---	---	---	---	---	---	---	N20	1A
Polecat Slough	---	---	---	---	1A	1A	---	---	---	---	---
NER											
Highway Pond NER	---	N00	---	N55	---	---	N00	---	---	---	---
NE Marsh NER	N44	---	N32	NB	O	---	---	O		N22	---
Flat Cr. Island NER						N00	N10	N00	N00	N20	N53
SE Marsh NER	N43	O	N11	N42	N00	N11	---	O	N11		N11
Central Marsh NER	N22	N44	N33	N57	N33	O	N55	N00	N11	N22	N22
Elk Jump Pond NER									N00	N00	N44
Pierre's Ponds	OM	O	OM	---	---	---	NB	O	---	---	OL
Romney Ponds	OM	OL	NB	N44	N44	N43	NB	O	NB	1A	OL
Bill's Bayou										OL	---
Jackson area											
Skyline/Puzzleface	O	NB	---	---	---	---	NB	NB	NB	OL	NB
WGF South Park	---	1A	OL	OM	OM	N44	N66	N44	N55	N43	N55
Buffalo Valley											
Pinto/Halfmoon	N31	N55	N33	N66	N44	N54	OM	N11	N00	N44	N44
Halfmoon BV								N44	----	OL	---
Blackrock slough									N60	N60	N20
Tracy Lake					OL	OL	OL	OL	NB	NB	NB
Lily Lake	---	---	---	---	---	---	---	---	---	---	---
Teton Wilderness											
Enos Lake	---	---	NB	NB	NB-3	---	NB	NB	NB	1A	1A
Atlantic Cr.	---	---	---	---	---	nc	OUID	O	N00	N22	nc
Salt River											
Kibby/Salt R Cove	N00	NB	---	---	---	---	---	---	---	---	---

Appendix 1. Continued.

Site	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Salt River (cont.)											
Alpine Wetland North	NB	NB	NB	N00	---	NB	NB	NB	NB	NB	NB
Alpine Wetland South				NB	O	N00	N00	N21	N00	O	N00
Jacknife Creek area									O	---	---
Gros Ventre River											
Lower Slide Lake	---		---	---	---	---	NB	NB	---	NB	---
Upper Slide Lake	N11	N22	N00	OM	OM	OM	OM	O	O	O	O
Grizzly L pothole	---	---	Dry	Dry		---	---	---	---	---	---
Burnt Fork	---	---	---	---	---	NB	---	---	---	---	---
Soda Lake	---	---	---	---	---	---	---	---	---	---	---
Green/New Fork Rivers											
Wagon Creek Lake	O	---	---	---	NB	---	---	---	---	---	---
Rock Crib	---	---	---	---	NB	---	---	---	---	---	O
Wagon Cr Pothole				N00	---	---	N42	O	O	---	---
Mosquito Lake	OL	---	NB	N32	N00	N00	O	OL	O	O	N22
Roaring Fork P.	---	---	---	---	---	---	---	---	---	---	---
Mud Lake	N50	N20	N20	N52	OE	---	OL	O	N00	O	O
Circle S slough							N00	---	NB	---	N11
Jensen Pond, Green R									O	---	---
Carney oxbow	N55	N22	N00	N44	N00	N00	N22	N00	O	O	O
Carney pond						N30	---	---	---	---	O
Q Y Bar Reservoir				O	O	---	---	---	---	---	---
O Bar Y pond new 2012									N44	N33	N44
Marsh Creek Pothole				N22	---	---	---	---	---	---	---
Kendall Wetland	N00	NB	NB	OL	N11	N33	OM	O	N44	N00	N22
Blatt Res Willow Cr									NB	O	O
Kitchen Main	N44	N22	N33	N54	N53	N11	N22	N32	N43	N00	N33
Kitchen Middle	NB	OM	OM	OM	O	N22	N55	N43	---	---	N43
40 Rod Cr slough							F	NB	NB	N20	O
Vichory Reservoir									NB	N11	NB

Appendix 1. Continued.

Site	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Green/New Fork Rivers (cont.)											
Webb Draw							F	N00	N10	N22	N20
McCroft Lane, Pinedale									N00	---	O
Fayette New Fork			NB	N33	N40	N00	---	N33	N55	N52	---
Swift New Fork					N54	OL	N33	OL	NB	NB	N00
Barden Slough	OM	OM	OM	---		---	---	---	---	---	---
Swift Reservoir	NB	---	OL	OL	NB	NB	OL	O	N21	N33	N11
EF Hunt Club/FH								N11	N21	N33	N00
Jensen Slough N Fork					OL	O	N22	O	N21	O	N11
Sommers Green R									O	N30	NB
Cottonwood Cr mouth									NB	---	---
Rimfire Rendezvous									NB	NB	NB
Rimfire Sophia/Alexander									OL	NB	O
Soaphole BLM pond									NB	N44	NB
Muddy Cr, n B. Piney									NB	---	O
Bench Corral Reservoir #8											O
Ferry Island				N22	N33	N00	N44	OL	N22	N22	N22
Shafer Slough	---	---	NB	---	---	NB	NB	---	NB	---	---
Reardon Draw								N11	NB	---	OL
Voorhees Pond	---	---	---	---	OL	---	N00	O	O	N40	O
LaBarge Cr Pond								O	----	---	---
Big Sandy Reservoir	---	---	NS	---	nc	---	---	---	---	---	nc
Eden Res.							1A	1A	NB2	---	nc
Farson area							N22	O	O	---	nc
Seedskadee NWR											
Hamp Unit	N33	N44	N53	O	N00	N00	N42	N42	N00	N22	N65
Hawley 1	N60	N65	N54	N22	N33	N43	NB	O	N55	O	O
Hawley 2	N54	N00	N66	N33	N66	N44	N55	N44	N66	N44	N20
Hawley 2 S							N43	N33	---	N33	O
Hawley 3	---	N33	---	NB	NB	---	NB	O	---	---	---

Site	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Green/New Fork Rivers (cont.)											
Webb Draw							F	N00	N10	N22	N20
McCroft Lane, Pinedale									N00	---	O
Fayette New Fork			NB	N33	N40	N00	---	N33	N55	N52	---
Swift New Fork					N54	OL	N33	OL	NB	NB	N00
Barden Slough	OM	OM	OM	---		---	---	---	---	---	---
Swift Reservoir	NB	---	OL	OL	NB	NB	OL	O	N21	N33	N11
EF Hunt Club/FH								N11	N21	N33	N00
Jensen Slough N Fork					OL	O	N22	O	N21	O	N11
Sommers Green R									O	N30	NB
Cottonwood Cr mouth									NB	---	---
Rimfire Rendezvous									NB	NB	NB
Rimfire Sophia/Alexander									OL	NB	O
Soaphole BLM pond									NB	N44	NB
Muddy Cr, n B. Piney									NB	---	O
Bench Corral Reservoir #8											O
Ferry Island				N22	N33	N00	N44	OL	N22	N22	N22
Shafer Slough	---	---	NB	---	---	NB	NB	---	NB	---	---
Reardon Draw								N11	NB	---	OL
Voorhees Pond	---	---	---	---	OL	---	N00	O	O	N40	O
LaBarge Cr Pond								O	----	---	---
Big Sandy Reservoir	---	---	NS	---	nc	---	---	---	---	---	nc
Eden Res.							1A	1A	NB2	---	nc
Farson area							N22	O	O	---	nc

Appendix 1. Continued.

Site	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seedskadee NWR (cont.)											
Hawley 5						N33	NB	NB	---	---	---
Hawley 6	N65	N77	N00	NB	NB	---	N44	N22	N55	N22	N66
Sage Pools				N31	N33	N75	N42	N22	N77	N55	N55
Other Wyoming											
Swamp Lake, Cody	---	---	---	---	NC	NC	NC	---	---	nc	nc
Trail Lake, Dubois		OM	OM	---	---	---	---	---	---	---	---
Dinwoody Lake							F	---	---	---	---
Lake Julia							O	1A	---	---	---
Martens Pond, Wind River								O	---	N55	N33
Alkali Lake, Wind River											NB
Colony eastern WY	NB	NS	NS	---	---	NC	NC	OL	NB	---	nc

WYOMING COMMON LOON SUMMARY REPORT, 2014

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Common Loon

FUNDING SOURCE: Ricketts Conservation Foundation

PROJECT DURATION: 1 June 2013 – 30 September 2017

PERIOD COVERED: 1 May 2014 – 30 September 2014

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ABSTRACT

Supported by a grant from the Ricketts Conservation Foundation, the Biodiversity Research Institute (BRI) has undertaken a continent-wide conservation study in support of the recolonization of the former breeding range for the Common Loon (*Gavia immer*), a key indicator of aquatic integrity for lakes and near-shore marine ecosystems across North America. As part of this study, BRI has begun a comprehensive study, in collaboration with the Wyoming Game and Fish Department, Yellowstone National Park, Caribou-Targhee National Forest, Bridger-Teton National Forest, and Grand Teton National Park, of the northwest Wyoming Common Loon population, an island population disconnected by over 320 km from populations to the north. These agencies have surveyed the presence of adults and large chicks since the late 1980s. Following an observed high of 21 territorial pairs, a decline in the number of pairs was detected starting in 2007. In the northwest Wyoming study area, Common Loon presence and reproductive success were monitored throughout the 2013-2014 breeding seasons by foot, boat, and aerial surveys. In 2014, eight loons were captured and banded using both diurnal and nocturnal capture methods. As part of the banding effort, three geolocators were deployed for determining wintering areas, and samples were collected as part of a comprehensive continent-wide health assessment of Common Loons. In 2014, the number of territorial pairs increased to 16 pairs from 14 pairs in 2013 and an all-time low of 13 pairs in 2012 in the study area. Territorial pairs in 2014 experienced the most productive year on record, hatching 20 chicks of which 18 (90%) survived (productivity = 1.13 chicks surviving per territorial pair). While inconsistent monitoring during and after the decline began in 2007 makes forecasting population changes in this population difficult, the current number of pairs, the presence of 10 resident unpaired adults, and a recent increase in productivity offer hope for future additional territorial pairs.

INTRODUCTION

The Common Loon (loon; *Gavia immer*) is a highly charismatic and iconic species of North America that has come to symbolize wild areas. Loons 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 human impacts in areas of their southern breeding range. In the western US, loons historically nested as far south as northern California, southern Idaho, and western Wyoming, but the southern boundary of their distribution was driven northward by human influences (Evers 2007). In summer 2014, 109 territorial pairs were known in the US west of the Dakotas. Most of these breeding pairs were located in Montana (n = 75 pairs; 69%) while Washington, Wyoming, and Idaho supported 17-18 (16%), 16 (15%), and 0 (0%) territorial pairs, respectively.

The Wyoming State Wildlife Action Plan (SWAP; WGFD 2010) lists the Common Loon as a Tier I Species of Greatest Conservation Need. Common Loons exhibit a "K-selected" life history pattern (i.e., long-lived, low annual fecundity, low annual adult mortality rate), so significant changes in their breeding population are symptomatic of chronic stressors (Evers 2007, Great et al. 2009, Evers et al. 2010). Therefore, this species is viewed as a biologically valuable indicator of aquatic integrity (Evers 2006). The Wyoming population consists of loons inside Yellowstone National Park (YELL), the Caribou-Targhee National Forest (CTNF), Grand Teton National Park (GRTE), and the Bridger-Teton National Forest (BTNF). Annual monitoring efforts across many lakes in the northwest Wyoming region have surveyed the number of adults and large chicks since the late 1980s and, beginning in 2007, these efforts documented a decline in the number of territorial pairs in northwest Wyoming.

In 2013, Biodiversity Research Institute (BRI) completed the first comprehensive loon monitoring effort throughout northwestern Wyoming. These efforts confirmed that the number of surveyed territorial pairs declined starting in 2006 from a historic count of 21 pairs. The steepness and extent of the decline is uncertain due to inconsistent monitoring, but survey efforts reported 15 pairs in 2007 and BRI's efforts identified 14 pairs in 2013. In 2014, BRI continued its efforts to monitor the Wyoming loon population and identify and mitigate anthropogenic threats and stressors.

This project was initiated in 2012 and 2013 using funding from the National Park Service (NPS) and the Wyoming Governor's Big Game License Coalition. Through a grant from the Ricketts Conservation Foundation (RCF) for a national-scale loon study, BRI biologists, working with state collaborators, are addressing three major conservation components in Wyoming and other states and provinces over 5 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 the potential translocation of chicks.

Although Common Loons in eastern and mid-western populations 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 in a region. 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 territory 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 2001). Secchi Disk readings of 1.5 m or less alter loon foraging behavior (Barr 1986). Loons prefer foraging in clear waters of littoral zones and tend to avoid deeper parts of large lakes. Preferred prey species that are 10-15 cm, such as yellow perch (*Perca flavescens*) in the mid-west and northeast US, are found in this zone (Barr 1996).

Nesting ecology of the Common Loon has been extensively studied in the northeast and mid-west. Loons nest in close proximity to the water's edge and tend to select small islands, floating bog mats, and marshy hummocks as nest sites. Loons prefer to nest on small islands, primarily on the lee side (Olson and Marshall 1952, Sutcliffe 1980, Titus and Van Druff 1981, Yonge 1981, Dahmer 1986, Jung 1987). Floating 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 within 1.2 m of the water's edge, and available submergent and emergent materials are often used to build a bowl-shaped nest structure. Common Loons often 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 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 Loon populations have been well studied across North America, particularly in the northeast and mid-west. Using long-term datasets from across different populations, Evers (2007) and Mitro et al. (2008) reported that, in order for a Common Loon population to remain stable, a territorial pair needs to fledge about one chick every other year (0.48 chicks surviving per territorial pair – CS/TP). Even with long-term reproductive success above 0.48 CS/TP, loons are poor colonizers of unoccupied habitat. Dispersal of individuals is limited and, therefore, loons are slow in re-colonizing new areas. Young loons returning to freshwater lakes after maturing on the ocean show an average dispersal of 13 km from their natal lakes; however, dispersal upwards of 92 km has been documented (Evers et al. 2000). Intra-season movements

of adults on the breeding grounds 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).

METHODS

Lakes with known loon presence in 2012 and 2013 were the primary focus of our surveys and were visited as early as travel and phenological 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 appearing to have characteristics of Common Loon use, but which were not known to have historical loon presence. Identifying lakes not currently occupied facilitates tracking of future population expansion.

Survey methods were consistent with those developed by the Loon Preservation Committee (LPC 2004). Lakes were often surveyed from shore. Canoes or kayaks were used if feasible and when an island nest site required access. Yellowstone Lake was surveyed from shore, canoe, and motorboat, as well as aerially. All lakes were surveyed using 10× binoculars and a 15-45× spotting scope. Information on breeding loons was obtained from the greatest distance possible to minimize impacts on nesting and brooding activities. Aerial surveys from a Piper Super Cub flown at low altitudes were conducted throughout the season to verify loon presence and reproduction, and to survey inaccessible lakes due to bear management area restrictions, snow conditions, or general remoteness.

Lakes with active nesting pairs in 2014, or nesting in previous years, were searched for nest sites. For each nest found, the location (island, marsh, or shoreline) and nest type (bowl, scrape, or hummock) were recorded and photographs were taken, if possible. Approximate coordinates of each nest were obtained using a handheld Geographic Positioning System unit or Google Earth location.

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 that are protected against incursion by other loons (and sometimes waterfowl) for a minimum of four weeks. Territory types were determined as occupying a single lake (whole lake territory), part of a larger lake (partial lake territory), or more than one lake (multiple lake territory). Territories are used as a unit of reference in describing loon breeding activity.

Nesting pairs were defined by the presence of at least one egg. Successful pairs hatched at least one chick. Unsuccessful nesting attempts were categorized as failed if conclusive evidence of nest failure could be determined. Possible causes of nest failure include: avian predation, mammalian predation, water level fluctuations (rise or fall), human disturbance, non-territorial loon disturbance, egg inviability, and unknown (e.g., egg(s) missing with no additional evidence or eggs cold and loon off nest). For successful nests, chicks hatched were recorded as

those that hatched completely out of their eggs. We define the term chicks surviving as loon young ≥6 weeks post-hatching, which we assumed to successfully fledge (Evers 2007).

We attempted to capture Common Loons using diurnal (suspended dive net) and nocturnal (night-lighting) techniques in the CTNF, BTNF, and YELL. Diurnal capture involves stretching an underwater mist net between two parallel floating PVC pipes, and using a loon decoy(s) and loon vocalizations to lure loons into the netted area. A loon is entangled when it swims underwater or dives from above into the net. Nocturnal capture is traditionally attempted from a boat or canoe for 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 captured, measured, and sampled each loon according to BRI's Protocols for Capturing and Banding Loons and Tissue Sampling Protocol for Loons (Evers 1993; BRI 2014a, b). We drew blood for genetics, stable isotope analysis, and health evaluation. Health analyses included hematology and plasma biochemistry, hemoparasite screen, blood mercury and lead (Pb) analysis, cyanobacteria detection, and infectious disease surveillance. We attached an aluminum USFWS band with an identification number and a colored band to one leg, and placed two colored bands on the other in unique sequences for individual identification. In 2014, we outfitted three adult loons with a geolocator (LOTEK Wireless LAT 2000 Series, Model LAT 2900, Newmarket, Ontario, Canada) attached 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 these devices need to be retrieved to download data, birds that received a geolocator must be re-captured in following years.

RESULTS

We identified a total of 16 territorial pairs (TP) across the study area, 13 (81%) of which nested (Table 1). A total of 20 chicks were hatched (CH) from these nesting pairs (NP), with 18 of these chicks surviving (CS). Chick survivorship (CS/CH) was high at 90%. Both nesting propensity (NP/TP; 88%) and hatching success (CH/NP; 1.43 young per nesting pair) were high compared to reported averages for other populations in the northeast and mid-west (Evers 2007). We documented only two nest failures, one at Bergman Reservoir (unknown cause) and the other at Wolf Lake (human disturbance). Overall loon productivity (CS/TP) for the region was 1.13 young per territorial pair.

Yellowstone National Park had 10 observed territorial pairs, Caribou-Targhee National Forest had 5 observed pairs, Bridger-Teton National Forest had 1 observed pair, and Grand Teton National Park had 0 observed pairs (Fig. 1, Table 2). Loon pairs within Yellowstone National Park provided the majority of productivity, with 78% of the chicks surviving in the study area, while CTNF, BTNF, and GRTE produced 11%, 11%, and 0%, respectively. In addition to these loon pairs, 10 unpaired adults were observed in the study area and constituted 24% of the total adult population.

Some changes occurred in the distribution of pairs across the study area from 2013 to 2014 (Fig. 1, Table 2). A territorial pair present in 2013 did not occupy Emma Matilda Lake, the southernmost known territorial loon pair in the western US. Early in the season, only one bird was seen behaving territorially on Emma Matilda and a second adult was not observed in the area. A new pair was discovered in the outer portion of the Flat Mountain Arm of Yellowstone Lake that nested on a sandbar and successfully fledged one chick. A pair was observed to have fledged two chicks on Lilypad Lake, which had not been reported as occupied since 2000. No pairs were observed during aerial surveys of Delusion Lake or South Delusion Lake, both of which had loon pairs in 2013. Monitoring efforts over the past 3 years have revealed that there are two pairs in the lower portion of the South Arm of Yellowstone Lake, specifically one territory surrounding Peale Island (Territory: Yellowstone Lake, South Arm – Peale Island), and a second territory occupying the coves and islands to the west of Peale Island (Territory: Yellowstone Lake, South Arm – West). A territorial pair was observed in 2014 for more than 4 weeks on Moose Lake, which has not been occupied since 2008.

Unpaired adults were widely distributed across the study area population in 2014. Three unpaired adults were consistently observed at the northern edge of the population utilizing Grebe Lake and the surrounding unoccupied lakes, and were seen intruding on the Wolf Lake territory. The western half of Shoshone Lake hosted two loons but, due to logistics, surveys were insufficient to determine if they were a territorial pair. We frequently observed loons in the northern half of the South Arm, suggesting the potential presence of a territorial pair. We observed some territorial behavior in the Grant Village area of Yellowstone Lake, with one to three loons present during the first half of the summer, suggesting future pair potential. We observed one loon in the southern Jackson Lake area, including Leigh Lake, and counted it as an unpaired adult. More loon presence may exist on Jackson Lake but, due to logistics, it was not fully surveyed. The single loon displaying territorial behavior on Emma Matilda Lake additionally utilized Two Ocean Lake and was counted as a single unpaired adult.

Gillnets are used by the NPS in Yellowstone Lake for the removal of the invasive population of lake trout (*Salvelinus namaycush*). In 2014, two loons were caught and drowned in gillnets on Yellowstone Lake. One adult in Flat Mountain Arm was caught on 7 October 2014, and another adult off Breeze Point was caught on 13 October 2014. The loon carcass from Flat Mountain Arm has not yet been necropsied, and the Breeze Point carcass was not saved. Due to the date of these mortalities, it is uncertain whether these loons were members of the Wyoming population. A Yellowstone Lake bycatch loon from 2013 was necropsied in August of 2014, and pathologic findings were consistent with drowning as a result of net entanglement. It is uncertain at this time whether this loon was a member of the Wyoming population.

In 2014, we captured and banded a total of eight loons in Wyoming using both diurnal and nocturnal methods (Table 3). We captured five loons in the CTNF, two in YELL, and one in the BTNF. We deployed three geolocators in 2014 to compliment the two we deployed in 2013 on Wyoming loons. We assessed mercury levels in both blood and feathers for all birds captured in 2014. Similar to 2013 results, loon mercury levels were below thresholds for adverse effect levels for both blood and feathers (3.0 mg/kg and 40.0 mg/kg, respectively; Evers et al. 2005, Evers et al. 2008). Over the 2013 and 2014 breeding seasons, we captured and banded a total of 10 adult loons in Wyoming.

We obtained complete hematology profiles on seven of the loons captured in Wyoming in 2014 (Table 4). Hematology values included complete blood counts, packed cell volume (PCV), total solids (TS), and blood lactate. A complete blood count provides information on the number of white blood cells present in the blood, as well as the relative distribution of the specific types of white blood cells such as lymphocytes, heterophils, monocytes, basophils, and eosinophils. Changes in the number and types of white blood cells can indicate a variety of health problems including infection, inflammation, chronic stress, bone marrow disease, and neoplasia. Of particular interest is the ratio of heterophils and lymphocytes (H:L ratio) present in the blood. In avian species, the H:L ratio is a sensitive indicator of chronic stress due to factors such as human disturbance, territorial disputes, disease, heat stress, or nutritional stress (Vleck et al. 2000, Maxwell 1993). The packed cell volume (PCV) measures the fraction of whole blood volume that consists of red blood cells. Abnormally low PCV values can indicate anemia due to disease or blood loss, while an abnormally elevated PCV value most often an indicates dehydration. TS is a measure of the total dissolved solids (mainly proteins) in plasma. Alterations in TS values can indicate inflammation, infection, dehydration, and other disease states. Blood lactate values indicate the amount of lactic acid present in the blood, which is produced as a result of anaerobic metabolism when oxygen delivery to the tissue is inadequate to support metabolic demands. Elevated blood lactate levels can be caused by physical exertion, dehydration, poor blood circulation, anemia, or severe respiratory disease.

Most hematology values from Wyoming loons were comparable to values from loons sampled in all other regions in 2014, including New England, New York, Minnesota, British Columbia, and Montana (Table 4). One notable exception was the Lewis Lake male. Of 76 loons sampled in 2014, this individual was found to have the highest H:L ratio, at 2.78. Because stress causes hematological changes in birds leading to increased numbers of heterophils and depressed numbers of lymphocytes, an elevated H:L ration in loons is an indicator of chronic stress (Vleck et al. 2000, Maxwell 1993). The Lewis Lake male also had an elevated blood lactate level at 5.2 mmol/L, which was one of the highest blood lactate levels recorded for loons in 2014. Of 59 loons tested in 2014, only 5 other birds had a blood lactate level greater than the Lewis Lake male, with the highest being 6.5 mmol/L. The elevated lactate level of this loon may be associated with increased physical exertion due to ongoing stressors.

Several other health analyses are currently pending for Wyoming loons sampled in 2014, including plasma biochemistry, Aspergillus fungal panel, avian influenza surveillance, blood cyanobacteria screen, blood lead (Pb) analysis, and hemoparasite screen. Samples have also been archived for future toxicology and infectious disease testing.

DISCUSSION

The surveyed Wyoming breeding loon population increased from 14 pairs in 2013 to 16 pairs in 2014 (Fig. 2). While this represents an improvement since the decline that began in 2007, the increase in territorial pairs in 2014 is uncertain, as additional monitoring could have revealed previously existing but undiscovered or unreported pairs. Pair occupancy of three territories in 2014 (Lilypad Lake, Yellowstone Lake – Flat Mountain Arm, and Yellowstone

Lake – South Arm West) contribute some evidence to potential earlier monitoring shortfalls. Lilypad Lake was last reported as occupied by a pair in 2000, but it is possible that infrequent monitoring or aerial surveys could have missed a pair on this territory. A territory has never been reported in the Flat Mountain Arm, but a pair nested and fledged a chick there in 2014. While this could be an entirely new pair to Yellowstone Lake, no pairs were observed at the adjacent Delusion and South Delusion lakes in 2014, and it is possible that a late ice-out displaced one or both pairs onto Yellowstone Lake. The southern portion of the South Arm of Yellowstone Lake has previously been reported to host a single pair, but two pairs were observed there in 2014 (South Arm – Peale Island and South Arm – West). Review of previous survey results suggests that two pairs may have occupied the area since at least 2012. Conversely to these three territories, Moose Lake had been monitored annually and reported as unoccupied since 2009, but in 2014 was found to be occupied by a territorial pair. The foundation of comprehensive monitoring that has been established in 2013 and 2014 will enable better tracking and understanding of population growth or decline in the future.

Given the advancements in understanding the northwest Wyoming loon population and recent survey results, the extent and severity of the decline in loons can be explored. Accounting for shortfalls in monitoring, the lowest count of breeding loons from 2007-2014 is 13-16 pairs, a range that is well below the historic count of 21 pairs. The historic high of 21 pairs was regularly reported as the annual count in 7 of the 18 years (39%) from 1989-2006, and a loss of 5-8 pairs represents 24-38% of the breeding population. In 2013 and 2014, pairs were observed reoccupying historic territories (Lilypad Lake, Emma Matilda Lake, and Shoshone Lake – East and West), as well as entirely new territories (Yellowstone Lake: South Arm – West and Flat Mountain Arm). The uncertainty of the status of loons on these lakes and others in the years preceding and immediately following the decline makes understanding the dynamics of this population difficult over the past decade.

Currently, the population appears to have stabilized. The estimated productivity threshold for population stability is 0.48 CS/TP, and recently the Wyoming population has achieved or exceeded this rate (Fig. 3). Productivity was very high in 2014 at 1.13 CS/TP and followed high productivity in 2012 and 2013 of 1.00 and 0.79 CS/TP, respectively. While only 41% of the known territories were surveyed from 2007-2010, productivity for those territories was still above 0.48 CS/TP, and productivity for 2009 and 2010 still remains above 0.48 if calculated with the estimated pair counts for those years (Figs. 2 and 3). In 2011, the monitoring effort improved from the previous four years, but that breeding season produced the poorest recorded productivity with 0.08 CS/TP. Overall, inconsistent monitoring of some territories prior to 2013 makes forecasting population changes based on productivity difficult.

Chicks produced will not have a measurable impact on a population until three summers later, as immature loons remain on the ocean before returning to the breeding grounds. Following periods of sufficient productivity, increases in the number of territorial pairs would require approximately three summers, as the average age for first obtaining a territory is 6 years (range 4-11 years) in northeast and mid-west Common Loon populations (Evers 2007). With 24% of the adult population unpaired in 2014, the Wyoming loon population could experience the formation of more pairs. While the observed increases in the number of adults or pairs could

suggest a recovery following the decline in 2007, formerly occupied territories with quality breeding habitat would need to be reoccupied to regain historic population levels.

We have defined four general aggregations of loon territories in Wyoming: Northern Yellowstone, Yellowstone Lake Area, Grassy Lake Road, and Jackson Lake Area. The long-term trends in productivity suggest that the territorial pair count in each region should be stable or increasing (Table 4). The five most productive territories since 1989 are observed to be Indian Lake, Riddle Lake, Cygnet Lakes, Loon Lake, and Arizona Lake. These territories, along with other highly productive territories (Beula Lake, Lilypad Lake) are widely distributed across northwest Wyoming and vary in lake size and nesting habitat type. The territory at Peale Island in the South Arm of Yellowstone Lake has long been regarded as one of the most productive territories, but it is uncertain whether its productivity can be attributed to the possible unreported presence of a second neighboring or intersecting territorial pair (South Arm – West) through time. With a banded population, future monitoring will show what degree of interconnectedness exists between these sub-regions across the northwest Wyoming study area.

Common Loon mortality has occurred as bycatch in gillnets on Yellowstone Lake. Since 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, YELL began hiring commercial netters for full seasons of lake trout control, and in that year 26,777 units of effort were put forth (one unit of effort = 100 m of gillnet set over one 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 regularly occur as bycatch in marine gillnetting operations (Forsell 1999, Warden 2010).

We could not determine if the recent bycatch birds in 2012, 2013, and 2014 were from Wyoming's breeding population, as they were all unbanded and some were killed during fall migration. 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 Yellowstone region as a flyway or stopover during migration (Yates et al. 2002). While official counts of loon bycatch are being tallied by the fisheries department at YELL, early estimates report an average of less than one loon caught each year (Doug Smith pers. comm.).

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Table 1. Common Loon (*Gavia immer*) monitoring results in the northwest Wyoming study area, 2014.

Demographics		Demographic rates	
Territorial pairs (TP)	16	Nesting propensity (NP/TP)	88%
Nesting pairs (NP)	14	Hatching success (CH/NP)	1.43
Chicks hatched (CH)	20	Chick survivorship (CS/CH)	90%
Chicks surviving (CS)	18	Productivity (CS/TP)	1.13
Unpaired adults	10	Percent population unpaired	24%

Table 2. Common Loon (*Gavia immer*) territory occupancy and reproductive success in the northwest Wyoming study area, 2014. TP = territorial pair, NP = nesting pair, CH = chick hatched, CS = chick surviving, UA = unpaired adult.

Location	TP	NP	CH	CS	UA
Yellowstone National Park					
Wolf Lake	1	1	0	0	0
Grebe Lake	0	0	0	0	3
Cygnet Lakes	1	1	2	2	0
Shoshone Lake – East	1	1	1	1	0
Shoshone Lake – West	0	0	0	0	2
Riddle Lake	1	1	2	2	0
Lewis Lake	1	1	2	2	0
Delusion Lake	0	0	0	0	0
South Delusion Lake	0	0	0	0	0
Heart Lake – East	0	0	0	0	0
Heart Lake – West	0	0	0	0	0
Beula Lake	1	1	2	2	0
Lilypad Lake	1	1	2	2	0
Yellowstone Lake					
Grant Village Area	0	0	0	0	1
Flat Mountain Arm	1	1	1	1	2
South Arm – Peale Island	1	1	2	0	0
South Arm – West	1	1	2	2	0
South Arm – East	0	0	0	0	0
Caribou-Targhee National Forest					
Bergman Lake	1	1	0	0	0
Indian Lake	1	1	1	1	0
Moose Lake	1	0	0	0	0
Loon Lake	1	1	1	1	0
Winegar/Junco/Fish Lakes	1	0	0	0	0
Bridger-Teton National Forest					
Arizona Lake	1	1	2	2	0
Lower Slide Lake	0	0	0	0	0
Grand Teton National Park					
Emma Matilda Lake	0	0	0	0	1
Jackson Lake	0	0	0	0	1
Leigh Lake	0	0	0	0	0
2014 Wyoming Totals	16	14	20	18	10

Table 3. Capture, banding, and mercury data for adult Common Loons (*Gavia immer*) caught in Wyoming, 2013-2014. YELL = Yellowstone National Park, CTNF = Caribou-Targhee National Forest, BTNF = Bridger-Teton National Forest.

Territory	Area	Sex	Weight (g)	Blood mercury mg/kg	Feather mercury mg/kg	Geolocator deployed
2014 Capture and Banding Results						
Lewis Lake	YELL	Male	3,500	1.414	18.117	X
Wolf Lake	YELL	Unknown	3,300	2.544	18.276	X
Indian Lake	CTNF	Female	3,250	0.586	6.542	
Indian Lake	CTNF	Male	3,950	0.697	6.220	
Bergman Res.	CTNF	Male	3,800	1.142	9.545	
Moose Lake	CTNF	Male	4,425	1.388	17.543	
Loon Lake	CTNF	Male	4,000	0.894	8.260	
Arizona Lake	BTNF	Male	3,810	1.759	17.359	
2013 Capture and Banding Results						
Arizona Lake	BTNF	Female	2,750	1.570	5.526	X
Loon Lake	CTNF	Female	3,050	1.195	20.265	X
Female weights (*n* = 3)		Range	2,750 – 3,250 g		Average	3,017 g
Male weights (*n* = 6)		Range	3,500 – 4,425 g		Average	3,356 g

Table 4. Select hematology data from Wyoming Common Loons (*Gavia immer*) and loons from all regions (New England, New York, Minnesota, Montana, and British Columbia) sampled in 2014. PCV = packed cell volume, TS = total solids, WBC = white blood cells, H:L Ratio = heterophil to lymphocyte ratio.

	Wyoming			All regions		
Value	Mean	Range	N	Mean	Range	N
PCV (%)	56	51 – 60	7	48	29 – 60	87
TS (g/dL)	3.8	3.0 – 4.0	5	4.3	2.6 – 5.6	65
Lactate (mmol/L)	2.9	1.9 – 5.2	7	3.2	1.3 – 6.5	59
WBC (cells/µL)	7,143	6,000 – 9,000	7	11,800	6,000 – 49,000	76
H:L Ratio	1.37	0.5 – 2.78	7	1.03	0.09 – 2.78	76

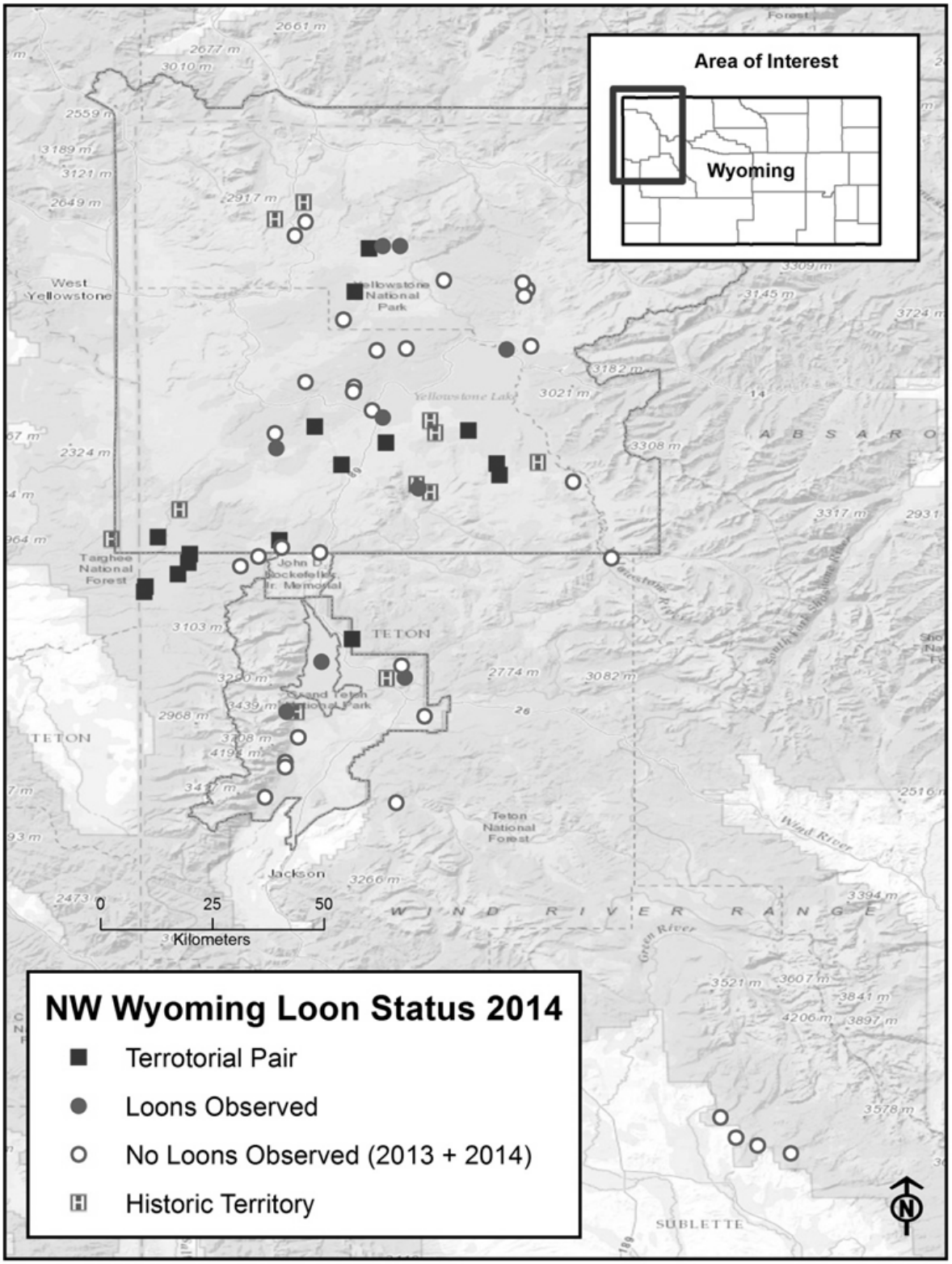

Figure 1. Common Loon (*Gavia immer*) presence observed and lakes surveyed by BRI in northwest Wyoming, 2014.

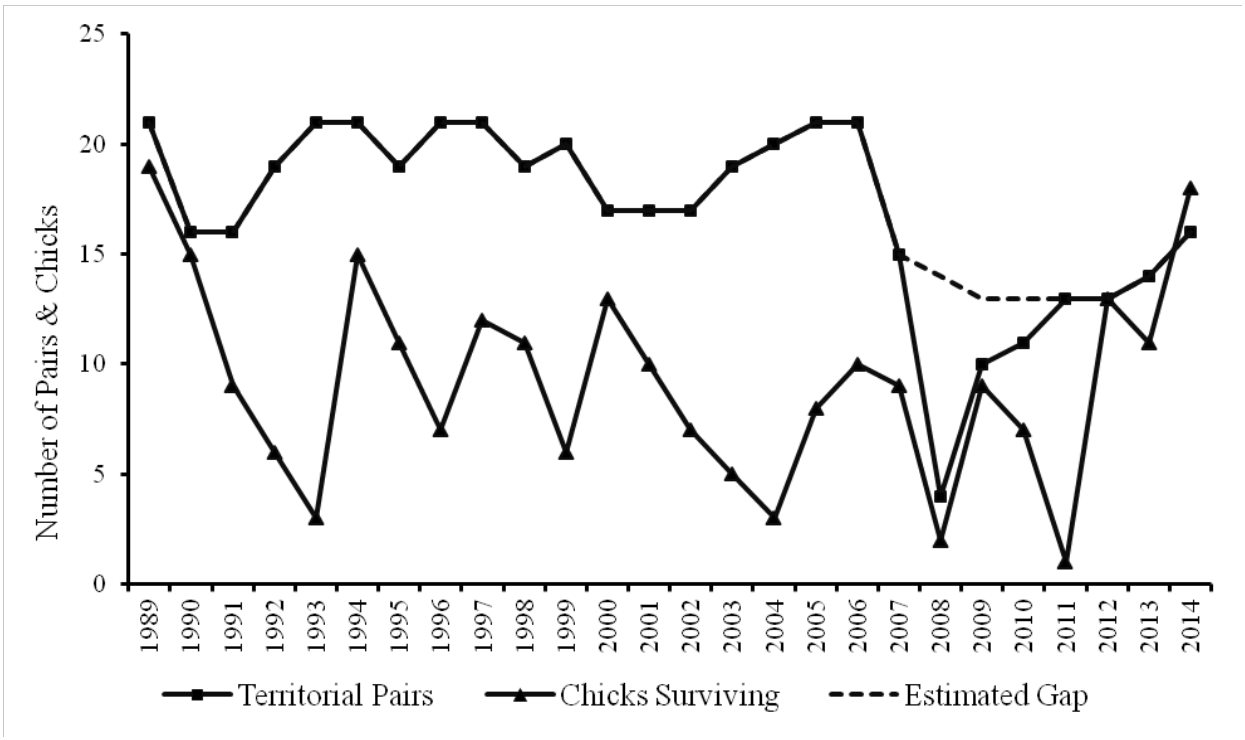

Figure 2. Numbers of observed northwest Wyoming study area Common Loon (*Gavia immer*) territorial pairs and chicks surviving, 1989 – 2014.

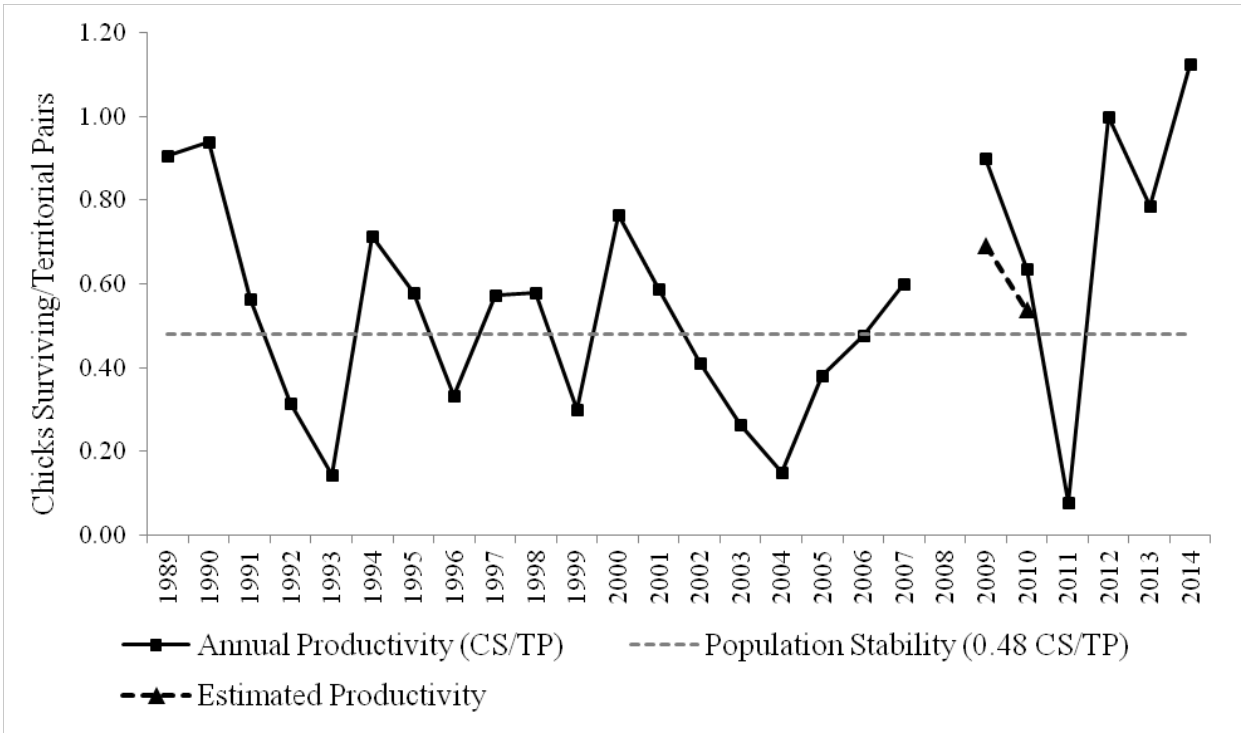

Figure 3. Northwest Wyoming study area Common Loon (*Gavia immer*) productivity (CS/TP) from 1989-2014. The horizontal dashed line represents the productivity threshold of 0.48 CS/TP estimated for population stability. In 2009 and 2010, productivity was calculated using the reported pair count (annual productivity) and the estimated pair count (estimated productivity). No surveys were conducted in YELL in 2008 so productivity was not calculated for that year.

EVALUATION OF MARSH HABITAT AND IMPLEMENTATION OF THE STANDARDIZED NORTH AMERICAN MARSH BIRD MONITORING PROTOCOLS FOR AVIAN SPECIES OF GREATEST CONSERVATION NEED IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – American Bittern, Virginia Rail
Secretive Marsh Birds

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

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

SUMMARY

The American Bittern (*Botaurus lentiginosus*) is classified as an uncommon summer resident in Wyoming (Orabona et al. 2012) and a Species of Greatest Conservation Need (SGCN) with a Native Species Status (NSS) 3, Tier II by the Wyoming Game and Fish Department because of severely limited wetland habitat necessary for reproduction and survival (WGFD 2010). Because of their secretive behavior, American Bitterns require a species-specific call-playback technique to document presence. In previous years, we used the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009) to conduct annual monitoring on the Cokeville Meadows National Wildlife Refuge (CMNWR) in western Wyoming to determine presence and evaluate population trend of American Bitterns over time. However, due to issues beyond our control (e.g., flooding, blocked access) and concern for human health and safety along the railroad right-of-way through a portion of the marsh habitat, we eliminated three existing survey routes on the CMNWR, but were able to add two new routes for a total of four routes on the refuge (Fig. 1).

To better ascertain distribution and status of American Bitterns and other secretive marsh birds in Wyoming, we evaluated marsh habitat throughout the state to locate additional sites suitable for implementing the standardized survey methods for secretive marsh birds. We set up 6 new survey routes [Yellowtail Wildlife Habitat Management Area (WHMA), $n = 3$; Table Mountain WHMA, $n = 1$; Dad Wetland, $n = 1$; and Hutton Lake NWR, $n = 1$] for a total of 10 routes in 5 wetland sites across Wyoming (Fig 2).

Starting in 2015, we will conduct annual surveys for the American Bittern at these sites, and will also include three additional national marsh bird focal species: Pied-billed Grebe (*Podilymbus podiceps*), Virginia Rail (*Rallus limicola*), and Sora (*Porzana carolina*). Although the Virginia Rail and Sora are game species, there are currently no survey efforts in place to ascertain their distribution and abundance in Wyoming. Furthermore, the Virginia Rail is classified as a SGCN NSS3, Tier II in Wyoming due to restricted population size and distribution (WGFD 2010).

Using the national secretive marsh bird call-playback technique will both standardize and add value to our survey efforts. Our results will be able to be compared with those from across the US where this method is also being employed, and our data will be added to the national marsh bird database to increase knowledge of species distribution and status on a larger scale.

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 Species of Greatest Conservation Need. Thanks to C. Conway, US Geological Survey, for assistance with questions regarding the Standardized North American Marsh Bird Monitoring Protocols. Finally, we thank Department personnel J. Altermatt, S. Tessman, and T. Mong for assistance with survey site locations and directions, and Nongame GIS Analyst D. Jensen for producing the survey maps.

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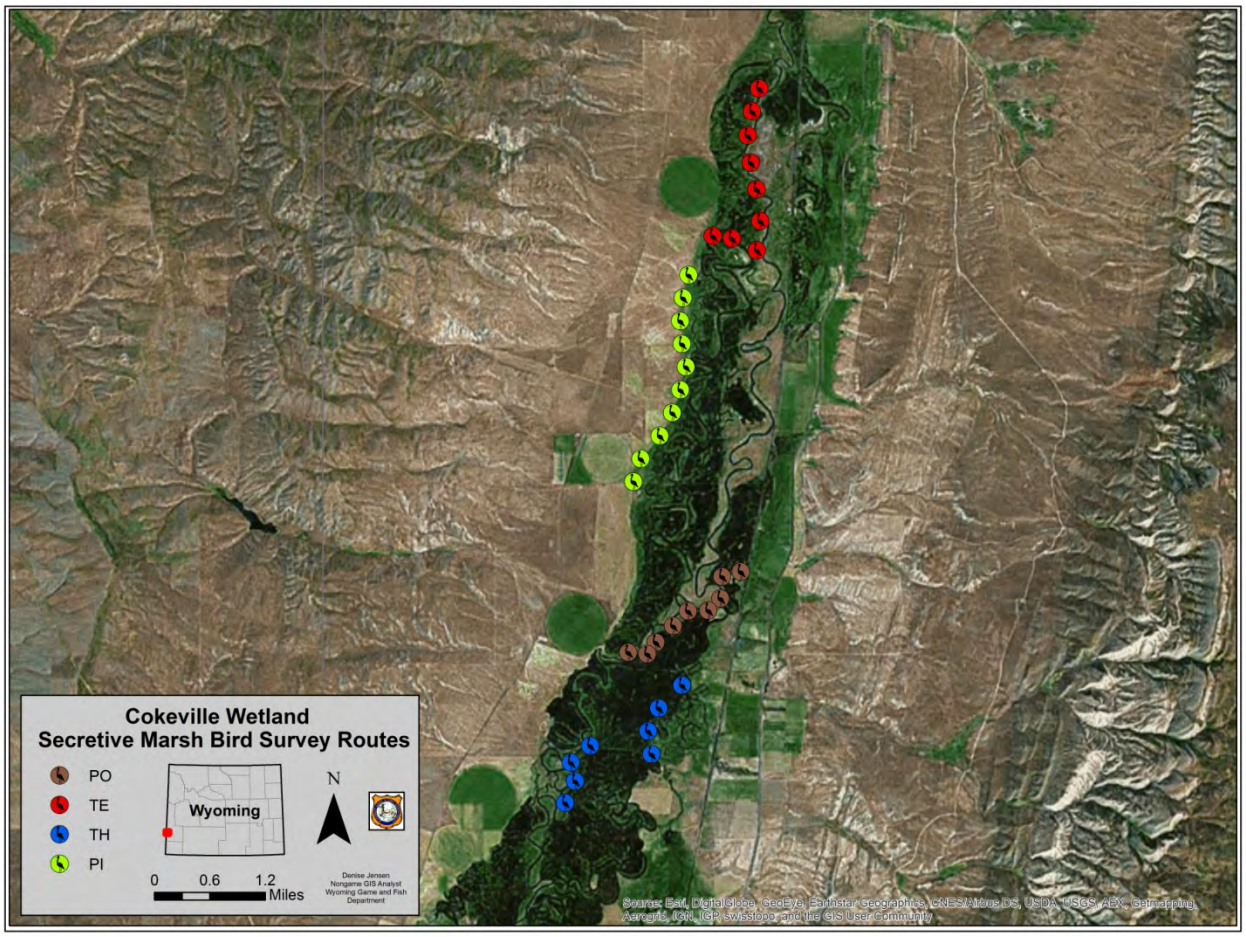

Figure 1. Locations of secretive marsh bird survey transects we established on the Cokeville Meadows National Wildlife Refuge using the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). PO = Pope route, TE = Teichert route, TH = Thornock route, and PI = Pixley route.

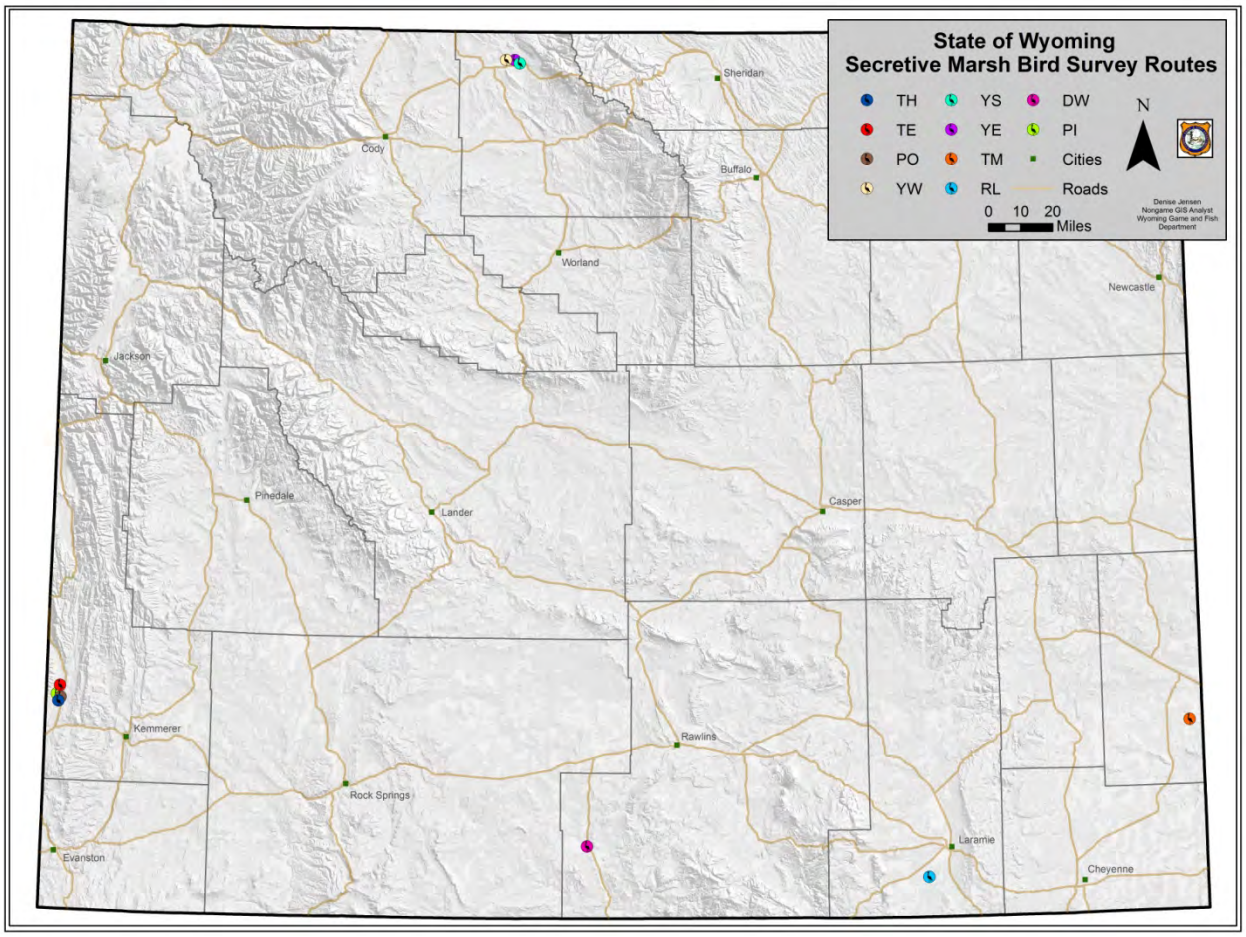

Figure 2. Statewide secretive marsh bird survey transect locations we established in 2014 in suitable wetland habitat for implementing the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). TH = Thornock route, TE = Teichert route, PO = Pope route, YW = Yellowtail West route, YS = Yellowtail South route, YE = Yellowtail East route, TM = Table Mountain route, RL = Rush Lake route, DW = Dad Wetland route, PI = Pixley Route.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) MONITORING IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

FUNDING SOURCE: United States Army Corps of Engineers
Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Susan Patla, Nongame Biologist

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 2014, 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 mid- to late March to document the number of occupied sites with incubating adults, and again in late May and 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 2014, we used a single observer and 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

March 14 and March 30, and productivity surveys on May 20 (Snake River) and June 9 (Green River). 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. Three different aircraft companies were used this year, all with pilots that had not previously flown eagle surveys.

Biologists from Grand Teton National Park, Seedskadee NWR, 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. These data are not included in this report; results can be accessed through the Department's Wildlife Observation System database. 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. Some wildlife consultant companies provided nest observation data as well.

RESULTS

In 2014, we evaluated occupancy status of 90 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 concentrated in western Wyoming where the majority of nests are known to occur and where the Department has collected nest site data since the late 1970s.

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, 73% of the territories checked for productivity in western Wyoming produced mature young. The number of mature young produced per successful nest was 1.42. Overall, 11 nest sites failed in the Jackson area, the same number as the previous year, most likely a result of cold snow storms that occurred in April during the hatching period. No emergency dike work was required by the Army Corps of Engineers along the Snake River dike system in 2014. A project to remove vegetation along the Snake River dikes was started on 14 July along the river south of Wilson.

A dead Bald Eagle that had died earlier was recovered in the Jackson area on 7 May after snow melt. This banded female adult (FWS 0679-02231) had been tagged in 2010 at her nest area in South Park, approximately 13 km from where her carcass was found.

DISCUSSION

The number of nesting pairs of Bald Eagles appears to have stabilized in the Snake River drainage in Wyoming, with some shift in pairs occurring over time but few new territories being discovered. Four new nest sites were documented in western Wyoming in 2014, one in Grand Teton National Park, one on the north end of the National Elk Refuge in Jackson, one along the river south of Jackson, and the fourth near Cottonwood Creek south of Daniel. 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 2014 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 2014: D. Patla (volunteer); B. Bedrosian (Craighead Beringia South); E. Cole (National Elk Refuge); T. Koerner and K. Theule (Seedskadee NWR); J. Stephenson, W. Scherer, and A. May (Grand Teton National Park); and B. Jones (Teton County). We appreciate funding provided by the ACE (Walla Walla office) for aerial surveys.

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United States Fish and Wildlife Service [USFWS]. 2012. Land-based wind energy guidelines. OMB Control No, 1018-0148. US Fish and Wildlife Service, Washington, D.C., USA.

Table 1. Summary of Bald Eagle (*Haliaeetus leucocephalus*) nesting data collected by the Wyoming Game and Fish Department Nongame Program in 2014. We present data by major drainages and geographic boundaries in Wyoming. [a] Greater Yellowstone Area (GYA) does not include data for three 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. nc = not counted.

Nesting data collected	Wyoming portion of GYA[a]	Green River[b]	Bear River	Salt River	Western WY total
Territories checked for occupancy (*n*)	50	38	nc	2	90
Territories occupied (*n*)	41	32	nc	2	75
Percent of territories occupied	82%	84%		100%	83%
Territories surveyed for productivity (*n*)	40	25		2	67
Territories that produced young (*n*)	27	20		2	49
Percent of successful nests [d]	68%	80%		100%	73%
Mature young produced [e] (*n*)	38	29		3	70
Mature young per successful nest ($\bar{x}$)	1.4	1.45		1.5	1.42

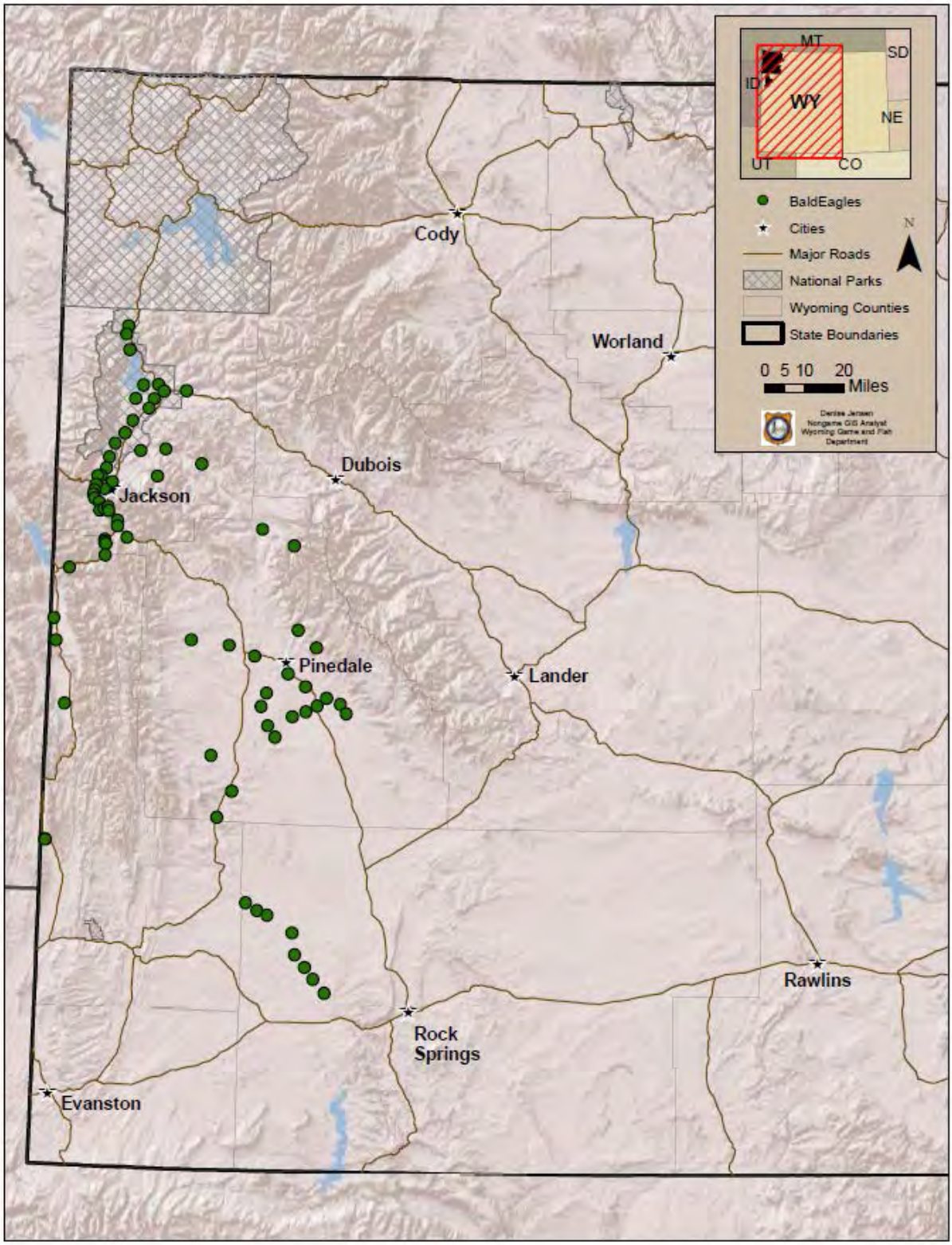

Figure 1. Map of Bald Eagle (*Haliaeetus leucocephalus*) nest sites occupied by nesting pairs monitored by the Wyoming Game and Fish Department in western Wyoming in 2014.

INITIATING LONG-TERM MONITORING FOR AVIAN GRASSLAND SPECIES OF GREATEST CONSERVATION NEED IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Mountain Plover, Upland Sandpiper, Long-billed Curlew, and Burrowing Owl

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

PROJECT DURATION: Annual

PERIOD COVERED: 1 April 2013 – 30 September 2014

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

SUMMARY

Grasslands are known to be one of the most biologically productive of all plant communities (Williams and Diebel 1996). Their exceptional productivity is a result of a high retention of nutrients, efficient biological recycling, and a structure that provides for an immense assemblage of animal and plant life (Estes et al. 1982). Of the 435 avian species that breed in the US, 330 are known to breed within the 1.3 million km^2 that comprise the Great Plains (Knopf and Samson 1995). Of those 330 species, 12 are endemic to the grasslands; an additional 25 species evolved on the grasslands, even though they may also range widely into adjoining habitat types such as sagebrush, shrub-steppe, and wetlands (Mengel 1970; Table 1; Fig. 1). All nine of the avian species deemed narrow endemics to the northern Great Plains grasslands occur in Wyoming (Knopf 1996; Table 1). Furthermore, 9 of the 12 grassland endemic species and 15 of the 20 secondary grassland-specific species are regularly occurring breeders in Wyoming (Table 1). The majority of bird species endemic to the shortgrass and mixed-grass prairies are associated with large grazing animals such as bison, while other species such as the Ferruginous Hawk, Prairie Falcon, and Burrowing Owl are either somewhat or strongly associated with the presence of prairie dog colonies on the landscape (Knopf and Samson 1997).

Land conversions from native prairie to agricultural uses, habitat loss and fragmentation, industrialization including wind energy development and natural resources extraction, the introduction and spread of invasive and noxious plants, urbanization, fire suppression, wetland draining, and the removal of native grazers have transformed the grasslands of the Great Plains into one of the most imperiled ecosystems in North America (Knopf 1996, Samson et al. 1998; Fellows and Jones 2009). As a group, grassland birds have shown steeper, more consistent, and

more widespread declines than any other guild of species in North America (Knopf 1992, 1994, 1996).

In 2003, Wyoming Partners in Flight presented information, issues, and recommendations for priority species in the Wyoming Bird Conservation Plan, Version 2.0 (Nicholoff 2003). Recommendations included dedicated monitoring for priority species. In 2006, Wyoming Game and Fish Department (Department) Nongame Program personnel developed A Plan for Bird and Mammal Species of Greatest Conservation Need in Eastern Wyoming Grasslands (Grassland Plan) that identified habitat and species issues and presented objectives to address these concerns (WGFD 2006). The objectives included maintaining inventory and monitoring programs for wildlife populations, working toward removing species from Species of Greatest Conservation Need (SGCN) classification, and working cooperatively with landowners to achieve common goals. The Wyoming State Wildlife Action Plan (SWAP) further identifies problems, conservation actions, and monitoring and research needs for all SGCN (WGFD 2010). Two grassland endemics—Mountain Plover (*Charadrius montanus*) and Long-billed Curlew (*Numenius americanus*)—and two secondary grassland associates—Upland Sandpiper (*Bartramia longicauda*) and Burrowing Owl (*Athene cunicularia*)—are classified as SGCN in the SWAP (WGFD 2010; Table 1).

Although objectives, inventories, and conservation actions were initially being addressed by the Department's Landowner Incentive Program Coordinator, this position was vacated and is no longer available, leaving a gap in the grassland SGCN monitoring program and a limited ability to adequately address management and conservation of these SGCN. With a probable increase in industrialization in Wyoming and associated habitat modifications, the need to fill these data gaps is of critical importance. This will enable us to determine population parameters of these species, identify risks and concerns, and apply timely actions to address issues and avoid potential listings under the federal Endangered Species Act (ESA).

This project addresses four avian SGCN, three of which are classified as Native Species Status Unknown (NSSU) and will benefit greatly from a dedicated monitoring program. Current long-term monitoring programs (i.e., Breeding Bird Survey and Integrated Monitoring in Bird Conservation Regions) adequately monitor numerous species of birds in Wyoming, but do not sufficiently quantify population parameters for these four grassland species due to the seasonal timing during which the surveys are conducted and/or the survey techniques used.

The Mountain Plover is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier I classification in the SWAP (WGFD 2010). A narrow range of habitat requirements combined with a high degree of site fidelity and susceptibility to disturbance during the nesting season increases its vulnerability to impacts that occur at breeding sites. In addition, crucial breeding areas are only partially identified, so management efforts may not adequately address conservation needs. Throughout its breeding range, the Mountain Plover is classified as uncommon to relatively common, but the species exists in low densities. The Mountain Plover was previously petitioned for listing as Threatened under the federal ESA on two separate occasions, further emphasizing the need to adequately determine population status (USFWS 1999, 2010).

The Upland Sandpiper is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier II classification in the SWAP (WGFD 2010). Populations in eastern Wyoming may be experiencing serious declines due to habitat conversions, the encroachment of woody vegetation into grassland habitats, humanization, and the invasion of noxious species, all of which severely degrade breeding habitat for this species. This species is also sensitive to human disturbance during the breeding season. Population status and trends are largely unknown in Wyoming, and current monitoring programs do not adequately track this species because populations occur at low densities.

The Long-billed Curlew is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSS3, Tier II classification in the SWAP (WGFD 2010). Although the breeding status is well known in the northwestern portion of Wyoming and monitoring is on-going, populations in eastern Wyoming are not well documented and may be declining significantly. Habitat degradation is one of the most considerable threats to this species, particularly in the Great Basin grasslands.

The Burrowing Owl is an uncommon summer resident in Wyoming (Orabona et al. 2012) with a NSSU, Tier I classification in the SWAP (WGFD 2010). It has experienced range-wide contractions due to habitat loss and degradation and the elimination of burrowing rodents. While distribution of this species is understood in the state, there is concern about the impacts of on-going and proposed oil, gas, and wind energy development in Burrowing Owl habitat in Wyoming, and informed management decisions are difficult to make without adequate occupancy and population trend information.

Project funds were used to hire a seasonal field biologist from April through September in 2013 and 2014 to assist the Department's Nongame Bird Biologist with implementing this long-term, targeted monitoring program. We used existing information to identify preferred breeding habitat for our focal species, and followed standardized, peer-reviewed survey techniques specifically designed for each of our focal SGCN to delineate our survey routes (Figs. 2-5).

Wyoming contains substantial areas of known and potential habitat for these SGCN, including areas where habitat degradation and conflicts with industrialization are likely to occur in the near future. However, due in part to personnel and funding constraints, important breeding areas and population status are only partially identified, which makes effective statewide management decisions challenging. Once we are able to implement targeted monitoring for these species, we can use survey results to address concerns, data deficiencies, and conservation actions presented in the Wyoming Bird Conservation Plan (Nicholoff 2003), Grassland Plan (WGFD 2006), and SWAP (2010). Moreover, avian grassland species are equally dependent on quality habitat in their breeding, migration, and winter ranges (Knopf 1996a). Thus, the results of this project will help inform management decisions, address conservation concerns, and direct conservation actions on these species' breeding grounds in Wyoming. Results will also enhance our ability to advance conservation and management of grassland birds and their habitats through full life-cycle conservation.

ACKNOWLEDGEMENTS

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Table 1. Endemic and secondary species associated with the Great Plains grasslands (Mendel 1970). Species that breed in Wyoming are denoted in bold. Native Species Status (NSS) and Tier are from the Wyoming State Wildlife Action Plan (WGFD 2010). NSSU = Native Species Status Unknown. Table excludes wetlands-associated species, and those species that have stronger ecological associations with sagebrush (*Artemisia* spp.) landscapes of the Great Basin.

Common name	Scientific name	Seasonal status	Native species status and tier
Endemic species			
Ferruginous Hawk	*Buteo regalis*	**Year-round**	**NSSU, I**
Mountain Plover	*Charadrius montanus*	**Summer**	**NSSU, I**
Long-billed Curlew	*Numenius americanus*	**Summer**	**NSS3, II**
Marbled Godwit	*Limosa fedoa*	Migrant	
Wilson's Phalarope	***Phalaropus tricolor***	**Summer**	
Franklin's Gull	***Larus pipixcan***	**Summer**	**NSS3, II**
Sprague's Pipit	*Anthus spragueii*	Migrant	
Chestnut-collared Longspur	***Calcarius ornatus***	**Summer**	**NSS4, II**
McCown's Longspur	***Rhynchophanes mccownii***	**Summer**	**NSS4, II**
Cassin's Sparrow	*Peucaea cassinii*	Accidental	
Lark Bunting	***Calamospiza melanocorys***	**Summer**	**NSS4, II**
Baird's Sparrow	***Ammodramus bairdii***	**Summer**	
Secondary species			
Sharp-tailed Grouse	***Tympanuchus phasianellus***	**Year-round**	**NSS4, II**
Greater Prairie-Chicken	*Tympanuchus cupido*	Accidental	
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*		
Mississippi Kite	*Ictinia mississippiensis*	Accidental	
Northern Harrier	***Circus cyaneus***	**Summer**	
Swainson's Hawk	***Buteo swainsoni***	**Summer**	**NSSU, II**
Upland Sandpiper	***Bartramia longicauda***	**Summer**	**NSSU, II**
Burrowing Owl	***Athene cunicularia***	**Summer**	**NSSU, I**
Short-eared Owl	***Asio flammeus***	**Year-round**	**NSS4, II**
Prairie Falcon	***Falco mexicanus***	**Year-round**	
Horned Lark	***Eremophila alpestris***	**Year-round**	
Clay-colored Sparrow	***Spizella pallida***	**Summer**	
Vesper Sparrow	***Pooecetes gramineus***	**Summer**	
Lark Sparrow	***Chondestes grammacus***	**Summer**	
Savannah Sparrow	***Passerculus sandwichensis***	**Summer**	
Grasshopper Sparrow	***Ammodramus savannarum***	**Summer**	**NSS4, II**
Henslow's Sparrow	*Ammodramus henslowii*		
Dickcissel	***Spiza americana***	**Summer**	**NSS4, II**
Eastern Meadowlark	*Sturnella magna*	Accidental	
Western Meadowlark	***Sturnella neglecta***	**Summer**	

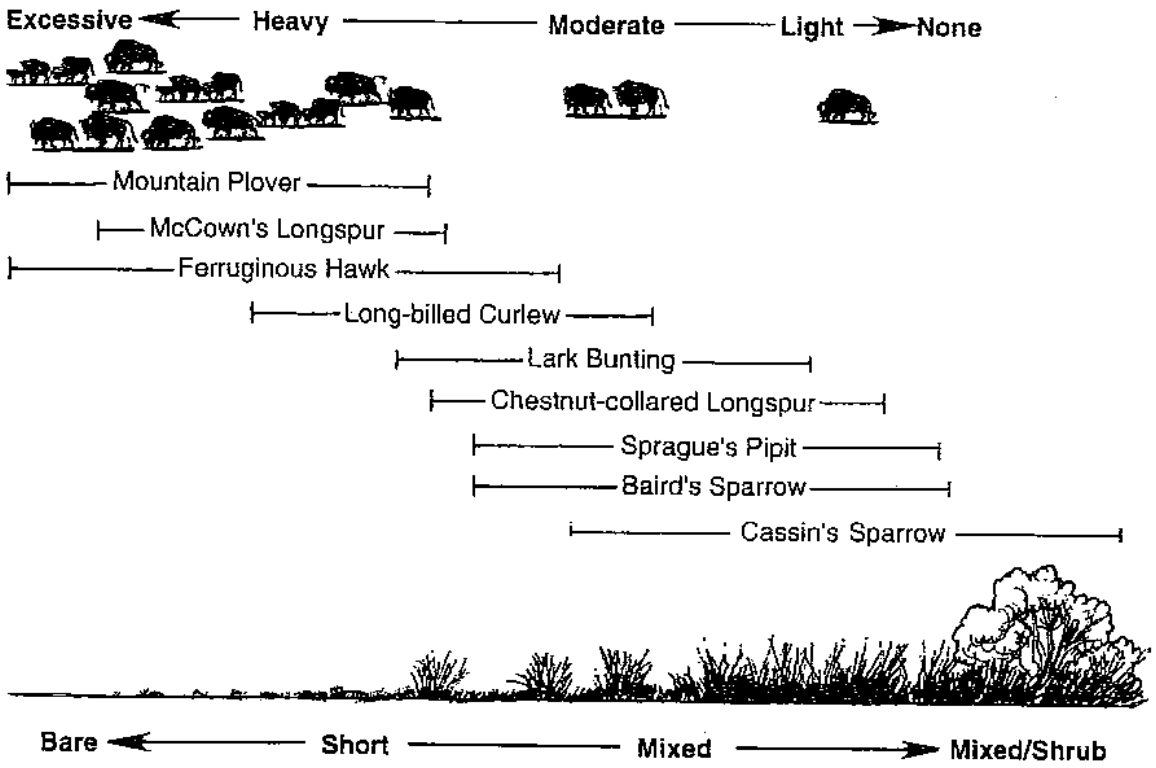

Figure 1. Distributions of avian species endemic to the Great Plains in relation to grassland type and historical grazing pressure (Knopf 1996).

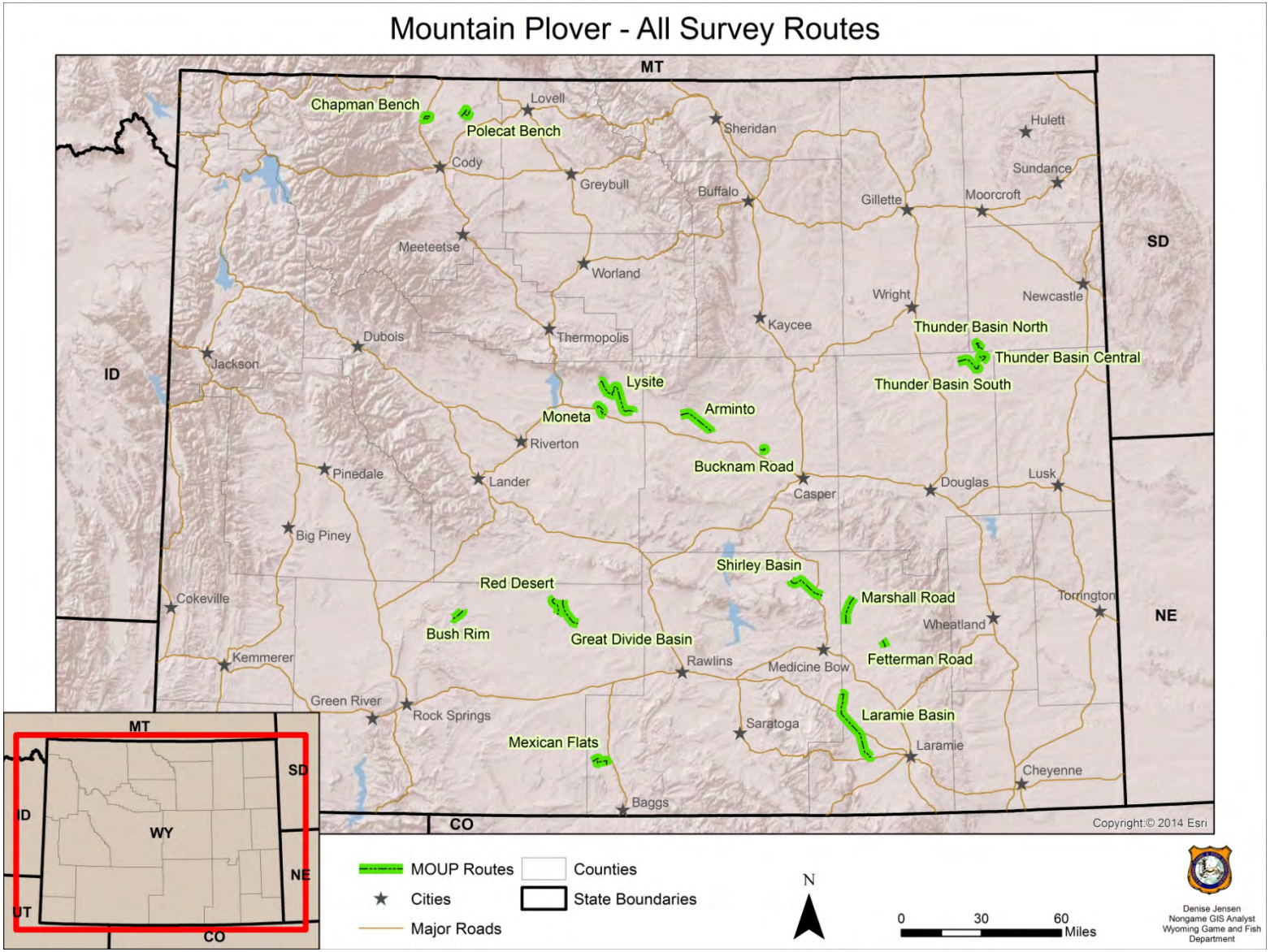

Figure 2. Survey routes we established in 2013 and 2014 for monitoring Mountain Plovers (*Charadrius montanus*) in Wyoming.

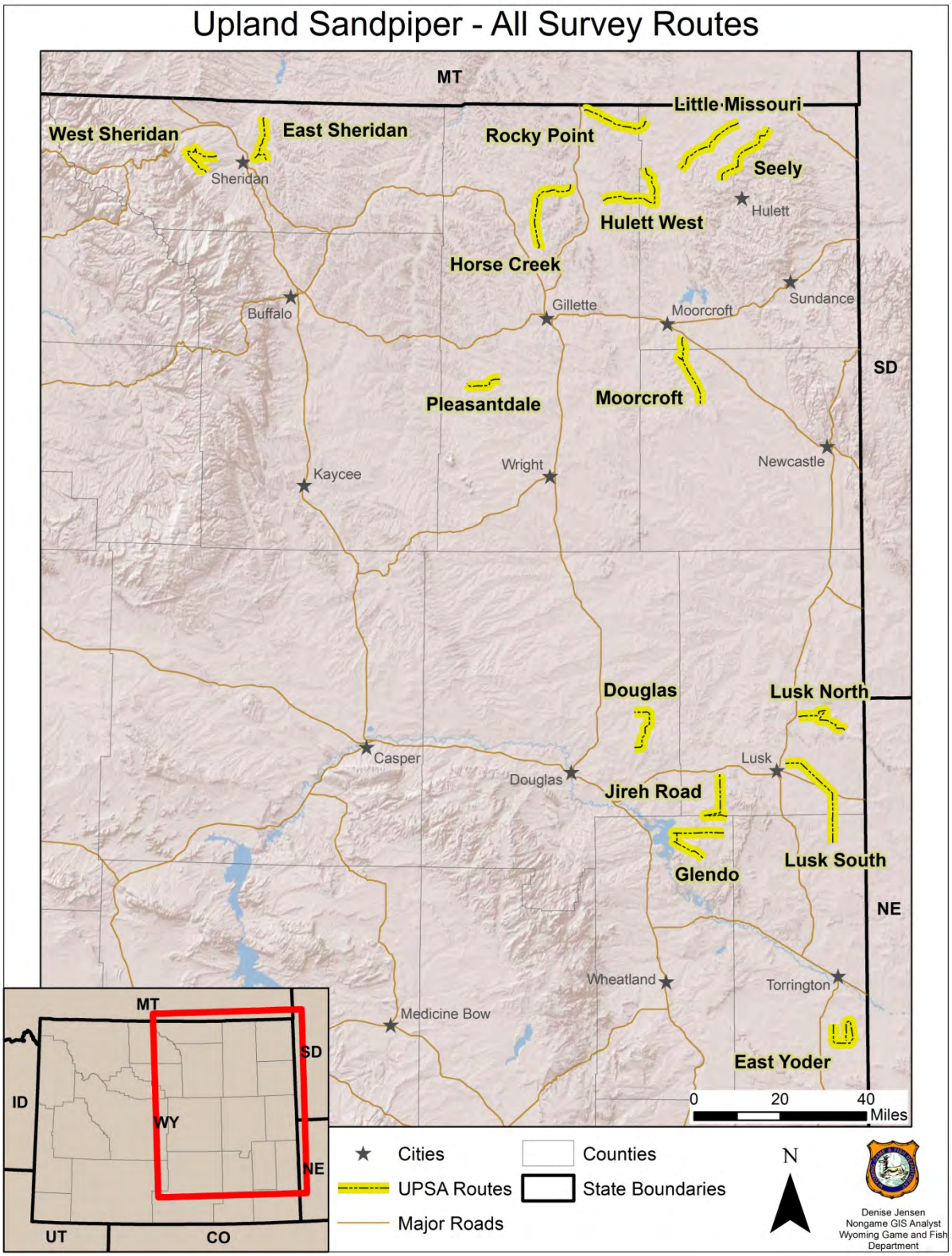

Figure 3. Survey routes we established in 2013 and 2014 for monitoring Upland Sandpipers (*Bartramia longicauda*) in Wyoming.

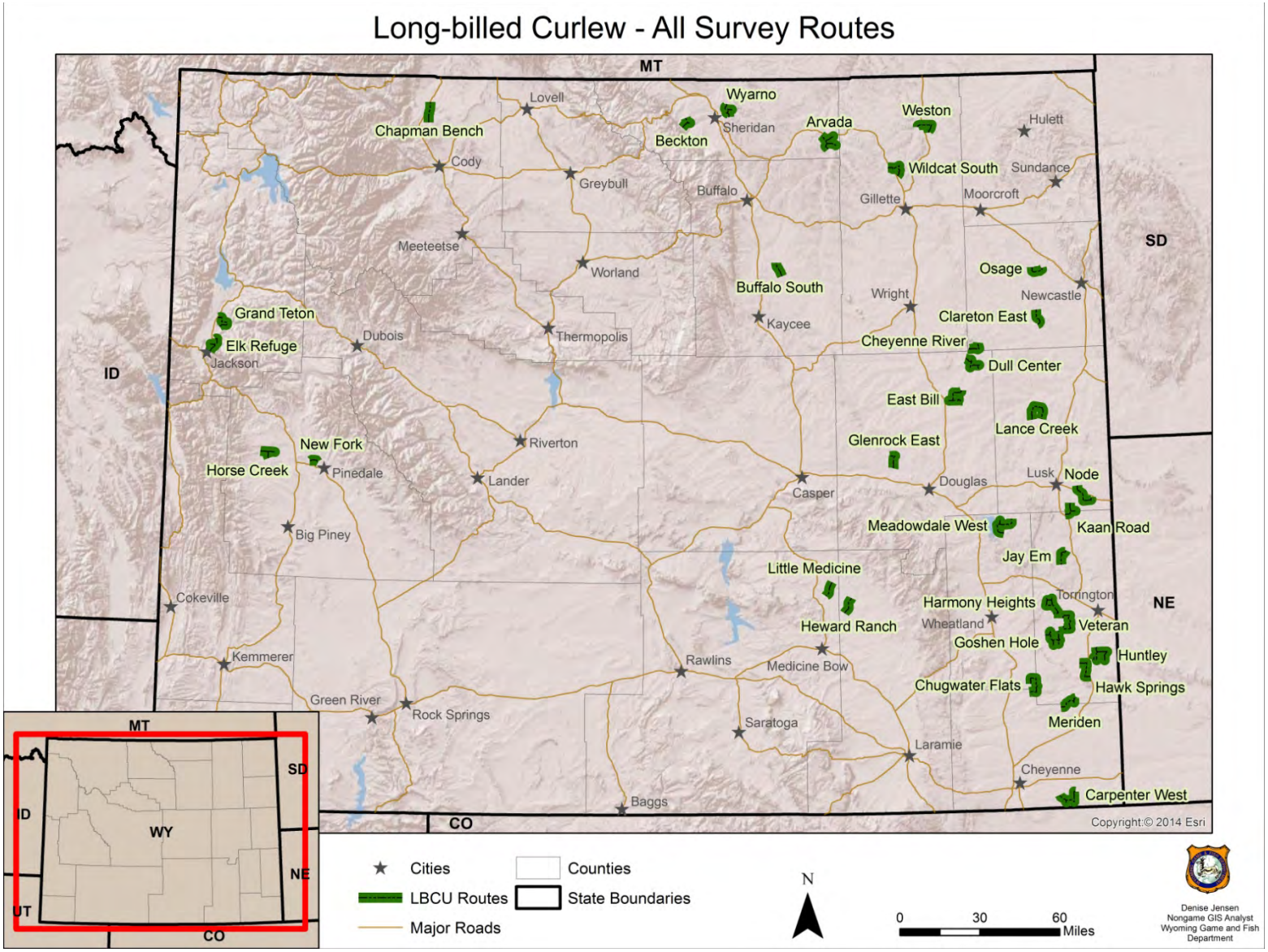

Figure 4. Survey routes we established in 2013 and 2014 for monitoring Long-billed Curlews (*Numenius americanus*) in Wyoming.

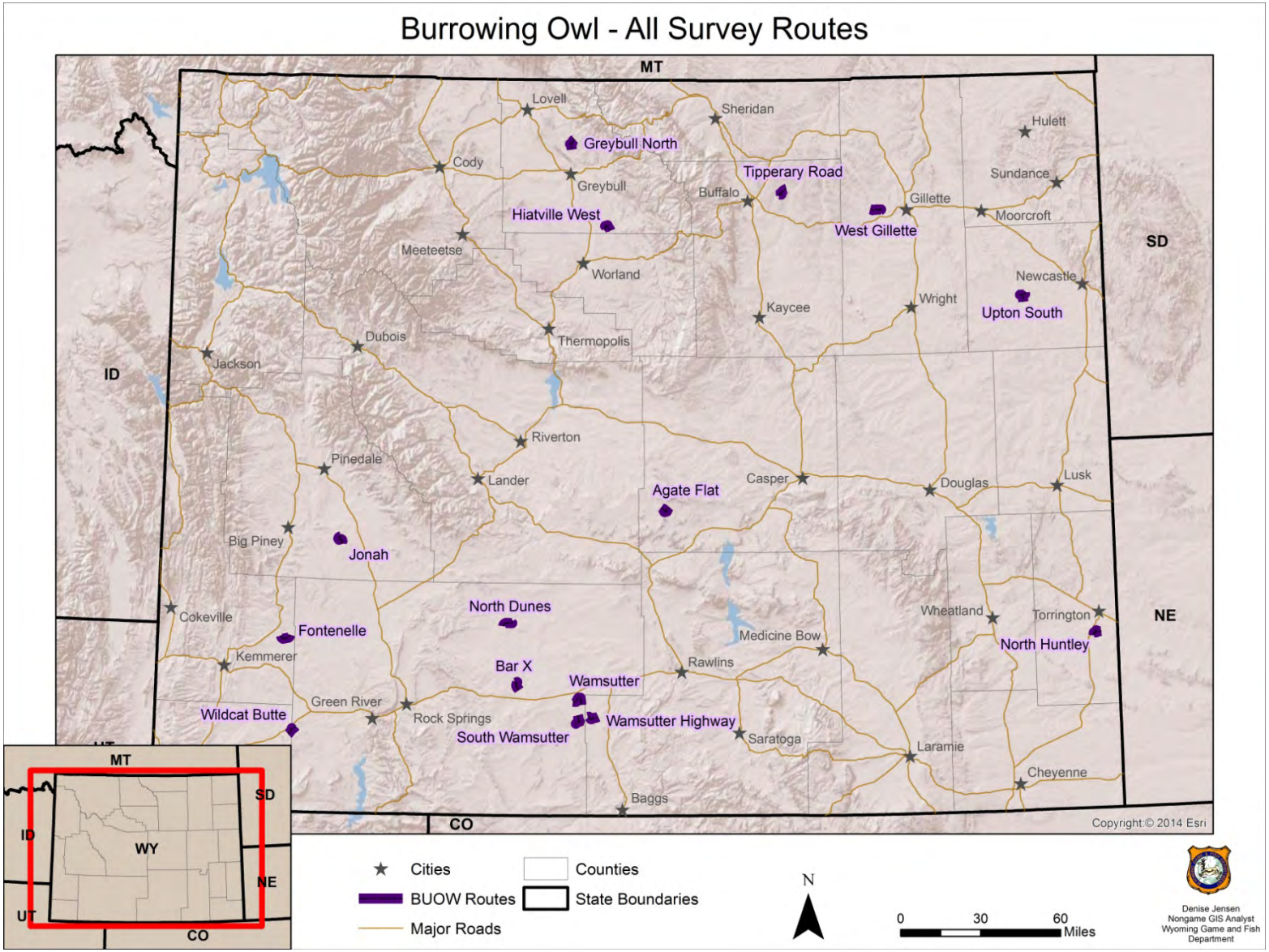

Figure 5. Survey routes we established in 2013 and 2014 for monitoring Burrowing Owls (*Athene cunicularia*) in Wyoming.

OCCUPANCY, NEST SUCCESS, AND HABITAT USE OF GREAT GRAY OWLS (*STRIX NEBULOSA*) 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 2014 – 31 December 2014

PREPARED BY: Bryan Bedrosian, 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 2015 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 estimated 10 Great Gray Owl territories occurred within the study area, and increased that estimate to 21 territories in 2014. Nest initiation was 60% in 2013 and 90% in 2014. Nest success also increased from 2013 to 2014, from 50% to 77%. We have marked and tracked 21 Great Gray Owls with satellite and/or VHF transmitters over the past 2 years and will continue to mark and monitor more owls in the coming years. In summer/fall 2013 and 2014, we surveyed small mammals within each nesting territory and began northern pocket gopher (*Thomomys talpoides*) surveys within each territory in 2014. 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 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 (NSSU, Tier I) in Wyoming (WGFD 2010). 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. 1988a, 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 2015 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 and 2014 included the base of the Teton Mountain Range from Teton Village to the Snake River Canyon. 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. Franklin (1988) found an average DBH of all Great Gray Owl nest trees of 52.7 cm in Wyoming and Idaho, but the average DBH of trees hosting stick nests used by Great Gray Owls was 38.6 cm (+/- 17.5 cm). 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 0.5 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. To maximize detectability, all vehicles were turned off and there was no movement or talking from surveyors during the survey period.

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, 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 or twice daily for approximately every 10-12 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. In 2014, we used yellow leg bands on fledglings to delineate that year's cohort. 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 at least once per week throughout the study. Relocations were obtained via homing techniques and locations were recorded within 30 m of the owl without disturbing it. If owls could not be located, the entire study area was searched on foot, by vehicles, 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 >25cm DBH to define potentially available nesting habitat. We then randomly projected points within this layer

that were ≥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 in 2013 (Fig. 1). In 2014, we surveyed 505 unique locations and re-surveyed 69% of those (349 locations). 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. In 2014, we altered the calling period to 18 February to 14 April but we did not detect the first calling Great Gray Owl until 3 March 2014.

In 2013, we recorded a total of 320 detections from seven different owl species. The most frequently detected owl species was the Great Horned Owl (*Bubo virginianus*; $n = 93$), followed by Boreal Owl ($n = 74$), Northern Saw-Whet Owl (*Aegolius acadicus*; $n = 70$), Great Gray Owl ($n = 66$; Fig. 2), Long-eared Owl (*Asio otus*; $n = 9$), Northern Pygmy-Owl (*Glaucidium gnoma*; $n = 6$) and Barred Owl (*Strix varia*; $n = 2$). In 2014, we documented a total of 162 owl detections from 6 species. We detected 86 Great Horned Owls (53%), 26 Great Gray Owls (16%; Fig. 2), 22 Boreal Owls (14%), 15 Northern Saw-whet Owls (9%), 11 Northern Pygmy-Owls (7%) and 2 Long-eared Owls (1%). 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 in 2013. Using survey data from both years, as well as fledgling surveys, we estimated a total of 21 Great Gray Owl territories in and around Jackson Hole, with direct evidence of breeding (current and historic) in 16 of those territories.

In 2013, 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 Northern 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. In 2014, we located nine active nests among suspected territories. Four nests were located in old hawk nests (likely Northern Goshawk nests), four in snags, and one in a mistletoe clump. Most (77%) of nests fledged young, with an average of two fledglings per nest.

While searching for Great Gray Owl nests, we also opportunistically located active nests of other species. In 2013, we found nests of the Great Horned Owl (n = 3), Red-tailed Hawk (*Buteo jamaicensis*; n = 2), Sharp-shinned Hawk (*Accipiter striatus*; n = 2), Canada Goose (*Branta canadensis*; n = 2), Common Raven (*Corvus corax*; n = 2), and Northern Goshawk (n = 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 the structure). In 2014, we checked all nests located previously and found an additional 41 potential and active nest structures from other raptors.

We completed 136 fledgling call-back surveys in August 2013 and located one additional Great Gray Owl family group that was not located during the nest searches. The three successful pairs we found fledged an average of 1.67 young per nest. Using the four nests found and additional family group located during fledgling surveys, the average nest success rate was 60%. In 2014, we did not conduct systematic fledgling surveys, but rather traversed suspected Great Gray Owl habitats where no known territories were located and called for adults and fledglings. We located one new family group in 2014 using this methodology.

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 in 2013, and 51 Great Gray Owl feathers in 2014. 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 in 2013, and 20 in 2014. 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 and 2014. We placed 50 traps in each territory (25 in forest and 25 in meadow habitats). We trapped in 8 territories in 2013 and 12 territories in 2014. The most abundant species trapped were chipmunks (*Tamias* spp.), followed by North American deer mice (*Peromyscus maniculatus*), southern red-backed voles (*Clethrionomys gapperi*), dwarf shrews (*Sorex nanus*), long-tailed voles (*Microtus longicaudus*), northern flying squirrels (*Glaucomys sabrinus*), and pocket gophers (*Geomys bursarius)*. In 2014, we also conducted pocket gopher surveys in 12 Great Gray Owl territories and recorded abundance of gopher mounds.

We captured and tagged a total of 10 Great Gray Owls during 2013, and placed transmitters on 9 of those individuals (Table 1). In 2014, we placed transmitters on 21 individuals, including 6 fledgling and hatch-year owls (Table 1). Of the 30 Great Gray Owls tagged with tracking devices in 2013 and 2014, we have documented four mortality events, including two car collisions, one predation, and one case of trichomoniasis.

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 one location every 4 hrs for 4-6 months for testing on several owls in 2013. After evaluating results obtained in 2013, we deployed eight more GPS units in 2014, but have changed the duty cycle to gather one to two locations per day for approximately 12 months.

In 2013, we gathered 145 relocations on all of the marked owls. We gathered an additional 320 locations from VHF marked birds in 2014 and 1,399 GPS relocations. We have created kernel density home range estimates (KDE) from owls within our main study area (Fig. 3).

During the summer of 2014, we re-visited marked Great Gray Owl relocations to gather vegetation data. We collected data on forest composition, canopy cover, and average DBH at 184 owl relocation sites. We found an average canopy cover of 26% and average stand DBH of 32 cm.

We set up 24 nesting platforms during fall 2013, and an additional 18 in 2014 (Fig. 4). The platforms were constructed with the aid of local Boy Scout and Girl Scout troops as part of our community outreach and education program. 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. As of winter 2014-2015, three nesting platforms erected in 2013 have been discovered by Great Gray Owls.

DISCUSSION

Over the past 2 years, 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 minimum convex polygon (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 KDE home range size of approximately 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 expanded the study area to the north and will continue to expand the study area in 2015. We have refined call-back survey protocols and timing to be more efficient by reducing the area surveyed at higher elevation, back-country sites where Great Gray Owls were not previously detected. In 2015, we have created habitat use model for adult Great Gray Owls in the breeding season to help refine call-back and search areas for new territories. We will be using these models to define survey areas and test the models for their utility in predicting Great Gray Owl nesting territories. We will also be further exploring detectability of nesting owls in the spring of 2015. We have defined methods for 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 subset 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. Our hope is to continue this project past the timeline outlined in our original State Wildlife Grants proposal by pursuing alternate funding and building on the great data gathered during this project.

ACKNOWLEDGEMENTS

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Table 1. Capture data for Great Gray Owls (*Strix nebulosa*) in northwestern Wyoming, 2013 and 2014.

Date	Location	Color band	Transmitter	Age	Gender	Date stopped	Cause
1/28/2013	Ely Springs	Blue A1	None	Juvenile	Male		
4/30/2013	Poison Creek	Blue A3	VHF	Adult	Female	20-Aug-13	Dropped transmitter
6/14/2013	Riverview Meadows	Blue A4	GPS	Sub-adult	Male		
6/18/2013	Taylor	Blue A5	GPS	Adult	Female	06-Feb-14	Transmitter fell off
7/4/2013	Paintbrush	Blue A6	GPS	Adult	Male	MIA	
7/16/2013	Resor	Blue A7	VHF	Adult	Female		
7/23/2013	Red Top	Blue A8	VHF	Adult	Male		
7/24/2013	Trail Creek	Blue A9	GPS	Sub-adult	Male	MIA	
9/27/2013	Paintbrush	Blue C1	VHF	SY	Male	01-Apr-13	Suspected predation
10/28/2013	Mead Ranch	Blue C2	VHF	Juvenile	Female	31-Oct-13	Hit by a car
1/16/2014	Granite Canyon	Blue C3	VHF	ASY	Male		
3/4/2014	Spring Gulch Road	Blue C4	VHF	ASY	Female		
3/12/2014	Ely Springs	Blue C5	VHF	Sub-adult	Female		
3/13/2014	Ely Springs	Blue C6	GPS	Adult	Female	23-Jul-14	Trich
3/28/2014	Skyline Ranch	Blue C7	VHF	Sub-adult	Male	31-Mar-14	Hit by car
3/31/2014	Sage Brush	n/a	GPS	Adult	Female	MIA	Battery dead
4/2/2014	Skyline	Blue C8	VHF	Juvenile	Male		
4/2/2014	Wilson	Blue C9	VHF	Adult	Male		
4/10/2014	Mosquito Creek	Blue E1	GPS	Adult	Female		
4/21/2014	Whitegrass	Blue E2	VHF	Adult	Male		
6/30/2014	Munger	Blue E3	GPS	Adult	Female		
7/22/2014	Red Top	Blue E5	GPS	Adult	Female		
9/17/2014	Munger	Yellow F1	VHF	Juvenile	Male		
9/17/2014	Munger	Yellow F2	VHF	Juvenile	Female		
9/18/2014	Red Top/Butler	Yellow F3	VHF	Juvenile	Male		
9/18/2014	Red Top/Butler	Yellow F4	VHF	Juvenile	Female		
10/7/2014	Pemble Ridge	Blue E4	GPS	Adult	Female		
10/10/2014	Taylor	Yellow F5	VHF	Juvenile	Male		

Table 1. Continued.

Date	Location	Color band	Transmitter	Age	Gender	Date stopped	Cause
11/6/2014	Ely Springs	Yellow F6	VHF	Juvenile	Male		
12/8/2014	Eli Springs	Yellow F7	VHF	Juvenile	Female		
12/20/2014	Wordell	Blue E6	GPS	Adult	Female		
1/7/2015	John Dodge	Blue E7	GPS	Adult	Female		

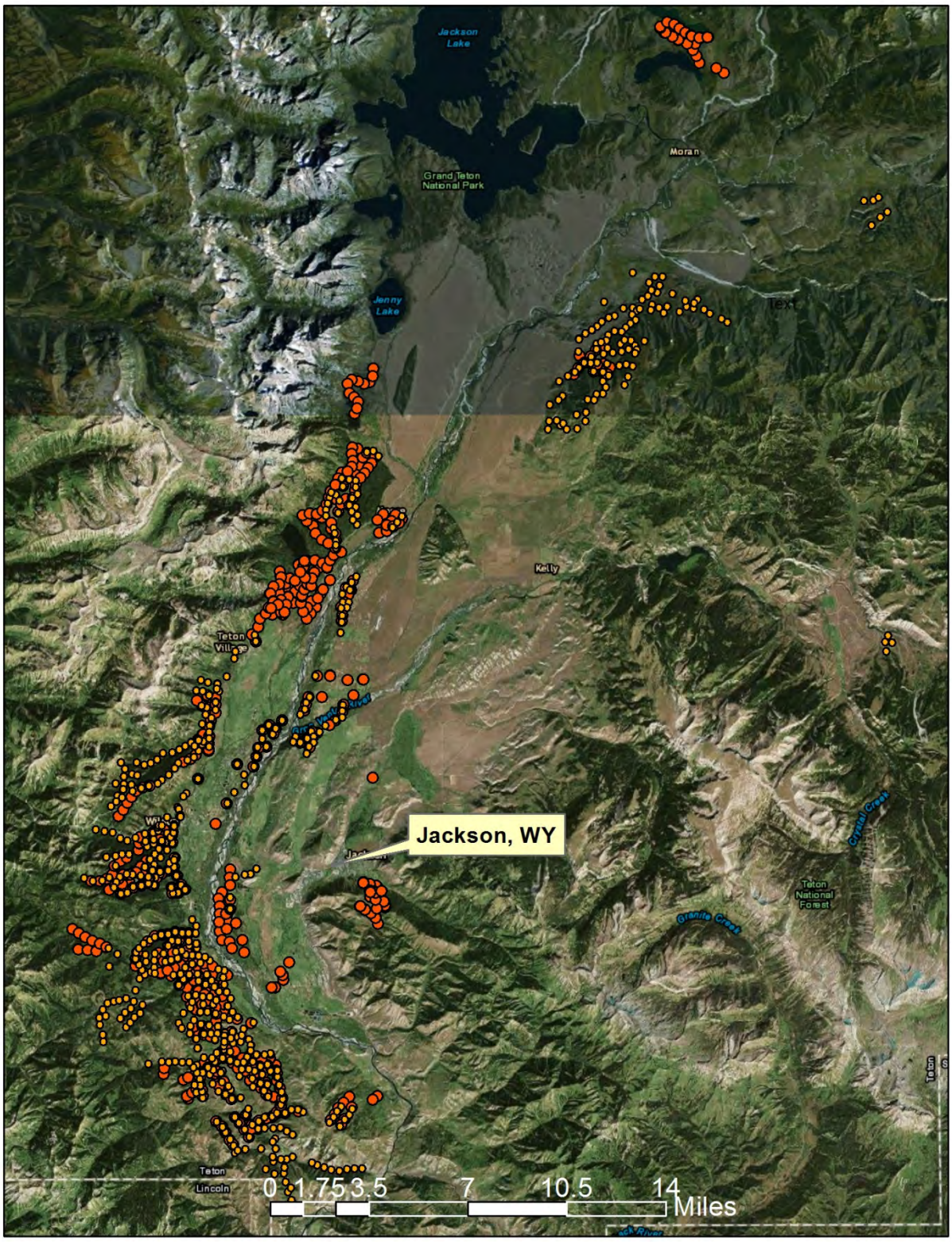

Figure 1. 2013 and 2014 nighttime call-back owl survey locations in Jackson Hole, Wyoming. Survey locations are depicted by small yellow dots (2013) and large orange dots (2014).

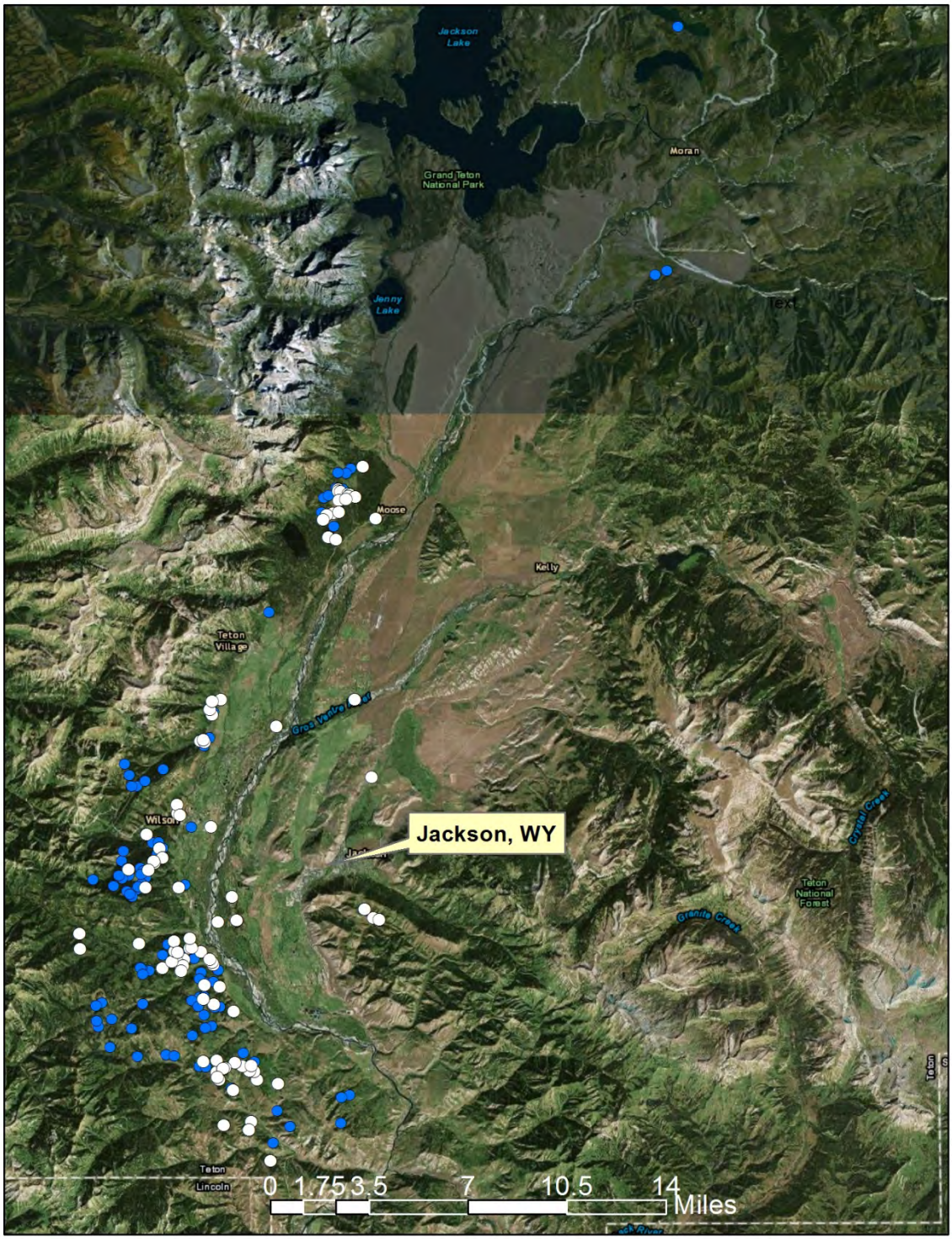

Figure 2. Great Gray Owl (*Strix nebulosa*; white) and Boreal Owl (*Aegolius funereus*; blue) detections during spring call-back surveys in western Wyoming, 2013 and 2014.

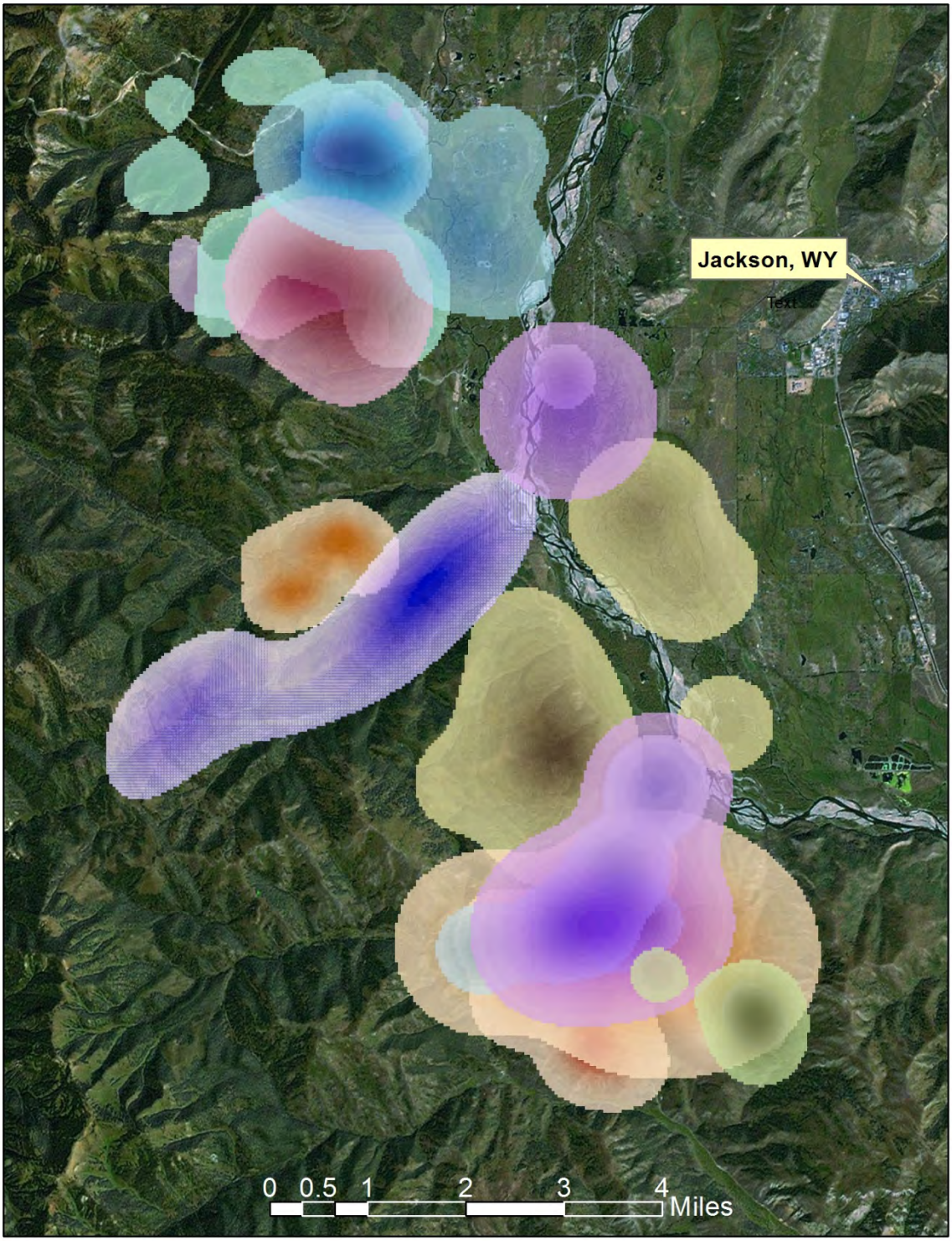

Figure 3. Kernel density estimate home-range estimates of radio-marked Great Gray Owls (*Strix nebulosa*) tracked in 2013 and 2014 within the main study area.

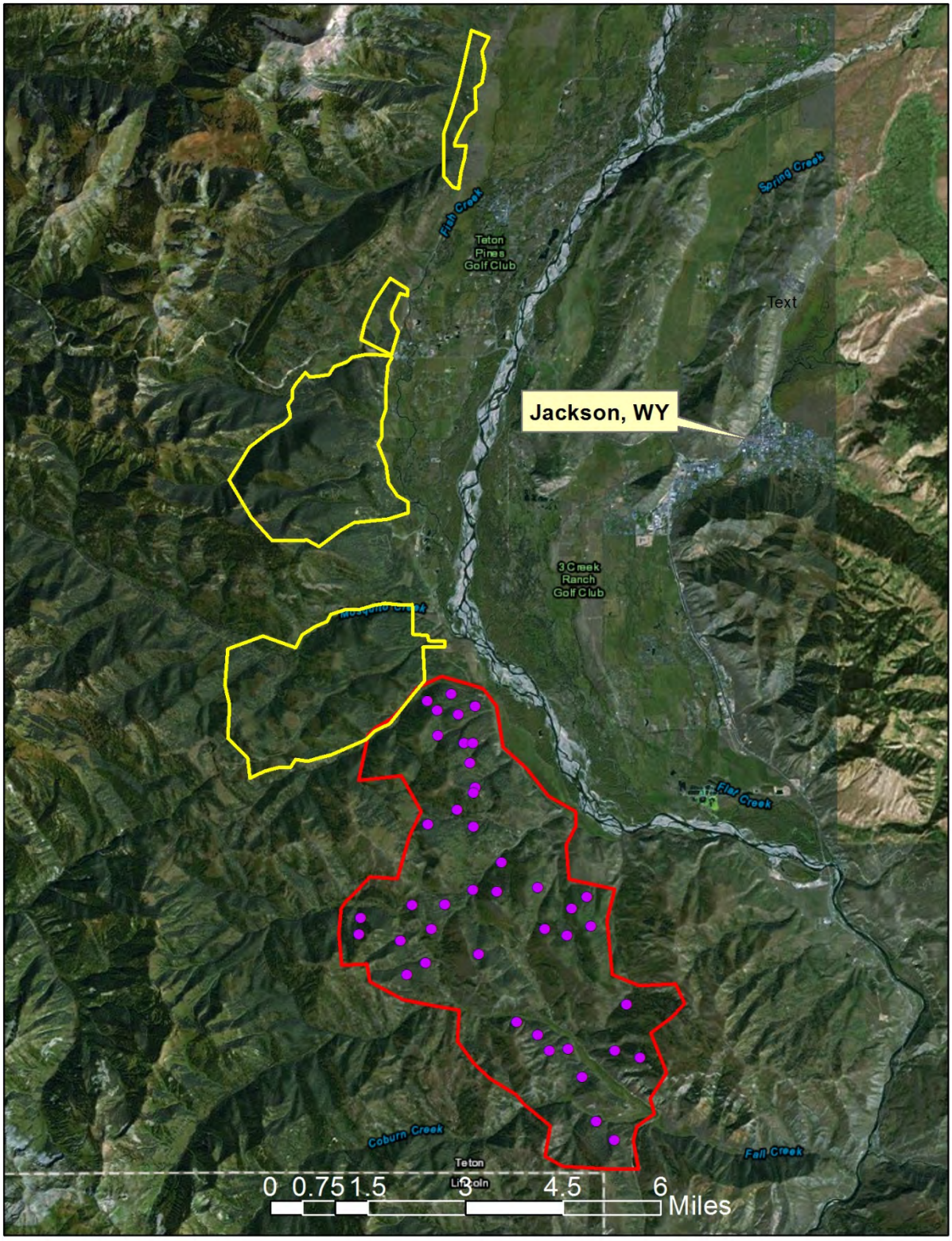

Figure 4. Control (yellow) and treatment (red) areas for Great Gray Owl (*Strix nebulosa*) nesting platform study. Purple dots indicate locations where platforms were placed in 2013 and 2014.

DENSITY AND ABUNDANCE OF BLACK-BACKED WOODPECKERS (*PICOIDES ARCTICUS*) IN A PONDEROSA PINE (*PINUS PONDEROSA*) ECOSYSTEM

STATE OF WYOMING

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

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

PROJECT DURATION: 2000 – 2001

PERIOD COVERED: 29 April 2000 – 25 June 2001

PREPARED BY: Sean R. Mohren, Wyoming Cooperative Fish and Wildlife Research Unit
Mark A. Rumble, US Forest Service, Rocky Mountain Research Station
Stanley H. Anderson, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

Black-backed Woodpeckers (*Picoides arcticus*) are usually associated with forest disturbance resulting in recently killed trees (Hutto 1995, Dixon and Saab 2000). While Black-backed Woodpeckers are attracted to areas affected by these disturbances, in the Black Hills they exist during interim disturbance periods in largely undisturbed forests. In 2012, a petition for listing Black-backed Woodpeckers in the Black Hills as a distinct population segment (Hanson et al. 2012) identified current population size and the population size necessary to minimize risk of extinction as key components of the decision process. Our objective was to estimate the population size of Black-backed Woodpeckers in the Black Hills National Forest of South Dakota and Wyoming during a period of relatively low disturbance (e.g., 2000-2001). The estimated population was 641 (95% CI = 405-990) and 456 (95% CI = 293-705) breeding pairs in 2000 and 2001, respectively (Mohren et al 2014). The average density of 0.12/km2 (95% CI = 0.07-0.18) was similar to densities in other undisturbed forests. This population estimate provides a starting point for population viability analyses during periods of relatively low disturbance by fire or insects.

Black-backed Woodpeckers occur in low density and a nonrandom distribution in undisturbed forests of the Black Hills. The recent petition for listing this uncommon species and low population/density suggest that some management to increase populations may be warranted. Intentional decisions allowing some forest disturbances that result in recently killed trees and management that sustains some of these areas is recommended if Black-backed Woodpecker populations are a priority. We recommend that if a cluster sampling design is

desirable, that transects be spaced >1,500 m apart to minimize chances of multiple observations of the same individual (Mohren et al. 2014).

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POPULATION ESTIMATE FOR BLACK-BACKED WOODPECKERS (*PICOIDES ARCTICUS*) IN THE BLACK HILLS OF SOUTH DAKOTA AND WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Black-backed Woodpecker

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds
United States Forest Service Rocky Mountain Research Station

PROJECT DURATION: 1 July 2012 – 30 September 2014

PERIOD COVERED: 15 April 2014 – 30 September 2014

PREPARED BY: Elizabeth Matseur, University of Missouri-Columbia

ABSTRACT

Natural disturbances, including fire and mountain pine beetle (*Dentroctonus ponderosae*) infestations have played an important role in shaping landscapes and bird distributions across western North America, including the Black Hills of Wyoming and South Dakota. Black-backed Woodpeckers (*Picoides arcticus*) are almost completely dependent on disturbed ephemeral habitats and rapidly colonize these areas to take advantage of prey availability. However, habitat quality declines after 2-3 years once beetle larvae have emerged from host trees. Despite the many benefits burned and beetle-killed forests provide for numerous wildlife species, much effort has been put into mitigating and preventing these disturbances. Black-backed Woodpeckers are uncommon to rare over broad landscapes. The Black Hills population was petitioned for protection as a Distinct Population Segment under the federal Endangered Species Act and a 12-month status review must be completed by 30 September 2017. Current demographic rates for Black-backed Woodpeckers in the Black Hills are available; however, current abundance estimates are contradictory so future population viability cannot confidently be assessed. Therefore, our project objectives are to: 1) determine relationships between environmental and habitat factors and the probability of detection and abundance of Black-backed Woodpeckers, and 2) use this information in a hierarchical model to map density and provide a population estimate of Black-backed Woodpeckers for the Black Hills and Bearlodge Mountains of South Dakota and Wyoming. Once an updated population estimate is attained, it can be used in conjunction with demographic rates to assess future viability of the Black-backed Woodpecker population in the Black Hills.

INTRODUCTION

Natural disturbances have played an important role in shaping landscapes and bird distributions across western North America (Hejl 1992, Hejl 1994). Fire has been a natural disturbance in the Black Hills for thousands of years. Prior to European settlement, fire was the predominant disturbance on the landscape (Gruell 1983) and was considered a keystone ecological process (Brown and Sieg 1996), creating a unique habitat for many plant and animal species. However, for much of the 20th century, fire has largely been suppressed due to potential human conflicts (Long 2012, Nix 2012) and the loss of marketable timber. These changes in the occurrence of natural fire regimes have altered the composition and structure of western forests, resulting in less early successional post-fire habitat, thus affecting bird communities (Hejl 1992, Hejl 1994).

Similar to fire, mountain pine beetle (*Dentroctonus ponderosae*; MPB) infestations are a natural disturbance and are currently a source of large scale disturbance in the Black Hills (Shinneman and Baker 1997). These infestations have resulted in widespread loss of trees in the Black Hills since 1895 (Lessard 1986). Historically, MPB populations occur at endemic levels with periodic outbreaks every 10 years lasting 8-13 years (Lessard 1986, Allen 2005). During MPB outbreaks, the structure, composition, and function of affected stands are significantly altered, with tree mortality reaching 60-90% spanning hundreds of thousands of hectares (Raffa et al. 2008). The habitats created by these disturbances contain temporary food resources which are exploited by organisms for a short time following the disturbance. This means these habitats are ephemeral and requires species that depend on them to constantly move among episodically disturbed habitat patches.

Black-backed Woodpeckers (*Picoides arcticus*) are almost completely restricted to disturbed ephemeral habitats. Black-backed Woodpeckers occupy unburned, late successional forests (Setterington et al. 2000, Tremblay et al. 2009, Mohren et al. in press) in low densities throughout their range, but are strongly associated with burned forests (Bock and Lynch 1970, Hutto 1995, Murphy and Lehnhausen 1998, Hobson and Schieck 1999, Dixon and Saab 2000, Hoyt and Hannon 2002, Nappi et al. 2003, Hanson and North 2008, Hutto 2008, Nappi and Drapeau 2009, Rota et al. 2013, Rota et al. 2014), as well as habitats created by beetle infestations (Goggans et al. 1989, Bonnot et al. 2008, Bonnot et al. 2009, Rota et al. 2013, Rota et al. 2014). These disturbances produce standing dead and dying trees that are important foraging resources due to the abundance of wood-boring (Cerambycidae and Buprestidae) and bark (Scolytidae) beetles, which are the main source of food for Black-backed Woodpeckers (Beal 1911, Bent 1939, Goggans et al. 1989, Murphy and Lehnhausen 1998, Dixon and Saab 2000, Powell et al. 2002).

Black-backed Woodpeckers rapidly colonize these areas due to the large quantity of prey present. However, after 2-3 years, the beetle larvae emerge from host trees and habitat quality declines (Murphy and Lehnhausen 1998, Rota et al. 2014). Bonnot et al. (2009) found that territory selection in the Black Hills by Black-backed Woodpeckers in MPB outbreaks relates more to food availability than nest-site availability. By year four post-disturbance, Black-backed Woodpeckers mostly disappear from these habitats, coinciding with the emergence of the beetles (Harris 1982). Accordingly, Rota et al. (2013) saw a dramatic increase in the home range size of Black-backed Woodpeckers between year two and three post-wildfire habitats, as well as larger

home ranges in MPB infestations compared to early post-wildfire habitats; both are thought to be attributed to the diminishing food resources between years and different habitat types. Due to the ephemeral nature of their preferred habitats, it is thought that Black-backed Woodpeckers rely on a patchwork of recently burned, beetle killed, and undisturbed forests to maintain their population (Hutto 1995, Rota et al. 2014).

Black-backed Woodpeckers have been observed nesting in burned forests as early as 2 weeks after a fire event (Villard and Schieck 1997) and are common to abundant throughout the first 2 years post disturbance (Harris 1982, Murphy and Lehnhausen 1998, Rota et al. 2013). Recent studies have shown high nesting success in recent burns (Saab and Dudley 1998, Dixon and Saab 2000, Saab et al. 2007, Vierling et al. 2008, Nappi and Drapeau 2009, Rota et al. 2014), as well as positive population growth, supporting these areas as population sources for the species (Rota et al. 2014). In the absence of fire, Black-backed Woodpeckers are attracted to beetle-killed forests. However, Black-backed Woodpeckers have lower nest success (Bonnot et al. 2008) and slightly declining population growth in beetle-killed forests in the Black Hills (Rota et al. 2014). Overall, Black-backed Woodpeckers reportedly have lower fledging rates, juvenile survival, and nest success in MPB infestations compared to wildfire habitat (Rota et al. 2014). Despite the negative population growth and lower demographic rates Black-backed Woodpeckers exhibit in MPB infestations, this habitat likely harbors some value to the species and ultimately keeps the population from declining precipitously when fire habitats are unavailable (Rota et al. 2014).

Despite the many benefits burned and beetle-killed forests provide for Black-backed Woodpeckers and other wildlife species, much effort has been put into mitigating and preventing these disturbances. This is largely due to the substantial ecological and economic ramifications of these disturbances, which has resulted in more aggressive timber harvesting and fire suppression (Nappi et al. 2004, Raffa et al. 2008). Post-fire salvage logging and sanitation logging in areas of insect outbreak are commonly used to mitigate the economic losses. However, many studies have reported lower Black-backed Woodpecker abundance in areas where salvage logging has taken place after a disturbance (Saab and Dudley 1998, Morissette et al. 2002, Hutto and Gallo 2006, Saab et al. 2007). For Black-backed Woodpeckers and other wildlife species, their highest occupancy in disturbed habitats is within the first couple of years. Unfortunately, salvage logging must occur shortly after a disturbance if any economic value is to be obtained. This has caused conflict following forest disturbance over which is more important: obtaining the highest economic value out of timber stands or conserving wildlife habitat.

Black-backed Woodpeckers are uncommon to rare over broad landscapes because of their dependence on disturbance, the ephemeral nature of high quality habitat, fire suppression, and salvage logging throughout their range (Saab and Powell 2005). Furthermore, the population of Black-backed Woodpeckers in the Black Hills of South Dakota, where a large portion of this study will take place, may be genetically isolated with little to no interchange between other populations (Pierson et al. 2010). These factors, along with low abundance throughout their range, have caused the US Forest Service to list the Black-backed Woodpecker as a Sensitive Species because population viability is currently a Forest Service Region 2-wide concern (USDA 2005), as a Species of Local Concern due to viability and limited habitat on a local Black Hills basis (Allen et al. 2002) and as a Management Indicator Species to reflect

major BHNF issues and challenges to public land management (USDA 2005). On a state level, Black-backed Woodpeckers are listed as locally rare, vulnerable to extinction, and a Species of Greatest Conservation Concern in the Black Hills ecoregion of South Dakota (SDGFP 2014) and a Species of Greatest Conservation Need in Wyoming (WGFD 2010).

Recently, the Black Hills population of Black-backed Woodpeckers was petitioned for protection as a Distinct Population Segment under the Endangered Species Act (Hanson et al. 2012) and a 12-month status review must be completed by 30 September 2017. The petition for listing the Black-backed Woodpecker in the Black Hills identified a need for more information on their population size in the region. Recent population estimate of Black-backed Woodpeckers in the Black Hills were calculated from density estimates of other areas and were far below the threshold value for an effective population size to ensure population viability (Hanson et al. 2012). Re-analysis of a population estimate by Mohren (2002) suggested approximately 50% more breeding pairs than estimated by Hanson et al. (2012). Current demographic rates for Black-backed Woodpeckers in the Black Hills are available; however, with contradicting abundance estimates future population viability cannot confidently be assessed. Habitat is continuously changing in the Black Hills under all land ownerships. Since the last population estimate in 2000 on Black Hills National Forest, varying levels of disturbance have affected 50-60% of the forest through wildfire and MPB infestation (USDA Forest Service 2014). The extent of change in forest structure combined with relative uncertainty of the population status and trend support the need to develop adequate monitoring techniques and species-specific surveys to obtain a population estimate that is current, reliable, and repeatable.

Therefore, my objectives are to: 1) determine relationships between environmental and habitat factors and the probability of detection and abundance of Black-backed Woodpeckers, and 2) use this information in a hierarchical model to map density and provide a population estimate of Black-backed Woodpeckers for the Black Hills and Bearlodge Mountains of South Dakota and Wyoming. Once an updated population estimate is attained, it can be used in conjunction with demographic rates to assess future viability of the Black-backed Woodpecker population in the Black Hills.

Our study will take place in the Black Hills National Forest (BHNF) and Custer State Park (CSP) located in southwest South Dakota and the Bearlodge and Elk Mountains in northeast Wyoming (Fig. 1). Additionally, we will make every effort to gain access to adjacent private lands to expand our sampling area outside of the BHNF and CSP. At nearly 486,000 ha combined, the BHNF and CSP consist of a variety of forested habitat with prairie habitat adjacent to much of the property boundaries. Elevation in the Black Hills and Bearlodge Mountains ranges from 1065 to 2207 m (Froiland 1990). Climate varies with latitude and increases with elevation, and annual precipitation ranges from 46 to 71 cm (Orr 1959).

The Black Hills and Bearlodge Mountains contain a variety of vegetation including Rocky Mountain coniferous forests predominantly comprised of ponderosa pine (*Pinus ponderosa*) and northern coniferous forests consisting of quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and white spruce (*Picea glauca*), which occur at higher elevations and on northeast slopes (Hoffman and Alexander 1987, Walters et al. 2013). The understory is dominated by western snowberry (*Symphoricarpos occidentalis*), white coralberry

(*S. albus*), juniper (*Juniperus comunis*), and kinnikinnick (*Arctostaphylos uvaursi*) (Hoffman and Alexander 1987, Severson and Thilenius 1976) along with a diversity of native and non-native grasses, sedges and forbs.

Historically natural disturbances, such as frequent fires and beetle infestations, have created a unique habitat in the Black Hills and Bearlodge Mountains. Between 1909 and 2013, wildfires have burned more than 216,000 ha in the BHNF. Wildfires frequent the landscape every couple of years, with several fires often occurring in the same year and individually ranging in size between 5 and 33 ha (USDA Forest Service 2013). Mountain pine beetles are endemic throughout the Black Hills, and there have been many outbreaks during the last century (Allen and Long 2008). The most recent MPB epidemic started in 1996 and has since affected 174,000ha, about a quarter of the Black Hills. Over 38,000 ha of the affected area was infested in the past 4 years; however, recent evidence indicates a decline in the rate of infestation in certain areas. Since the late 1990s approximately 50-60% of the BHNF has been affected by wildfires and beetle infestations (USDA Forest Service 2014).

METHODS

Sampling Design

Due to the widespread and scattered condition of MPB infestation across the landscape and the limited area of recent wildfires in the BHNF, we will use a stratified-random sampling design for our point count surveys to ensure adequate detections of Black-backed Woodpeckers. Our sampling design will be based on a grid of hexagons spread throughout the study area, representing potential point count sites where each side of a hexagon is 250 m, the area is approximately 16 ha, and the center points of adjacent hexagons are approximately 450 m apart (Fig. 2). We will *a priori* classify each hexagon as potential low or high density habitat for Black-backed Woodpeckers based on the proportion of pixels in the hexagon disturbed by MPB or fire.

Color and infrared aerial photography have been used to update the status and extent of the MPB epidemic in the BHNF since 2010. We will obtain the most recent infrared photography available (2013 or 2014) and classify strata representing potentially low to high density habitats for Black-backed Woodpeckers. We will re-sample the aerial photographs to create a 1 m resolution raster and then conduct a supervised classification to classify forested pixels as live trees, dead trees with needles (red tops), and dead trees with no needles (Fig. 3). We will also obtain the wildfire history and prescribed fire GIS coverages for the BHNF, and characterize hexagons based on fire by the percentage of dead tree pixels in each hexagon and year since fire. We will then intersect the hexagon grid with the raster to determine the percent of each hexagon represented by the three classes of trees and hexagons that have had fire within the last 5 years. This will allow us to determine cut points to define hexagons with high disturbance that represent potentially high density habitat.

Starting points for each point count transect will be determined randomly, with 20% of the starting points occurring in potentially low density habitat and 80% representing potentially

high density habitat for Black-backed Woodpeckers. Due to the low detection rates for the species (White and Giroir 2008) we want to increase our detection probability, which we can do by placing more points in areas where they are more likely to occur. Despite potential low detection rates for Black-backed Woodpeckers in low density habitat, it is still important to sample in these areas because the woodpeckers still occupy them. Each start point will be at least 100 m from a road to avoid noise factors associated with roads. After we have randomly selected our starting points, we will select additional points along transects using ArcGIS to maximize sampling efficiency (Fig. 4). Each transect will contain 10 points, because this is the estimated number of points a technician will be able to complete in a sampling day. We also anticipate a total of 65 sampling days in a season. With these estimates, the highest number of points six technicians can complete in a season is 3,900 points (1,300 points repeated three times). If we obtain 100 detections (the number of detections needed to fit the model) of Black-backed Woodpeckers across all three visits in the BHNF, our estimated detection rate would be 0.0256. This detection rate is close to the average detection rate the Rocky Mountain Bird Observatory calculated for Black-backed Woodpeckers when they conducted point counts to monitor the birds of the BHNF between 2001 and 2008 (White and Giroir 2008).

Field Methods

We will conduct point count surveys for Black-backed Woodpeckers in the Black Hills and Bearlodge Mountains of South Dakota and Wyoming from 1 March 2015 through 30 June 2015, and again from 1 March 2016 through 30 June 2016. We will conduct surveys starting at official sunrise and terminating approximately 5 hours later (Mills et al. 2000). We will navigate to and between points with the aid of a Global Positing System (GPS) unit. We will record the point number, observer, Universal Transverse Mercator (UTM) coordinates, visit number, time, date, and weather conditions (temperature, wind speed, cloud cover, and precipitation) for each survey. We will conduct a 5-minute point count and record the time of first detection and distance to the first detection (using a digital laser range finder) of every individual Black-backed Woodpecker heard or seen. After the 5-minute count, we will broadcast a Black-backed Woodpecker drum using a FOXPRO NX3 digital game caller (FOXPRO Inc., Lewistown, Pennsylvania, USA) for 30 seconds, followed by 1.5 minutes of listening and watching, and record any additional detections and response (e.g., drumming, vocalization) to broadcast calls. Broadcast calls have been shown to significantly increase detection probability for this species compared to passive point counts (Siegel et al. 2010, Saracco et al. 2011). Additionally, Black-backed Woodpeckers drum year-round and it is not considered an aggressive social behavior, whereas vocalizations are associated with social interactions or aggression (Dixon and Saab 2000) which would likely draw individuals to the observer. Each point will be visited three times throughout the year to allow for estimates of detection probability. Every sampling session will survey each point before moving onto the second and third sampling sessions.

Weather is variable and can change quickly in the Black Hills; thus, we have developed an inclement weather protocol. Other factors that could influence our ability to detect Black-backed Woodpeckers will be recorded such as noise disturbances (vehicle traffic, logging, excessive animal vocalization), habitat landscape (presence of cliffs), and other observer disturbances (sneezing, coughing, etc.).

We will also characterize vegetation at each point. During the first site visit, we will estimate basal area by species group at each point using a factor 10 prism as a measure of forest structure. During the last site visit, canopy coverage will be estimated at each point using a convex spherical densiometer. Measurements will be taken in each of the cardinal directions and averaged to obtain the percent canopy coverage.

Analytical Methods

Our robust sampling design will allow us to use time-removal, distance sampling, and N-mixture models to estimate density; however, we anticipate using the N-mixture model approach to estimate abundance of Black-backed Woodpeckers (Royle 2004) because it makes best use of multiple visits to a point. Two key assumptions of this model are: 1) there is some number (potentially 0) of individuals occupying each site (N_i), which is governed by the Poisson distribution, and 2) whether an individual is detected or not is a function of species-specific detection probability (p; Donovan and Hines 2007).

The N-mixture models the number of observed individuals, n_{it}, recorded at $i = 1, 2,\ldots, R$ locations during $t = 1, 2,\ldots, T$ sampling occasions. Let n_{it} be the number of distinct individuals counted at location i, in time t. Counts, n_{it}, are binomial random variables with index N_i, representing the actual number of individuals present during the survey, and p, representing the probability of detecting each individual. The likelihood for the data from site i is

$$\mathrm{L}(N_i, p|\{n_{i1}, \ldots, n_{iT}\}) = \prod_{t=1}^{T} \mathrm{Bin}(n_{it}; N_i, p)$$

where $\mathrm{Bin}(n_{it}; N_i, p)$ is the binomial likelihood. By multiplying all the sites binomials you can obtain the combined likelihood from replicated samples at R locations in space. This joint likelihood is modeled as

$$\mathrm{L}(\{N_i\}, p|\{n_{it}\}) = \prod_{i=1}^{R} \{ \prod_{t=1}^{T} \mathrm{Bin}(n_{it}; N_i, p)\}.$$

This model is dependent on the R abundance parameters, $\{N_i : i = 1, 2,\ldots, R\}$, and a detection probability, p. In a survey period, the actual number of individuals, N_i, has a distribution $f(N_i, \theta)$, which can be modeled using the Poisson or negative binomial distribution. This combined likelihood can be expressed as

$$\mathrm{L}(p, \theta|\{n_{it}\}) = \prod_{i=1}^{R} \{ \sum_{N_i = max_t n_{it}}^{\infty} [\prod_{t=1}^{T} \mathrm{Bin}(n_{it}; N_i, p)] f(N_i; \theta)\}$$

where θ is the parameter of $f(N_i, \theta)$ and specifically θ is the mean (e.g. $\theta = \lambda$) of the Poisson distribution (Royle 2004, Donovan and Hines 2007, Joseph et al. 2009).

The detection probability will be dependent on seven covariates. Black-backed Woodpeckers begin cavity excavation in late April, mostly by males (Dixon and Saab 2000), and

the average date of the first egg occurrence in the BHNF was 29 May, with the earliest occurrence on 6 May and the latest on 21 June (Rocky Mountain Research Station, unpubl. data). Both males and females spend time on the nest incubating, resulting in a lower probability of being off the nest as compared to before and after nesting. This may result in lower detection rates for the species during incubation time. Because of this, we will model detection probability as a non-linear function of day of year.

Time of day has also been shown to effect detection of bird species during point counts and, consequently, will be used to model detection. Specifically, Black-backed Woodpecker vocalizations and drumming are most readily heard 0.5 hours after sunrise, with peak detection occurring 1-2 hours later. Vocalization and drumming continue throughout the day but are more variable (Goggans et al. 1989). Weather conditions such as temperature, wind speed, cloud cover, and precipitation will also potentially cause variability in p. It is also assumed that observers will have different experience (i.e., observers who have surveyed Black-backed Woodpeckers vs. those who have not) and abilities (i.e., hearing) resulting in variability in p.

We will model abundance in the N-mixture model using the Poisson distribution, which assumes events occur at random in space. This means the number of individuals inhabiting one site is random and independent of the number of individuals at other sites. This distribution can be expressed as

$$f_x = \frac{e^{-\lambda}\lambda^x}{x!}$$

where λ (or θ in the N-mixture model) is the mean of the Poisson distribution, x is the number of individuals at a given site, and f_x is a generic term for any probability distribution (Royle 2004, Dovonan and Hines 2007).

Covariates that can influence the abundance of Black-backed Woodpeckers will be incorporated in the abundance models using a general linear regression. The covariates we will use to model abundance include: percent of live trees, percent of dying or dead trees with needles still on (red top), percent of dead trees with no needles, year since fire, basal area, and canopy coverage. In addition to modeling detection with the covariates, we will also include a null model to evaluate the improvement in the model with the covariates.

We will fit models that account for detection and abundance covariates in R package "unmarked" (Royle 2004). Candidate models containing covariates for both detection and density will be created and ranked in order of support using Akaike's information criterion adjusted for small sample sizes (AIC_c). The best fit model is characterized by the model with the lowest ΔAIC_c value (Joseph et al. 2009). We will examine model goodness of fit using a K-fold approach or sequentially "leaving one out" approach that examines the correlation between the predicted number of birds and number of birds detected. We will use the best supported density model, or model averaging if appropriate, to predict the number of birds in all hexagons across the Black Hills and Bearlodge Mountains. The sum of the predicted abundance values over all pixels will represent the total population size for Black-backed Woodpeckers and enable us to map density across the Black Hills and Bearlodge Mountains (Sillett et al. 2012).

RESULTS

Data obtained during point counts will be recorded on individual data sheets. All raw data sheets will be duplicated as soon as possible, and copies will be retained with Mark Rumble. Those data sheets will be entered into Excel spreadsheets at the end of each day. Back up files will be stored on Liz Matseur's laptop, a portable hard drive, Mark Rumble's desktop PC, and also the Unit space for RWU-4254 on the O drive.

DISCUSSION

The population estimate from this study will provide important information on the status of Black-backed Woodpeckers in the Black Hills and Bearlodge Mountains, including the BHNF and CSP. We will also extrapolate these estimates to the immediate surrounding area with similar attributes to provide an overall estimate for the Black Hills and Bearlodge Mountains. Our population estimate can be used in conjunction with demographic rates to determine the future viability of the population. An updated population estimate for Black-backed Woodpeckers will assist wildlife management entities with a benchmark for future goal setting and for continued evaluation of impacts of the various disturbance regimes occurring in the Black Hills. Manuscripts resulting from this study will be published in ecological and wildlife management journals. Results will be presented at professional wildlife meetings.

This study will involve travel by vehicle on maintained and primitive roads. Health and safety concerns include driving in mountainous terrain. Also, field technicians will be required to hike through sometimes rugged and forested habitats. Field technicians will be provided with training on defensive driving, driving in winter conditions, and First Aid. Technicians will also require orienteering skills. Field crews will usually be comprised of one person, and a cell phone will be provided to each technician for emergency purposes.

No adverse environmental effects will result from this study. No permanent markers will be placed in the field and no destructive sampling will take place.

The study schedule will be as follows:

Study Plan Development	August-December 2014
Site and Route Identification	January-February 2015
Sampling and Data Collection (first spring)	March-June 2015
Preliminary Data Analysis	Summer-Fall 2015
Sampling and Data Collection (second spring)	March-June 2016
Data Analysis and Thesis Writing	Summer-Fall 2016
Final Thesis and Report Submitted	December 2016

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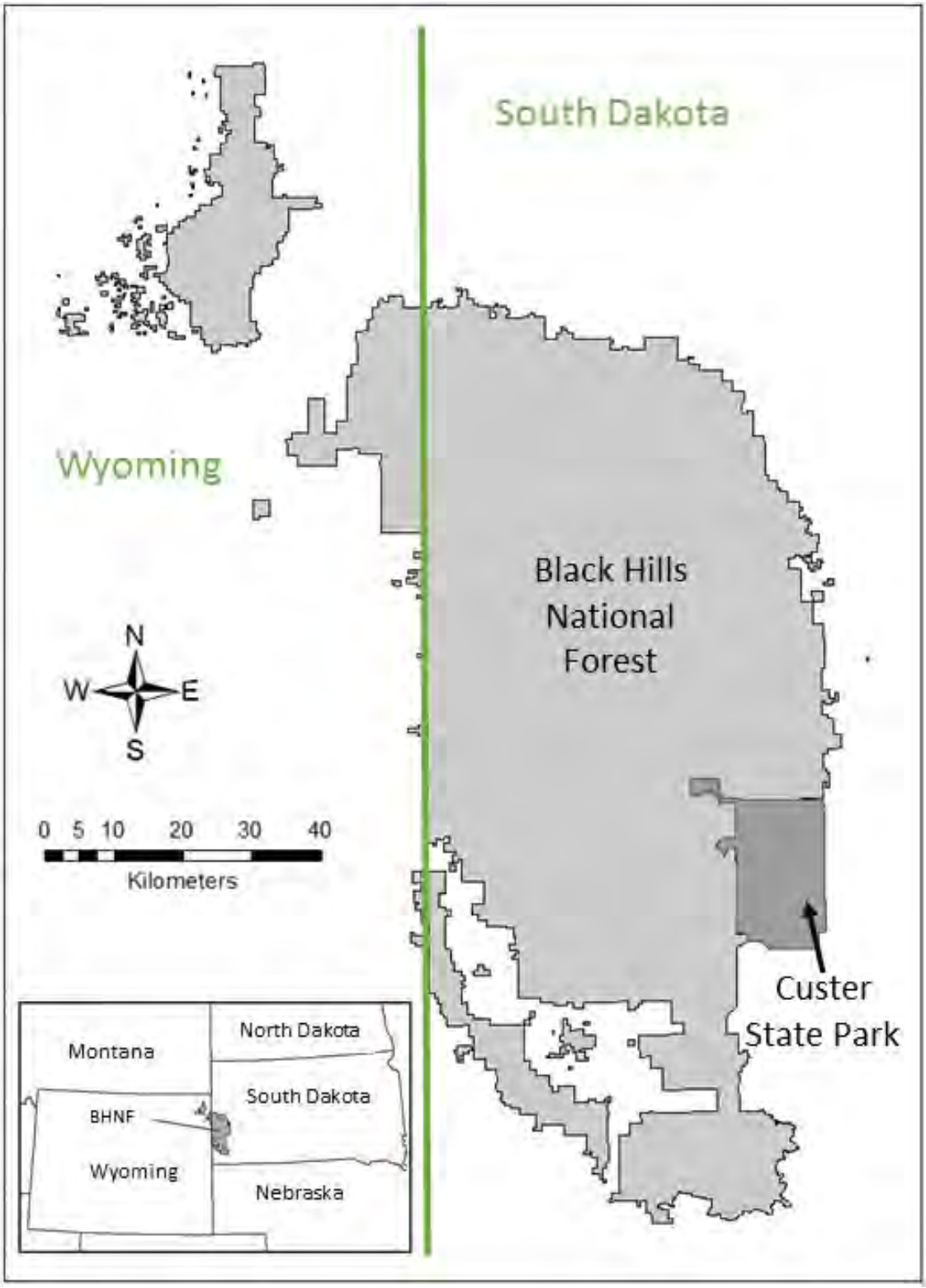

Figure 1. Study Area: Black Hills of South Dakota and Wyoming, and Bearlodge Mountains of Wyoming.

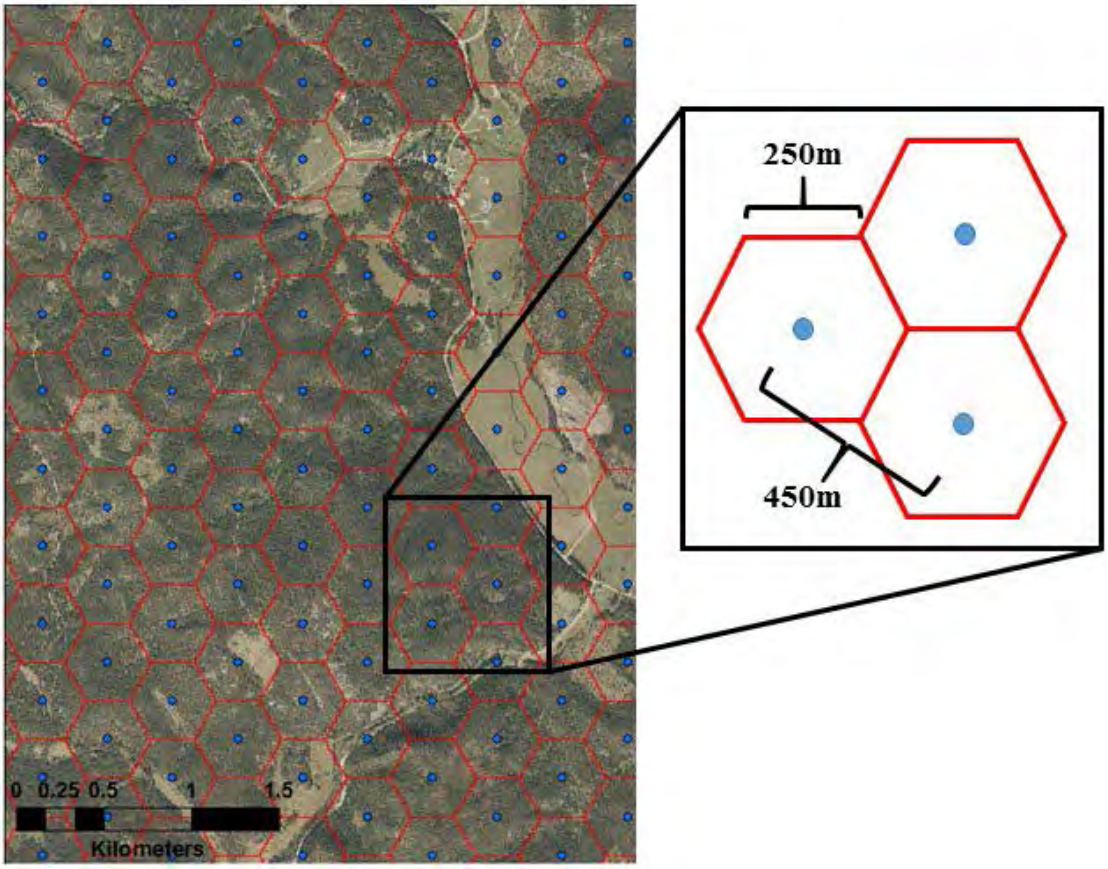

Figure 2. Hexagons outlined in red with the center point in blue (where the point count for that hexagon would take place) laid over part of the Black Hills National Forest landscape.

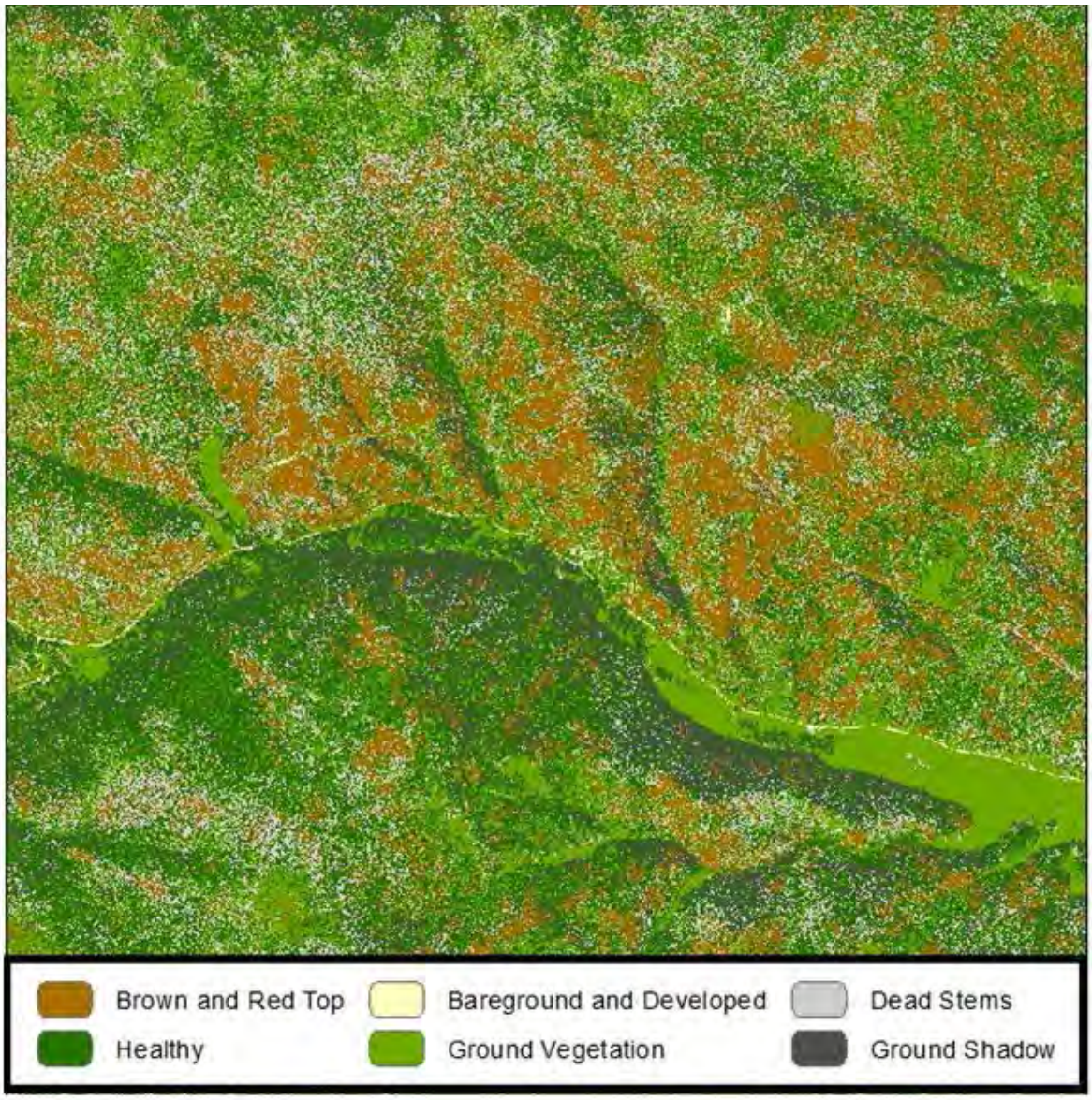

Figure 3. The classification of forested pixels into six categories which will be used to further classify hexagons as potentially low and high density habitat for Black-backed Woodpeckers across the Black Hills and Bearlodge Mountains.

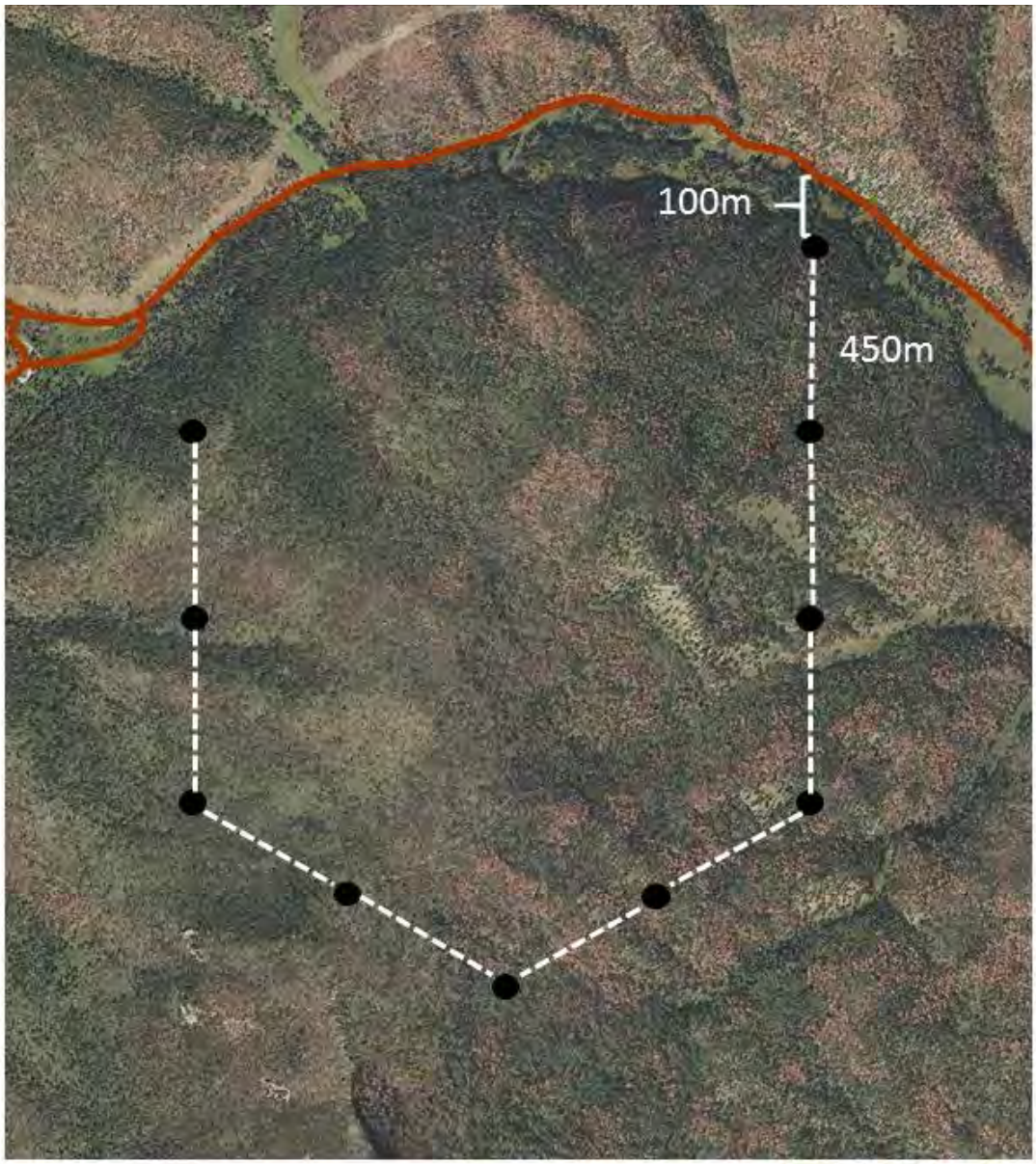

Figure 4. An example of a transect containing a start point at least 100 m from a road and nine additional points spaced 450 m apart, which will be laid out in the Black Hills and Bearlodge Mountains.

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
United States Fish and Wildlife Service State Wildlife Grants

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Bob Oakleaf, Nongame Coordinator (retired)
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 2014, we found 38 of 40 (95%) nesting territories occupied, which fledged 65 young or 1.7 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.

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 the US Fish and Wildlife Service (USFWS), National Park Service, the US Forest Service, Bureau of Land Management, and state wildlife agencies in Idaho and Montana to ensure maximum results to re-establish this species. Peregrine reintroduction and monitoring

efforts are detailed in previous Department Nongame Annual Completion Reports and annual reports completed by The Peregrine Fund, Inc. In 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 USFWS, we monitor a subset of known peregrine nest sites in Wyoming every 3 years using supplemental funding from the USFWS. We have conducted peregrine nest site monitoring in 2003, 2006, 2009, and 2012. We have also monitored nesting performance of peregrines in Wyoming on an annual basis between these USFWS-sponsored surveys. Our objectives in 2014 were to continue annual monitoring of 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 territories 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 territories were automatically selected, and an additional 15 were randomly chosen in an effort to annually monitor ≥30 territories. We included additional territories that we observed as time allowed during travels to selected territories and sites observed by cooperators with interest in specific territories. However, we present data separately for random sites, additional sites, and all monitored sites combined.

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.

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, and by 2014 we have documented at least 120 nesting territories in Wyoming. Results of the USFWS-sponsored surveys we conducted in 2003, 2006, 2009, and 2012 are presented in Table 1. In 2014, we surveyed 29 randomly selected nesting territories to document reproductive performance. Twenty-six (90%) of these

random territories were occupied and fledged 47 young, for an average of 1.8 young per occupied territory (Table 2). We also surveyed for occupancy and production an additional 11 nesting territories in 2014, for a statewide total of 40 territories. Thirty- eight (95%) of these territories were occupied by breeding adults (Table 3). These 38 occupied territories fledged 65 young or 1.7 young per occupied territory. When we added survey data from 2014 to cumulative data collected since 1984, we have monitored ≥1,022 nesting attempts at 95 different territories. These attempts have resulted in ≥1,546 young and a mean of 1.5 young fledged per nesting attempt.

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.

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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, 2005-2014. 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
2014	29	26	21 (81)	47	1.8
Mean	27.9	26.9	17.3 (69.2)	39.5	1.6
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
2014	40	38 (95)	29 (76)	65	1.7
Mean	48.3	46.1 (95)	35.3 (77)	77	1.7
SD	10.9	11.8	10.8 (9.8)	24.3	0.20

SPECIES OF GREATEST CONSERVATION NEED – MAMMALS

INVENTORY OF BATS ASSOCIATED WITH CLIFF AND CANYON HABITATS OF EASTERN 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 2014 – 30 June 2016

PERIOD COVERED: 15 April 2014 – 27 February 2015

PREPARED BY: Leah Yandow, Nongame Biologist
Laura Beard, Nongame Biologist

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 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 for, 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 30 grids. We captured 595 individuals, with 42% being female and 12.6% being juvenile. Approximately 42% of captured bats were reproductive, with nearly equal numbers of reproductive males and females. Using acoustic survey equipment, we detected most species of bats that we captured. The most commonly captured species was the little brown myotis (*Myotis lucifugus*) followed by the big brown bat (*Eptesicus fuscus*), which together made up over half of the captures. The most commonly detected species using acoustic detectors were the silver-haired bat (*Lasionycteris noctivagans*), western small-footed myotis (*M. ciliolabrum*), and little brown myotis, which were also among the most frequently captured species. We occasionally detected some species that we did not capture at the site, such as the pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and spotted bat (*Euderma maculatum*). 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 inventory will be used to update current databases and provide informed assessments

on species status, as well as facilitate and prioritize management in response to large-scale disturbances.

INTRODUCTION

With >1,250 species, 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 and 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 desctructans*. 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 News 2013). 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 alternate 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 has led to recent petitions to list two species of bats that are residents in Wyoming for additional protection under the Endangered Species Act. On April 2nd, the northern long-eared bat was listed as threatened under the ESA (USFWS 2015). 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, 13 of which are considered Species of Greatest Conservation Need in the eastern half of the state (Orabona et al. 2012). All of these bats either primarily use cliff and canyon habitats for activities such as roosting, foraging, hibernating, and rearing offspring or occasionally utilize resources within those habitats. 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 2014 field season was to use mist nets and acoustic detectors to collect data on distribution, reproductive status, and diversity of bats that occurred in cliff and canyon habitats in eastern Wyoming. We have completed the first year of the 2-year inventory and we report results here from that survey effort.

METHODS

Survey sites were selected differently in this inventory than in the western cliff and canyon bat inventory due to differences in characteristics of available habitat, our inability to accurately and remotely model potential habitat, and logistical challenges with access to private lands. In previous survey years, desired attributes were mapped, the bat grid was laid over this map, and grids with suitable habitat were randomly selected for trapping. In the eastern half of Wyoming, there is less public land and fewer rocky features on the landscape. The model used in the western part of the state failed to produce many trappable sites, and we were forced to rely on ground-truthing to find survey sites. We selected netting and acoustic survey sites by choosing areas that: 1) were 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, flyways), 3) were among or adjacent to cliff or canyon habitat, and 4) were suitable for setting up mist nets and/or acoustic detectors.

In an effort to be consistent with past surveys, we mapped the sites we chose in the field and overlaid the 100 km^2 grid used in previous years (the bat survey grid) onto it. In most grids, we trapped only one site, which is consistent with previous bat surveys. We surveyed at 30 sites, representing 28 grids. Grids were grouped into degrees of Latitude and Longitude (latilong degrees) for entry into the *Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming* (Orabona et al. 2012).

At each site, we used a combination of mist nets (Avinet, Inc., Dryden, NY) and an acoustic detector (Song Meter SM2BAT, Wildlife Acoustics, Inc., Concord, MA) to maximize the likelihood of detecting a species at a survey site. Occasionally we chose two sites to survey, one using mist netting protocol and the other using the acoustic detector. This decision was based on local characteristics and a desire to sample as much good bat habitat within an area as possible. In one grid, we completed two nights of mist netting and one purely acoustic survey.

These three nights of data were combined to supply the biodiversity information for that grid, and in all cases data from both methods within a grid were combined to gain information about bats that occurred within that grid. In two instances, we performed acoustic surveys only because of local site characteristics and weather that were unsuitable for netting.

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

Capture Surveys

We used mist nets to capture bats and investigate bat activity, diversity, reproductive status, and morphology. We chose mist net configurations to optimize capture potential using a net set of single high (2.6 m) or triple high (7.8 m) with varying lengths (2.6, 6, 9, 12, or 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. We opened the mist nets no more than 30 min after sunset 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 descended and swollen. We classified each bat as adult or juvenile by illuminating the wing and examining the epiphyseal plates for ossification. We also measured forearm length and ear length, and determined wing damage score according to Reichard and Kunz (2009). We followed the WNS protocol according to the National White-Nose Syndrome Decontamination Protocol - Version 06.25.2012 (whitenosesyndrome.org 2013) and decontaminated equipment at the end of each survey.

To summarize the capture data, we counted the number of captures for each site and estimated the number of net meter hours by multiplying the length of nets used during a survey by the number of survey hours. We estimated captures per unit effort for each grid by dividing the number of captures by net meter hours multiplied by 100 to provide an index of bat activity. We also counted species diversity for each grid.

Acoustic Surveys

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. Acoustic equipment was most often placed adjacent to our netting site. The microphone was positioned 2-3 m above the ground pointing skyward between 45-65°C depending on terrain and potential flight path of bats. We programmed detectors to start recording at sunset and record for 4 hrs.

For the acoustic analysis, we used Sonobat Batch Attributer utility to attribute metadata to the existing call files and remove 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, little brown, and 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 three similar 40 kHz species, we classified calls to the frequency group, "40 kHz bats". We also counted the number of classified files per survey hour as an index of activity and number of species detected for species diversity.

RESULTS

For 2014, we surveyed sites located within the eastern part of Wyoming which included the 15 counties on the eastern side of the state (Fig. 1). A majority of sites were within 1 km of cliff and canyon habitat. About two-thirds of the survey sites were comprised of xeric shrubland, sagebrush, or mixed-grass prairie habitats. The other third of sites were located within woodland or pine dominated habitat. Mean (± SE) elevation of sites we surveyed was 1,804 m (± 9 m).

Capture Surveys

We primarily netted over open water, including riparian, ephemeral and permanent streams and rivers, reservoirs, and small ponds, as well as one cave. Sites we surveyed covered as much of eastern Wyoming (i.e., spatial variation) and as much ecological diversity as possible. For all 28 grids that we mist netted in 2014, we captured 595 bats that represented 10 different species (Table 1; Fig. 2). We used a mean of 116.5 net meters (± 11.0 m) per survey with a mean survey length of 3.0 hrs (± 0.03 hrs). The mean number of individuals captured per survey night was 21.2 (± 4.0; range = 1-70; Fig. 2). Morphometric measurements for 99% of captures were within the range of historical measurements for Wyoming (Table 2). In instances of extremely high capture rate, we identified bats to species, checked for wing damage, noted sex and reproductive status, and released them. In the interest of safety to the bats, we did not take the time to record morphometric measurements. This was the case for 145 captured bats. The little brown myotis (34%) was the most commonly captured species, followed by big brown bat (*Eptesicus fuscus*; 23%), and the silver-haired bat (*Lasionycteris noctivagans*; 15%). The remaining species each comprised <10% of all captures and included the long-legged myotis (*M. volans*), western small-footed bat (*M. ciliolabrum*), long-eared myotis (*M. evotis*), hoary bat (*Lasiurus cinerus*), eastern red bat (*L. borealis*), pallid bat (*Antrozous pallidus*), and Townsend's

big-eared bat (*Corynorhinus townsendii*). Figures 5-15 show locations of captures for each species.

A total of 42% of captured bats were female, 56.3% were male, and sex could not be determined for 1.7% (Table 3). Adults comprised 83.7% of all captures, while 13% were identified as juveniles, and the remaining 3.5% were released without determining age (Table 3). Approximately 56% of captured female bats were reproductive and 33% of captured males were reproductive. In 3.4% of captures reproductive status was not determined (Table 3). There was occasional notable wing or tail membrane damage, which most often consisted of pin holes and old scarring. However, 79% of bats had no notable physical damage. We failed to detect evidence of damage from WNS; therefore, all bats received a score of 0.

Captures per unit of effort as well as the diversity of species captured per survey were highest in the Guernsey area followed by the Casper area (Figs. 2 and 3). Overall species diversity was highest in the Seminoe Mountains and the eastern portion of the Laramie Range, as well as the Guernsey area. Captures contributed to several updates in the Department's *Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming* (Orabona et al. 2012; Table 4).

Acoustic Surveys

We placed one detector at each survey site for a total of 30 acoustic survey nights, with mean 4.1 (± 0.0 hrs) per survey night (Fig. 1). The detectors recorded a total 13,676 files and we classified 3,296 files to species. We classified 6 files as "40 kHz bats". Additionally, we aurally detected three spotted bats, which is the only bat with a frequency low enough for the human ear to detect. Detections included 10 resident and 1 peripheral species across all grids. We had a total of 3,305 bat acoustic detections in 2014 (Table 1).

The silver-haired bat (31%) was the most frequently detected species followed by the western small-footed myotis (19%), the little brown myotis (18%) and the big brown bat (16%). All other species, long-legged myotis, long-eared myotis, hoary bat, eastern red bat, pallid bat, and Townsend's big-eared bat, each comprised <10% of the detections. Figures 5-15 show locations of where we detected each species with acoustic equipment. The highest diversity of species was detected in the Guernsey area and the southern portion of the Bighorn Mountain Range, which is consistent with the capture data. Acoustic detections contributed to one update in the Department's *Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming* (Orabona et al. 2012; Table 6).

DISCUSSION

During the first year of this 2-year inventory project, we successfully detected 10 species classified as residents, 9 of which are SGCN, that occur in eastern Wyoming. By targeting cliff and canyon habitats in the eastern portion of the state, we were able to collect information about species that were underrepresented in previous inventory efforts (e.g., forest bat inventory 2008-2011, cliff and canyon bat inventory of western Wyoming). The cliff and canyon inventory will be the single largest survey effort for bats in this habitat type in eastern Wyoming and, upon

completion, 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 2012*a*, 2012*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 cliff and canyon specialists, notably the pallid bat, spotted bat, and Townsend's big-eared bat, at some of our sites. Consistent with the western cliff and canyon bat inventory, cliff and canyon specialists were lacking at many sites we surveyed, despite our expectations of suitable habitat. Cliff and canyon specialists are difficult to detect and are likely more rare on the landscape than other more commonly captured bats.

The overall quantity of bats that we captured was significantly higher (>100 individuals greater) than any other single inventory year. The high number of captures and acoustic detections speaks to the importance of low elevation, arid regions of the state where bats of many species are abundant. We most frequently captured little brown bats and big brown bats, which have consistently been two of the most frequently captured species throughout the state, on multiple inventory efforts. These two species are habitat generalists utilizing trees, rock crevices, cliffs, canyons, and anthropogenic structures for roosting and foraging habitat. At most sites surveyed in 2014, we detected tree-roosting species that are primarily associated with forest habitats: silver-haired bats and hoary bats. For these tree-roosting species, cliff and canyon habitats may provide a buffer against developed and unsuitable habitats. For example, cliff and canyon habitats 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 habitats, they may use such habitats to move between their preferred areas. Our results, therefore, emphasize the importance of cliff and canyon habitats for a broad suite of species that includes, but is not limited to, cliff and canyon specialists.

Sexual segregation along an elevational gradient during the reproductive season is common for bats (McGuire and Boyle 2013). Females require warm roosts to minimize energy expenditure and maximize reproductive success and survival of juveniles, often at lower elevations. Males are more opportunistic in their selection of roosting sites and can utilize higher elevations during summer months. The higher number of males than females captured at our sites was somewhat surprising because our sites were generally at lower elevations for the elevations of eastern Wyoming. We also captured the highest percentage of juvenile bats of any inventory effort, indicating reproductive success of maternity colonies. Proximity to local roosting sites can have a substantial impact on the apparent demographics of captured bats (e.g., one net placed directly adjacent to a bachelor colony catches 20 adult males and a net 10 m away catches no bats). Given the overall high capture rate and number of reproductive adults, these sites appear to be important broadly across demographics: reproductive and non-reproductive males, females, and juveniles. In addition to proximity to local roosting sites, differences in availability of prey and environmental conditions likely 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. 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, though 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. Analysis error in the call analysis software is a potential source of some of the discrepancy between captures and acoustic detections. As acoustic technology continues to advance, analyses will become more refined and accurate in coming years. In spite of this drawback, we believe that by combining acoustic and capture techniques our methods enable us to maximize the detections of species within a survey grid.

We have made considerable progress toward improving our understanding of the status and distributions of bat species associated with cliff and canyon habitats in eastern 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. Next year, we will continue efforts in cliff and canyon habitats in eastern Wyoming, and we 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 2014 survey (June-August). Status of residency for bats are represented with the following abbreviations: 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 habitats (Adams 2003). Native Species Status (NSS) 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 (common name)	Resident status	Cliff and canyon assoc.	Native Species Status	Captures	Acoustic detections
Antrozous pallidus (Pallid bat)	R	S	NSS3	1	2
Corynorhinus townsendii (Townsend's big-eared bat)	R	S	NSS2	3	3
Eptesicus fuscus (Big brown bat)	R	G	NSS4	134	526
Euderma maculatum (Spotted bat)	R	S	NSS3	0	3
Lasionycteris noctivagans (Silver-haired bat)	R	N	NSS4	88	1038
Lasiurus cinereus (Hoary bat)	R	N	NSS4	32	147
Myotis ciliolabrum (Western small-footed myotis)	R	S	NSS4	41	639
Lasiurus borealis (Eastern red bat)	P	N	NSSU	6	0
Myotis evotis (Long-eared myotis)	R	G	NSS3	31	298
Myotis lucifugus (Little brown myotis)	R	G	NSS4	203	613
Myotis septentrionalis (Northern myotis)	R	G	NSS3	0	0
Myotis thysanodes (Fringed myotis)	R	G	NSS3	0	0
Myotis volans (Long-legged myotis)	R	G	NSS3	56	30
Myotis californicus (California myotis)	P	G	-	0	0
Myotis yumanensis (Yuma myotis)	P	G	-	0	0
Tadarida brasiliensis (Brazilian free-tailed bat)	P	G	-	0	0
Nyctinomops macrotis (Big free-tailed bat)	A	G	-	0	0
Perimyotis subflavus (American perimyotis)[1]	A	G	-	0	0

[1] American perimyotis is also known as the tri-colored bat.

Table 2. Mean and standard error (SE) of measurements taken from individual bats captured in eastern Wyoming, June-August 2014. 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	55.30	0.00	1	29.00	0.00	1	28.00	0.00	1
Corynorhinus townsendii	45.20	0.25	3	33.00	0.58	3	11.00	1.15	3
Eptesicus fuscus	45.54	0.23	84	14.10	0.11	84	17.51	0.35	80
Lasiurus borealis	39.80	0.59	5	10.20	0.20	5	14.40	1.08	5
Lasiurus cinereus	52.74	0.83	29	14.66	0.20	29	24.69	0.53	29
Lasionycteris noctivagans	41.35	0.31	67	12.42	0.11	67	10.94	0.24	67
Myotis ciliolabrum	32.73	0.14	39	12.35	0.11	39	5.10	0.27	39
Myotis evotis	38.60	0.22	28	19.59	0.18	28	6.76	0.18	29
Myotis lucifugus	37.63	0.08	129	12.24	0.11	128	7.20	0.10	132
Myotis volans	39.10	0.16	56	11.62	0.09	55	8.61	0.21	54

Table 3. Population parameters for bats captured in eastern Wyoming, June-August 2014. 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	1	0	0	1	0	0	0	1	0
Corynorhinus townsendii	2	1	0	3	0	0	1	2	0
Eptesicus fuscus	34	98	2	117	14	3	31	100	3
Euderma maculatum	0	0	0	0	0	0	0	0	0
Lasiurus borealis	4	1	1	5	0	1	5	0	1
Lasiurus cinereus	8	22	2	26	4	2	25	5	2
Lasionycteris noctivagans	34	54	0	56	32	0	67	21	0
Myotis ciliolabrum	23	17	1	37	3	1	21	19	1
Myotis evotis	16	13	2	27	2	2	18	11	2
Myotis lucifugus	94	107	2	173	17	12	125	67	11
Myotis volans	34	22	0	53	3	0	32	24	0
Total 2014	250	335	10	498	75	21	325	250	20

Table 4. Updates to the *Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming* (Orabona et al. 2012) from surveys in eastern Wyoming, June-August 2014. 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	21	O	B
Corynorhinus townsendii	19	O	B
Eptesicus fuscus	12	h	O
Lasiurus cinereus	12	__	O
	18	a	O
	20, 21	O	B
Lasiurus borealis	20	h	O
Lasionycteris noctivagans	18	a	O
	19	O	B
Myotis ciliolabrum	19, 20	O	B
Myotis evotis	11	__	a
	18, 21	O	B
	27	a	B
Myotis lucifugus	18, 19	O	B
Myotis volans	11	b	B
	18, 19	O	B

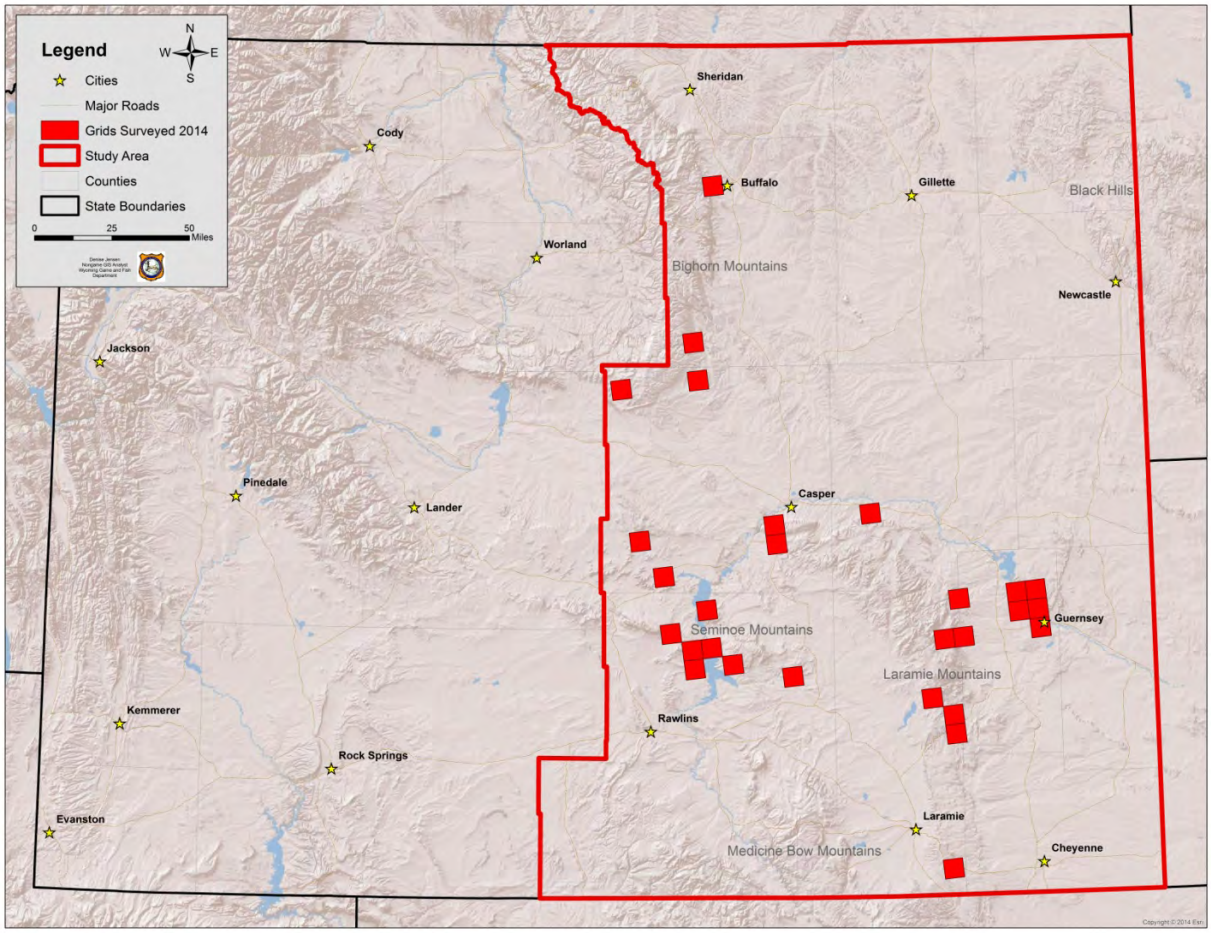

Figure 1. Study area and location of grids we surveyed for bats associated with cliff and canyon habitats in eastern Wyoming, June-August 2014.

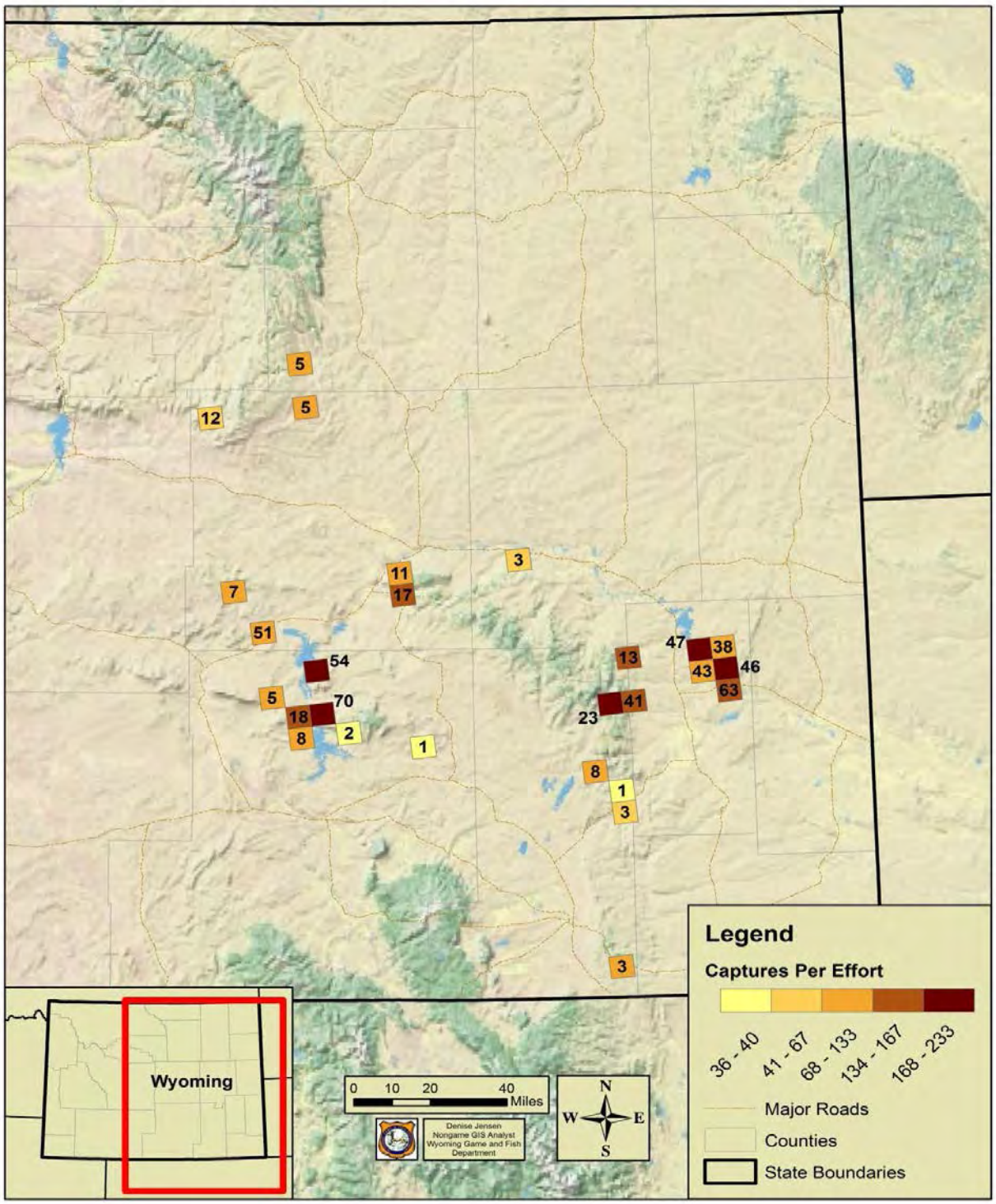

Figure 2. Location of grids we surveyed throughout eastern Wyoming, June-August 2014. We present both captures per unit effort and individuals captured. Colors correspond to captures per unit effort. Labels show the number of individuals we captured per grid.

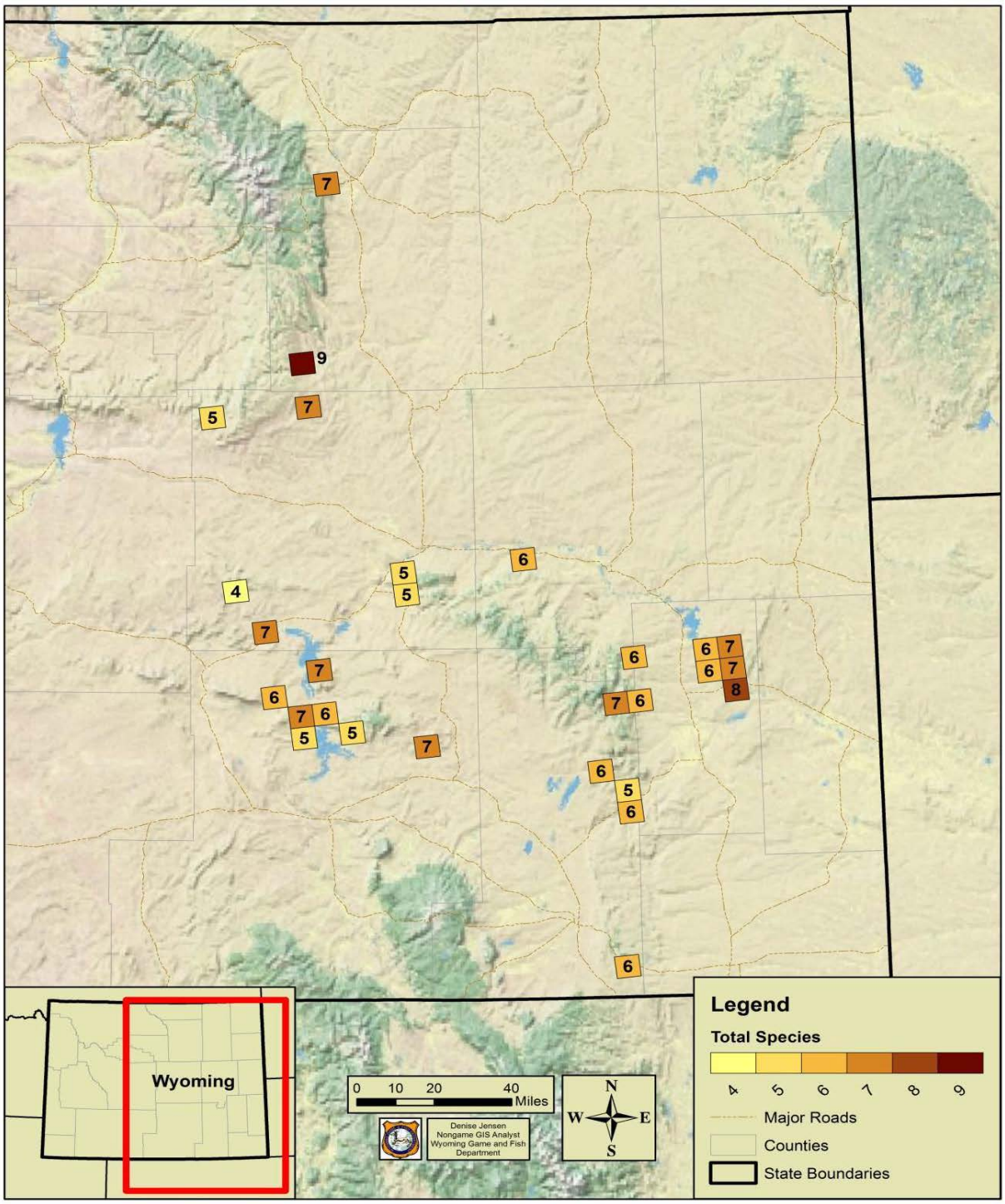

Figure 3. Location of grids we surveyed throughout eastern Wyoming, June-August 2014. Colors correspond to the number of species of bats we detected (acoustic and captures) within each grid that we surveyed.

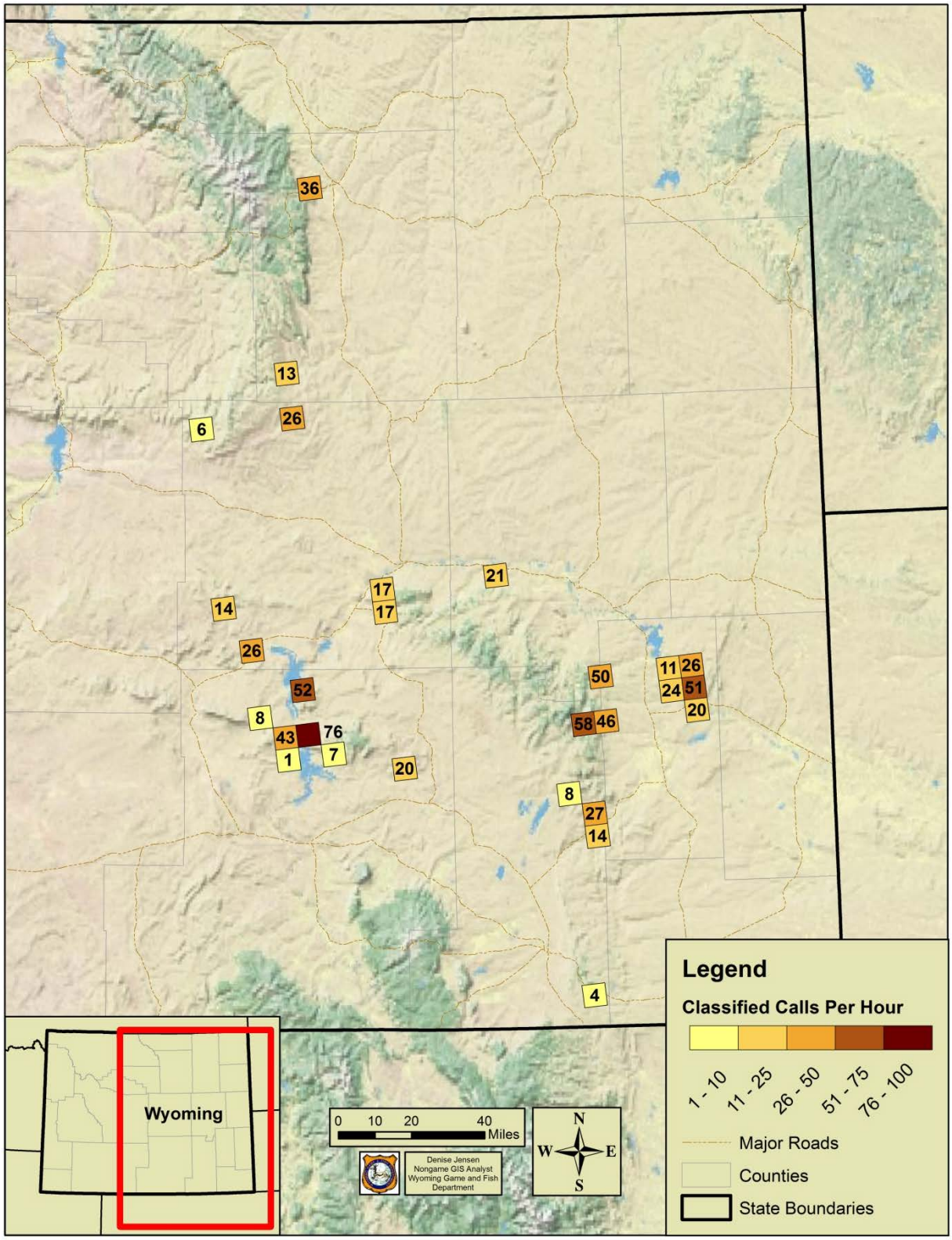

Figure 4. Location of grids we surveyed throughout eastern Wyoming, June-August 2014. Colors and labels correspond to classified calls per hr for each grid.

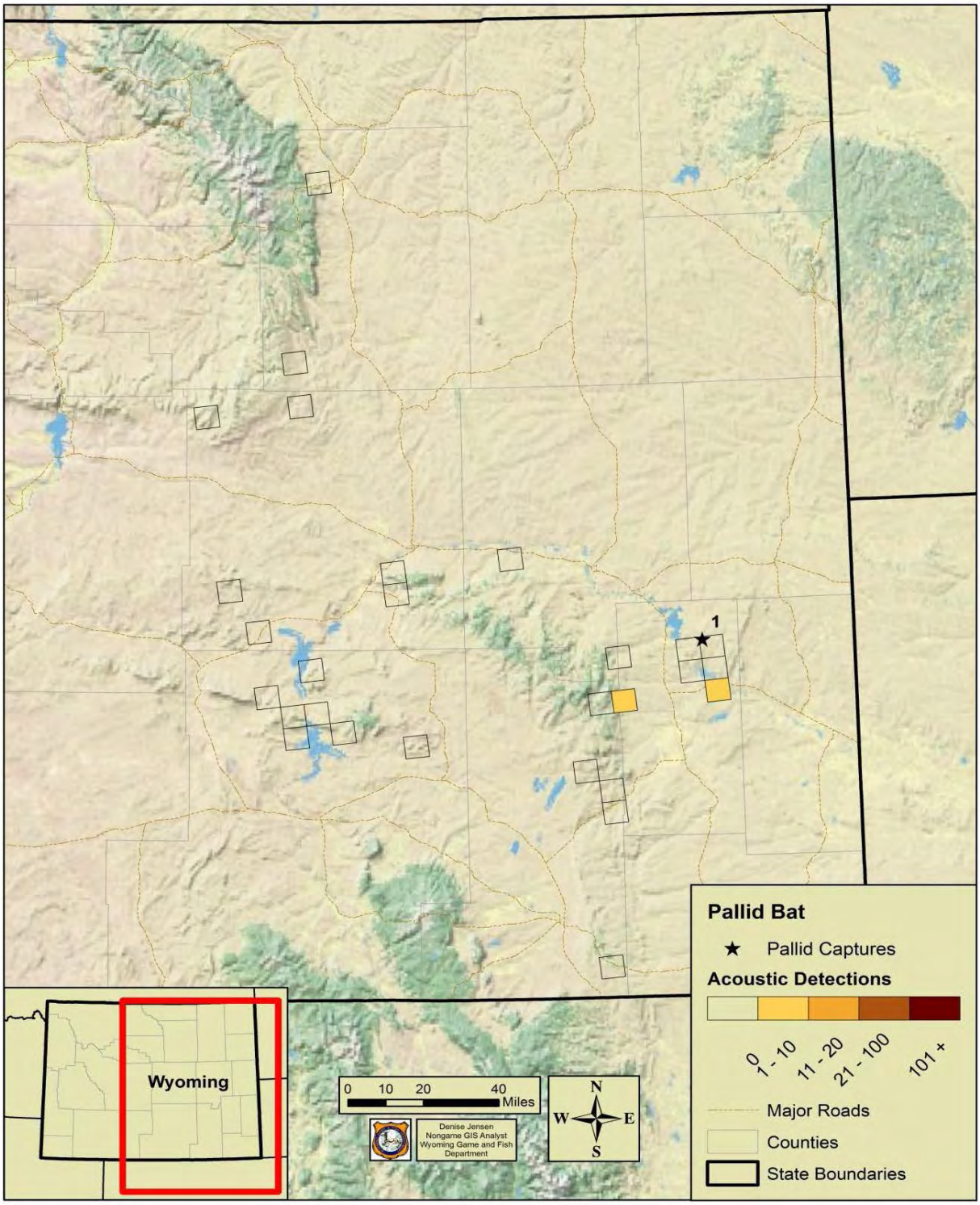

Figure 5. Locations where we captured and detected pallid bats (*Antrozous pallidus*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

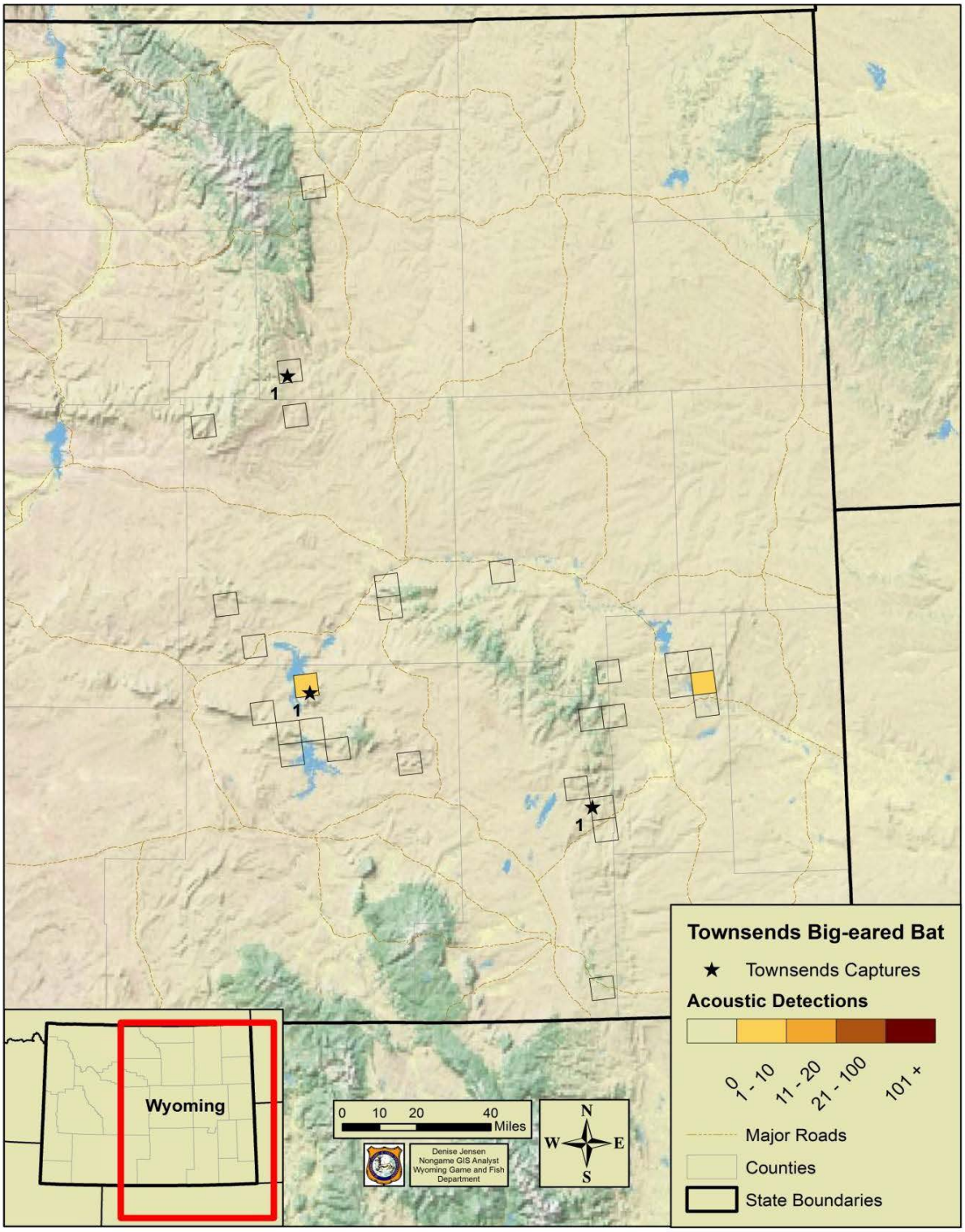

Figure 6. Locations where we captured and detected Townsend's big-eared bat (*Corynorhinus townsendii*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

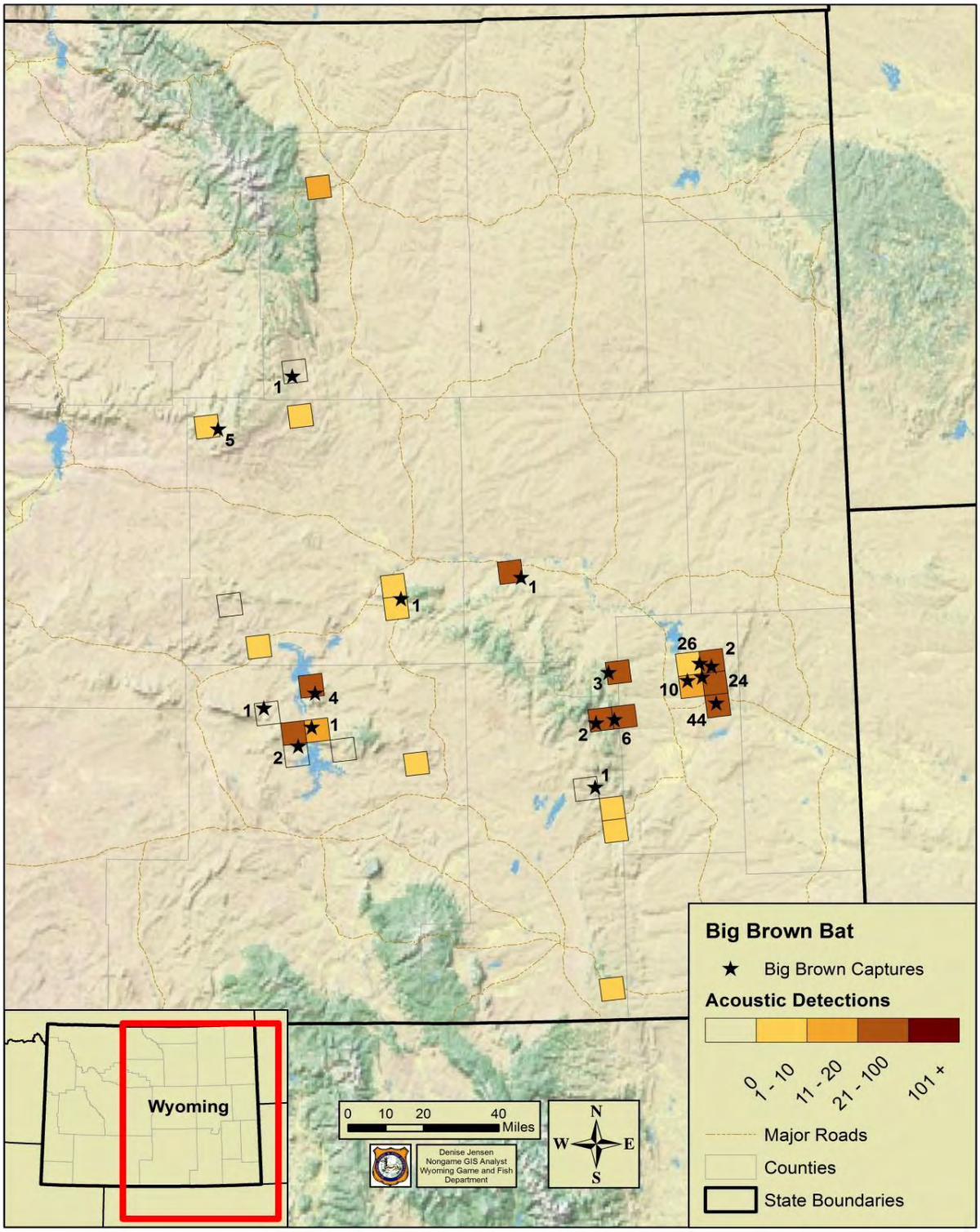

Figure 7. Locations where we captured and detected big brown bats (*Eptesicus fuscus*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

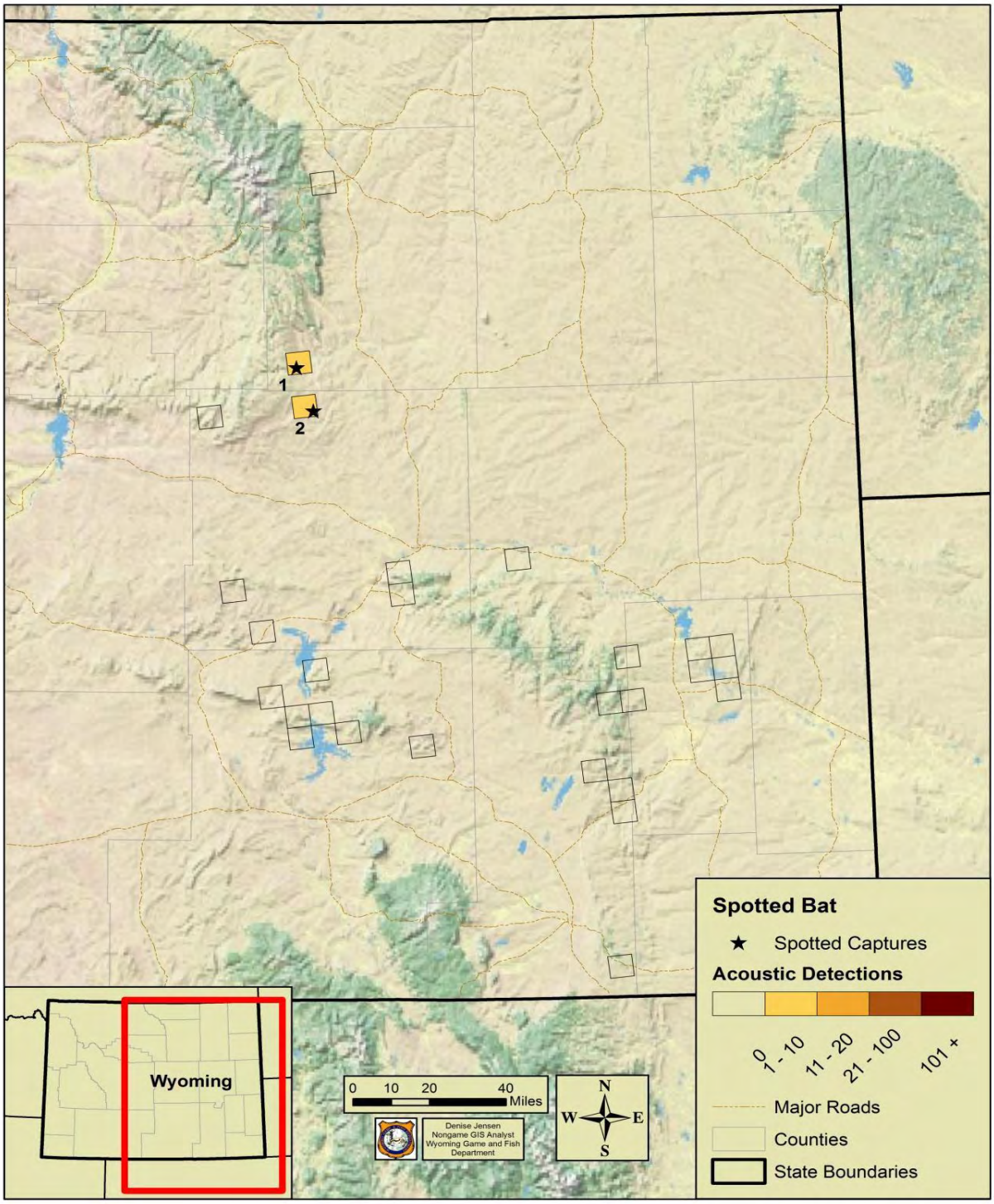

Figure 8. Locations where we detected spotted bats (*Euderma maculatum*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of acoustic detections including classified call files and aural detections of this species.

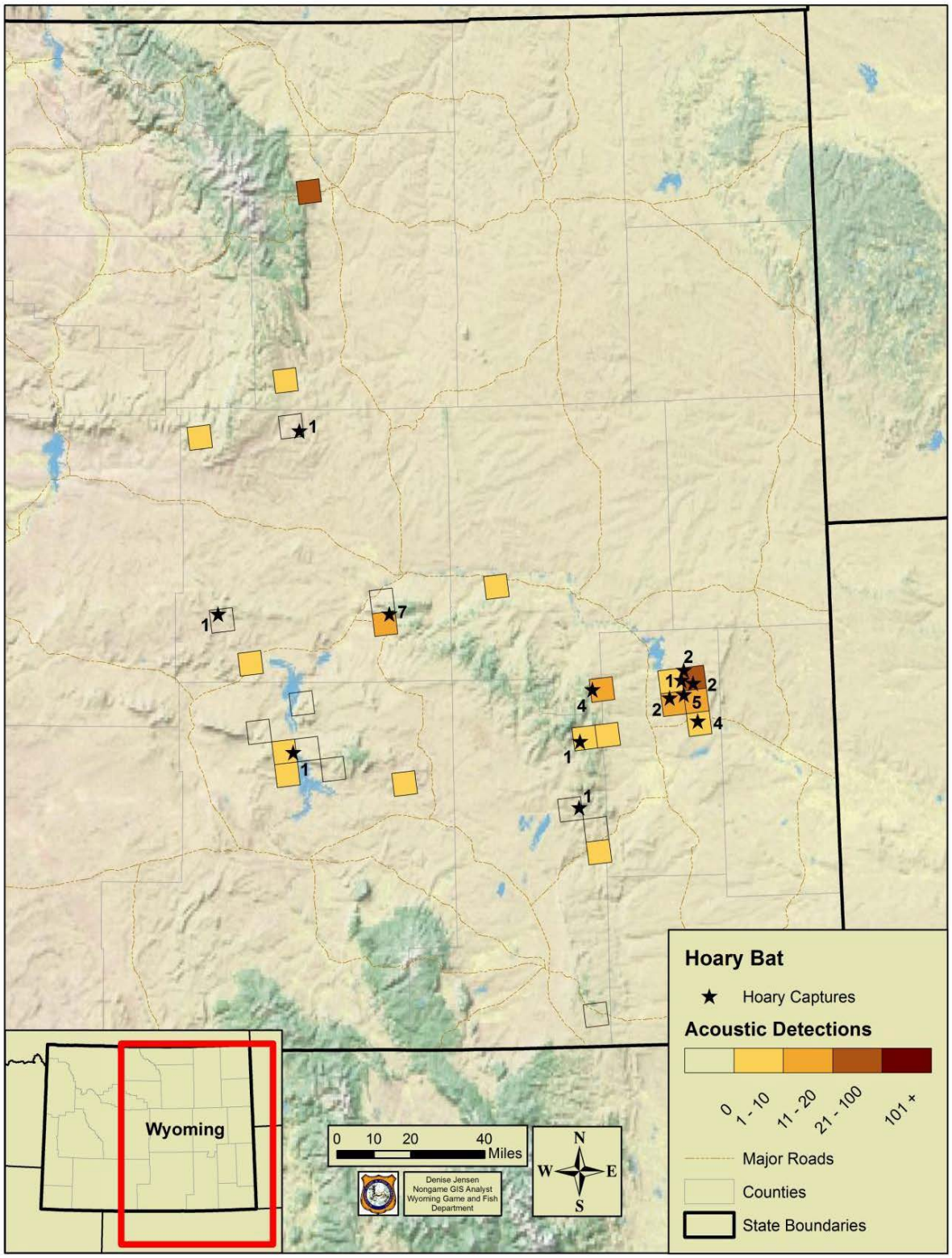

Figure 9. Locations where we captured and detected hoary bats (*Lasiurus cinereus*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

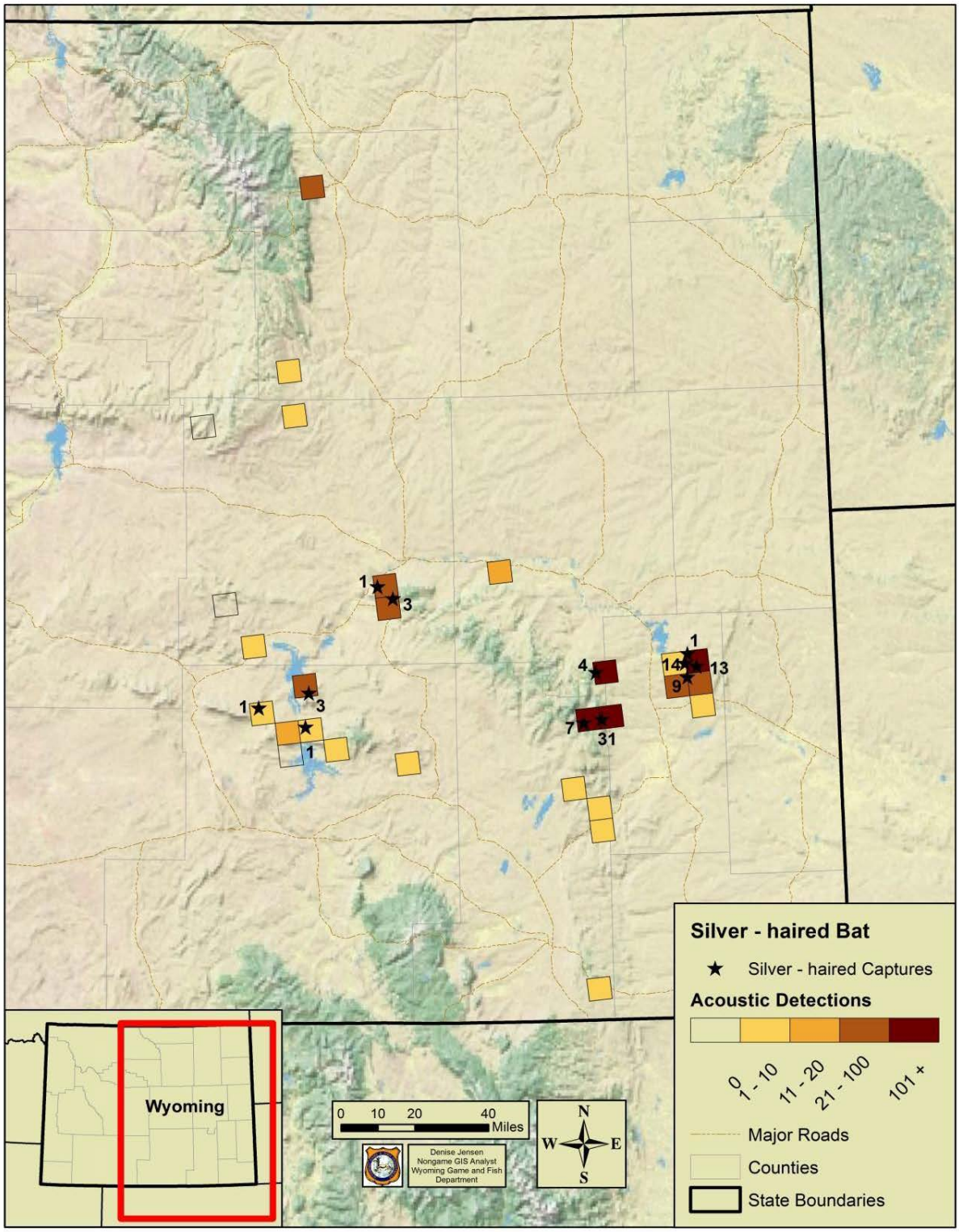

Figure 10. Locations where we captured and detected silver-haired bats (*Lasionycteris noctivagans*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

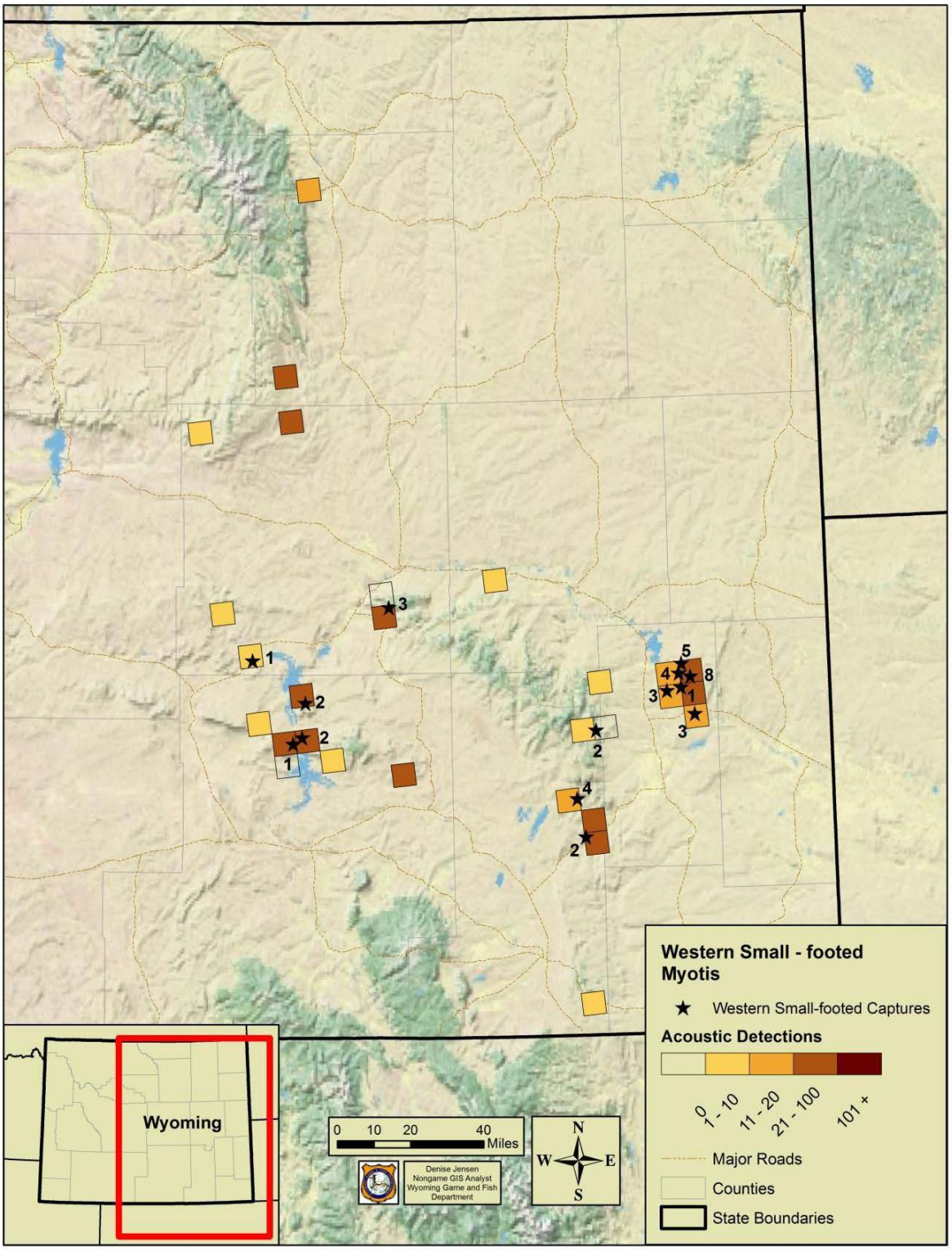

Figure 11. Locations where we captured and detected western small-footed myotis (*Myotis ciliolabrum*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

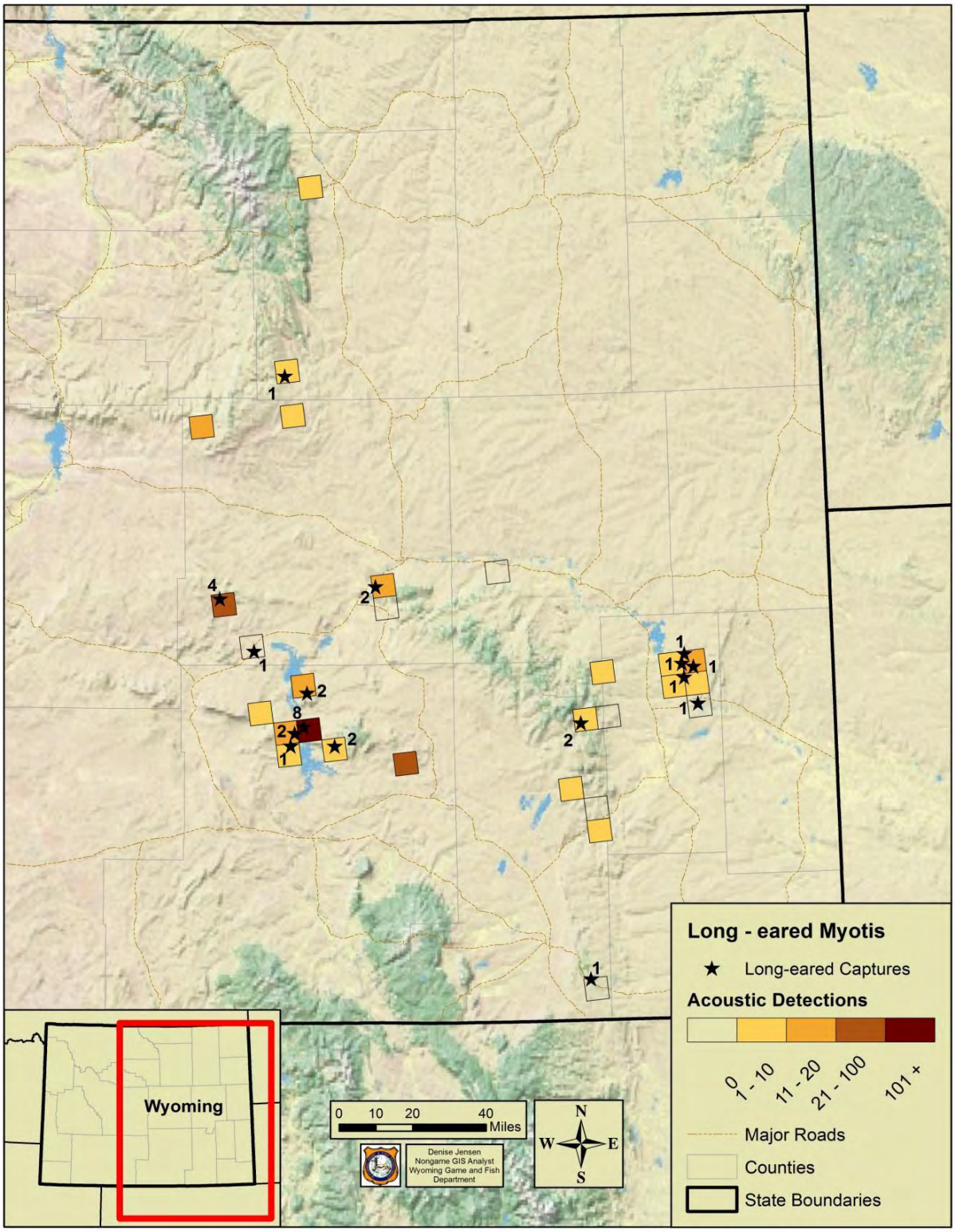

Figure 12. Locations where we captured and detected long-eared myotis (*Myotis evotis*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

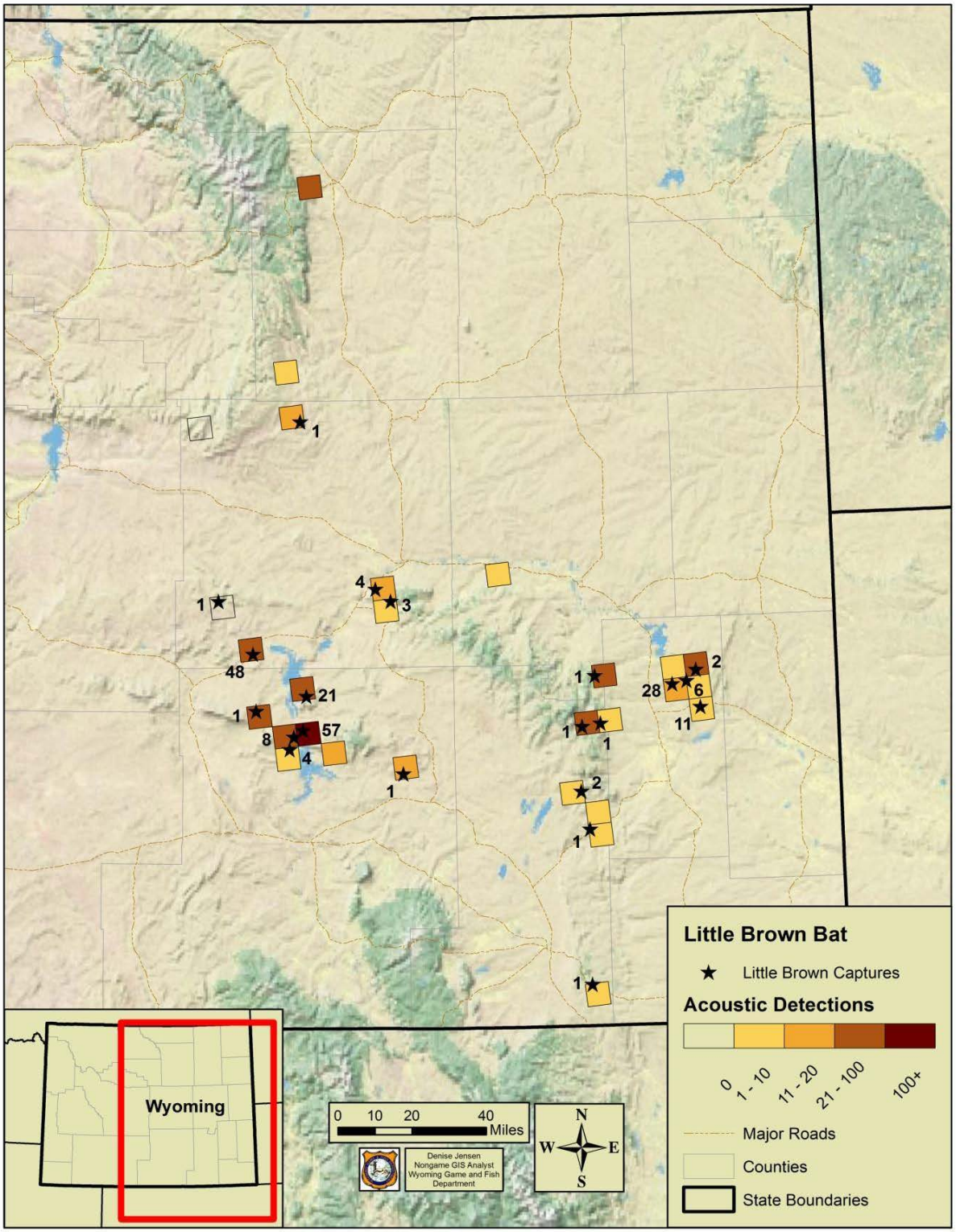

Figure 13. Locations where we captured and detected little brown myotis (*Myotis lucifugus*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

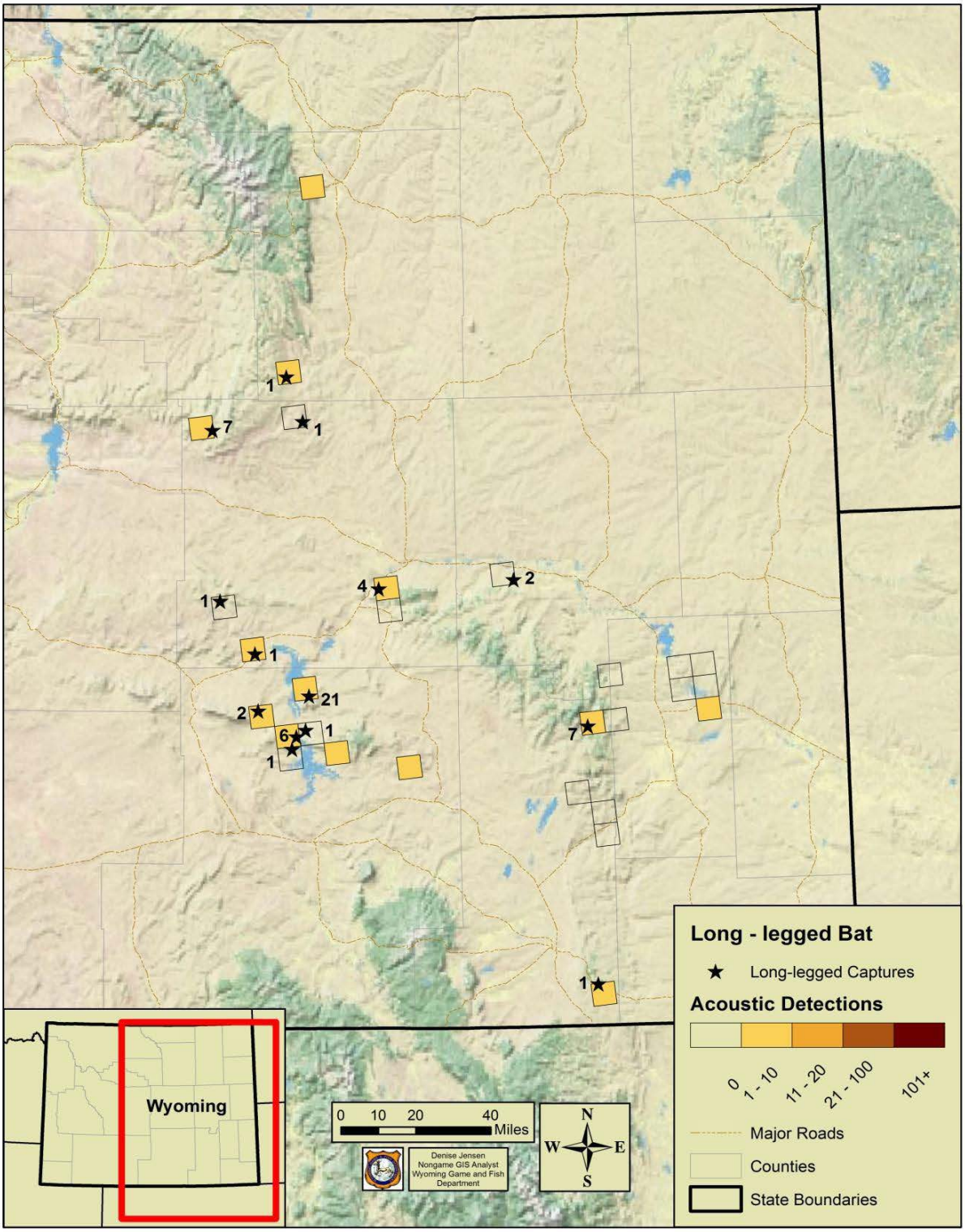

Figure 14. Locations where we captured and detected long-legged myotis (*Myotis volans*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

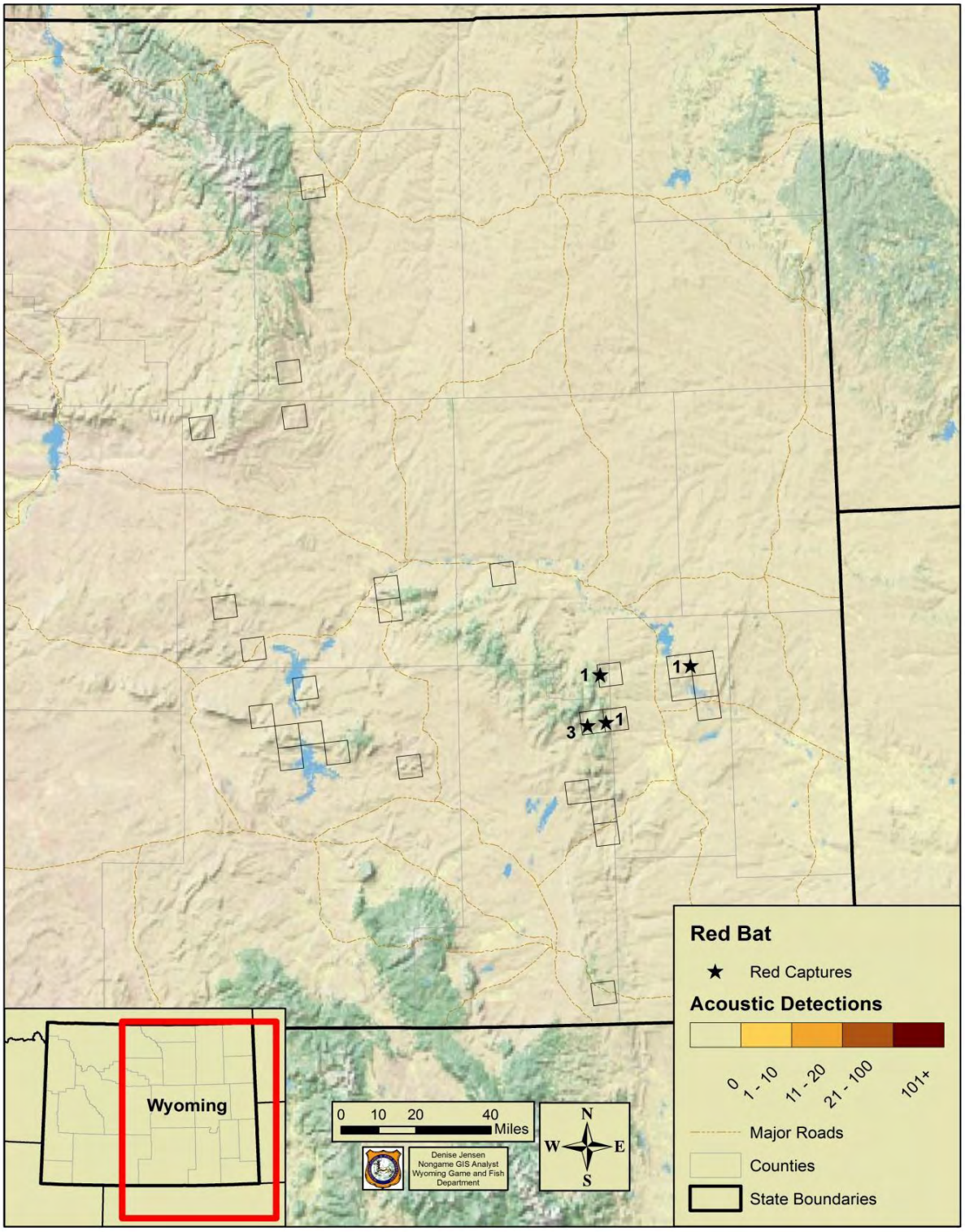

Figure 15. Locations where we captured and detected eastern red bat (*Lasiurus borealis*) for each survey grid in eastern Wyoming, June-August 2014. Stars within each grid represent netting locations and corresponding labels refer to the number of captured individuals for this species. Color of each grid corresponds to the number of classified call files for this species.

SURVEILLANCE OF HIBERNATING BATS AND ENVIRONMENTAL CONDITIONS AT CAVES AND ABANDONED MINES IN 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: Annual

PERIOD COVERED: 15 April 2013 – 10 March 2015

PREPARED BY: Laura Beard, Nongame Biologist

ABSTRACT

Wyoming bat species that hibernate in caves and abandoned mines are at risk of contracting white-nose syndrome if the causative fungus, *Pseudogymnoascus destructans*, continues spreading west. Three species of bats found in Wyoming are known to be particularly vulnerable to white-nose syndrome in their eastern range, including the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*Myotis septentrionalis*), and American perimyotis (*Perimyotis subflavus*), also commonly known as the tri-colored bat. Populations of bats in caves and abandoned mines of Wyoming are orders of magnitude smaller than those in eastern North America, making it difficult to determine if white-nose syndrome will affect populations at the same scale should it be introduced in the west. Conditions for optimal growth of *P. destructans* are specific, and environmental conditions of caves and abandoned mines in Wyoming are largely unknown. Data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming are limited; this project represents the first effort to monitor conditions inside caves over time. Our objective for this project is to understand the environmental conditions inside hibernacula used by bats in Wyoming; we are especially interested in myotis hibernacula and caves at increased risk for *P. destructans* introduction. Another important objective is to census hibernating bats present at each site. We successfully monitored 7 sites. At each site the environment in the hibernation zone was more stable than the exterior environment. At six sites, we observed hibernating bats, including Townsend's big-eared bats (*Corynorhinus townsendii*), big brown bats (*Eptesicus fuscus*), western small-footed myotis (*M. ciliolabrum*), little brown myotis, and long-eared myotis (*M. evotis*). Our final objective is to monitor for the potential arrival of the fungus in Wyoming. In 2014 and 2015, we participated in a national effort to identify *P. destructans* infected sites. None of our sites tested positive for the fungus.

INTRODUCTION

Bats that hibernate in caves and abandoned mines in North America are at risk of contracting white-nose syndrome (WNS), a disease that is causing major declines in bat populations in the eastern United States and Canadian provinces. WNS is named after a conspicuous white fungus, *Pseudogymnoascus destructans,* which infects the skin of hibernating bats, causing increased energy use and prematurely depleted fat stores (Verant et al. 2014). Death due to *P. destructans* infection results from a cascade of physiological disturbances, beginning with increased energy use and changes in blood chemistry; leading to increased water, electrolyte, and fat reserve loss; and ultimately resulting in death (Verant et al. 2014). WNS and *P. destructans* has been confirmed in 25 states and 5 Canadian provinces, and may continue spreading west (Coleman et al. 2014).

Species found in Wyoming that are known to be vulnerable to WNS are the little brown myotis (*Myotis lucifugus)*, American perimyotis (*Perimyotis subflavus),* formerly the eastern pipistrelle or tri-colored bat (*Pipustrellus subflavus)*, northern long-eared myotis (*Myotis septentrionalis*), and big brown bat (*Eptesicus fuscus*) (Coleman et al. 2014). Virginia Big Eared Bats (*Corynorhinus townsendii virginianus)*, a close relative of Townsend's big eared bats (*Corynorhinus townsendii)*, are known to carry the fungus while exhibiting no ill effects (Coleman et al. 2014). In Wyoming, Townsend's big-eared bats have often been observed sharing hibernacula with little brown and western small-footed myotis, making them a possible vector of infection for vulnerable species. Northern long-eared myotis and American perimyotis are rare in Wyoming; however, the little brown myotis is widespread and is the most commonly captured and reported bat species in the state (Abel and Grenier, 2012a, 2012b). It is unknown how WNS will affect the rest of Wyoming's bat species. Some western species of myotis are considered analogous to an eastern species, such as the long-eared myotis (*myotis evotis)* to the Northern long-eared myotis, with the important difference being that the western bats consistently roost in much smaller numbers than their eastern counterparts (Knudsen et al. 2013). This pattern holds true for the eastern and western populations of little brown myotis, as well. For example, there are 88 known little brown myotis roosts in Wyoming; however, survey data suggest the majority support <50 individuals. Since roosts in Wyoming commonly support populations of bats that are orders of magnitude smaller than populations found in roosts of eastern North America, it is unknown whether WNS will similarly impact populations of bats in Wyoming should it spread west.

Conditions for optimal growth of *P. destructans* include cool temperatures (12.5-15.8^{o} C) and high humidity, though the total growth range of the fungus is larger, between 1 and 19° C (Flory et al. 2012, Coleman et al. 2014). If the fungus is introduced in Wyoming, habitats in caves and abandoned mines must provide suitable conditions that would support and promote the growth of *P. destructans* in order for it to become established. There is limited historic data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming. All data prior to this project are from single surveys and were taken from interior locations not adjacent to the surfaces where bats roost during hibernation. Thus, our understanding of how these parameters vary inter- and intra-seasonally and reflect the environment experienced by hibernating bats has been limited. It has been hypothesized that caves and abandoned mines in

Wyoming may be cooler and dryer than those in eastern North America and, because of this, may not be favorable for optimal growth of *P. destructans.* However, *P. destructans* has been shown to survive in suboptimal conditions and could become established in western states. Hoyt et al. (2015) show the ability of the fungus to survive as viable spores for years in dry conditions such as those found on some cave floors. The primary goal of this project is to assess whether suitable conditions for *P. destructans* exist within caves and abandoned mines in Wyoming. The secondary goal of this study is to census hibernating bats present at each site. The final goal is to collect samples from caves and mines in Wyoming to monitor for the presence of *P. destructans* in the state.

METHODS

We selected sites that we considered were at risk for contracting *P. destructans* due to human and bat visitation. While selecting sites, we considered historical use by hibernating bats, recreational pressure, and whether the roost was gated (Truex, personal communication). We chose to survey roosts that had not been surveyed in the last 3 or more years in an attempt to minimize disturbance to bats and their environment. Within each site, we deployed iButton devices (DS1923-F5, Maxim Integrated, San Jose, CA; data loggers). Each iButton (data logger) was placed in an iButton key ring (DS9093A+, Maxim Integrated, San Jose, CA) before being deployed. We installed data loggers at seven sites in 2012 and one additional site in 2013 (Fig. 1). Data loggers were collected every 12-18 months from each site, and at least once since deployment. Data loggers were replaced and are still in operation at seven sites. At the remaining site (143), equipment was stolen and not replaced.

Each data logger was numbered uniquely with a three digit numerical code (ID no.). Data loggers were programmed to record temperature and humidity once every 3-6 hrs. When a data logger was deployed, we recorded the ID no., description of location, name of the chamber or passage, and the method we used to attach the data logger. Additionally, we measured the temperature and humidity at each location using a pocket weather station (Kestrel 3500, Kestrel Meters, Birmingham, MI). Data loggers were placed inside the entrance and at one to two locations exterior to the site. We then deployed data loggers throughout the cave, within hibernation zones when possible. At some sites, hibernation zones were unknown at the time of data logger deployment and identified on a return visit during the hibernation season. Hibernation zones were identified as the area from where the first bat was seen during any hibernation survey, to the last bat during any hibernation survey. We adhered to all WNS survey and decontamination protocols outlined in the National White-Nose Syndrome Decontamination Protocol (USFWS 2011). In three caves where data loggers were deployed, hibernation counts were repeated in 2015 (Sites 71, 91, and 40). At sites visited during the hibernation season, we counted individual bats and attempted to identify each bat to species.

Starting in 2014, we began participating in the US Fish and Wildlife Service (USFWS) WNS surveillance program, using hibernation surveys to collect samples to be tested for the presence of *P. destructans*. Five sites (Sites 71, 407, 133, 121, and 40) were tested for the presence of *P. destructans* by swabbing hibernating bats, cave walls, and the cave floor (USGS

National Wildlife Health Center 2013). These samples were sent to National Wildlife Health Center for PCR analysis.

RESULTS

In general, these data provide a multi seasonal picture of the environment in each cave, though the monitoring period at each site varies. Hibernation counts were similar to previous surveys in both numbers of bats and species recorded. The exception is that no big brown bats were recorded during the project, though some caves have historic records of this species being present in low numbers (one to three individuals). We have included all known recorded species for each site. Species counts for the latest hibernation survey are found in Table 1.

Site 71 is a moderately popular recreational cave. While it has a gate, it has not been reliably locked during the hibernation season. Site 71 is a hibernacula for little brown bats, western small-footed myotis, long-eared myotis, and Townsend's big-eared bat. Exterior data loggers experienced a wide range of temperature and humidity (Table 2; Figs. 2 and 3). Though some data were lost because of stolen or malfunctioning data loggers, two data loggers placed within hibernation zones successfully recorded temperature and humidity data for approximately 5 months during the winter of 2012-2013. The data for these months show an environment that is warmer and more humid than the exterior environment (Table 2; Figs. 2 and 3). Temperatures within the cave fluctuated little over the 5-month period (Table 2, Fig. 2). The data show that the cave is more stable further from the entrance (Table 2; Figs. 2 and 3). Unfortunately, in this cave surviving data loggers were adjacent to Townsend's big-eared bats exclusively. The two data loggers placed in the chamber where myotis species have been found malfunctioned; therefore, no data have yet been gathered on hibernation conditions for myotis at this site. Little brown myotis, western small-footed myotis, long-eared myotis, and Townsend's big-eared bats were swabbed for *P. destructans* in 2015, and environmental samples were taken. Swabs from site 71 were found to be negative for the fungus.

Site 407 has no gate. As three data loggers were stolen from the cave's interior, it experiences at least some recreational use. It is primarily documented as a Townsend's big-eared bat hibernacula, though big brown bats and western small-footed myotis have been recorded hibernating in this cave as well. The single data logger retrieved from the interior of this site shows a stable, humid environment that is close to the average temperature of the cave's exterior (Table 3; Figs. 4 and 5). The interior data logger was retrieved from a chamber where western small-footed myotis were observed hibernating. Site 407 was swabbed for the presence of *P. destructans;* results from these swabs were negative, though only environmental samples were taken.

Site 133 has no gate. It is located on private land and visited with permission of the landowner. The interior of this site is known to be used by the landowner and guests. Little brown myotis, western small-footed myotis, big brown bats, and Townsend's big-eared bats have been found hibernating at this site. Data loggers located within the hibernation zone show an environment that is more stable, more humid, and slightly cooler than outside conditions throughout the two years this site was monitored (Table 4; Figs. 6,7). Site 133 was swabbed for

the presence of *P. destructans*; samples included two swabs from western small-footed myotis, and the samples from the cave were negative for the fungus.

Site 91 has a gate that remains locked year round, though it was previously well known and used by the public. The gate remains locked due to public safety and vandalism concerns. Data from the hibernation zone of this cave shows an environment that is more stable and humid than the exterior environment, as well as slightly cooler during the time monitored (Table 5; Figs. 8 and 9). Small numbers of Townsend's big-eared bats and big brown bats have been found hibernating at this site.

Site 392 has some recreational use, though access is difficult during the hibernation season. It has no gate. Data collected over one year at this site shows a hibernation zone that is more stable than the outside environment, though this site shows far more variation in humidity than the previous four sites (Table 6; Figs. 10, 11). Humidity at this site is only slightly higher than the outside environment, and may reflect greater airflow. Another possible reason for similar humidity could be data logger placement. Data loggers were located on walls rather than ceilings. Temperature is significantly more stable in the hibernation zone than the outside environment (Table 6, Fig. 10). Townsend's big-eared bats and western small-footed myotis have been found hibernating at this site.

Site 121 has a gate that is closed year round, though the public is allowed limited access. Data collected over 16 months show that the temperature of the hibernation zone is similar to the exterior temperature on average, but significantly more stable (Table 7, Fig. 12). This cave was slightly more humid than the outside environment during the time recorded. Internal humidity seems to be less stable in this site than at any of the other caves, though it is somewhat more stable than the external environment (Table 7, Fig. 13). This site was not surveyed for hibernating bats during the project, but Townsend's big-eared bats are historically the only species known to hibernate at this site.

Site 40 is a publically well known recreational cave; however, it is very difficult to access during most of the hibernation season. A permit is legally required to enter the cave; however, no physical barrier exists to prevent entrance to the hibernation zone. Approximately 20 feet before the interior limit of the hibernation zone, a gate has been installed to prevent vandalism to the extensive cave system. This gate is always locked, but a key may be loaned to experienced cavers. In the most recent survey, only two bats where found roosting beyond the gate. Data collected over nearly two years at this site show that temperatures in the hibernation zone are similar to the outside environment on average, but the range covered is much smaller within the hibernation zone (Table 8, Fig. 14). Data loggers at site 40 recorded the only sub-zero temperatures within the hibernation zone of any site studied. It should be noted that data loggers at this site were significantly lower in the cave than roosting bats in most cases, being placed on the walls 1.5-3 meters above the ground. Bats were observed roosting on the ceiling 3-12 meters above the cave floor. However, the "before crawl" data logger is both central to the hibernation zone and closer to the level of roosting bats, as the ceiling in this part of the cave descends to 3-4.5 meters above the cave floor and the data logger is place around 2.5 meters above the cave floor. The "before crawl" data logger never recorded a temperature below freezing (Table 8). The humidity within the hibernation zone at this site varied less than the outside environment,

but was similar (Table 8, Fig. 15). This site is primarily a Townsend's big-eared bat hibernation site; however, small numbers of long-eared and western small-footed myotis were observed roosting here. This cave was sampled for *P. destructans*; most samples were environmental, however three Townsend's big-eared bats were low enough to be swabbed, as well. The site tested negative for the fungus.

DISCUSSION

Though there are variations between caves, temperature and humidity data for each cave consistently show that a stable, humid environment exists in the cave's interior. In many cases, data loggers placed in cave interiors recorded relative humidity (RH) over 100% for long periods of time. This is most likely due to a saturation error that occurs when the equipment is exposed to humidity greater than 95% for a prolonged period of time (Maxium Integrated 2015). Thus, humidity readings above 100% can be concluded to be between 100% and 95%. Because of this saturation error, any average humidity calculations are biased. The range of humidity found in hibernation zones was 22.22-100% (recorded RH as high as 118.56%, a result of the saturation error), with average humidity at all sites ranging from 58.45-100%. With a range of 2.18-8.59^{o} C, average temperatures in the observed hibernation zone for all sites are lower than the optimal range for *P. destructans*. The total range of temperature in hibernation zones is much larger, (-9.01 – 17.09^{o} C), with a large portion of that range falling within the optimal growth range for the fungus. Thus, in light of recent findings on the persistence of *P. destructans* under various conditions, as well as our own data regarding the conditions in Wyoming's hibernacula, we cannot conclude that environmental conditions are unsuitable for growth and persistence of the fungus. Only one site (71) monitored during this project has a record of Myotis species roosting in clusters and in relatively high numbers, and no data were collected in the part of the hibernacula where myotis have been observed roosting. More work is needed to determine the conditions present in Wyoming's Myotis hibernacula.

Five caves were tested for *P. destructans*. In two caves (Sites 407 and 121), only environmental samples were taken; in the remaining three caves (Sites 71, 133, and 40) bats were swabbed, as well. Though environmental samples are not thought to be as good for early detection of *P. destructans* as samples from bats (A. Ballman, personal communication), the negative results from all five sites are encouraging. The failure to find big brown bats at the four sites where they have been previously found, while interesting, does not indicate a large die off, as the original numbers were extremely low. The negative *Pd* test results in addition to the lack of any abnormal mortalities of hibernating bats reported in the state supports the national surveillance team's assertion that Wyoming is still free of WNS (Coleman et al. 2104).

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Table 1. Species observed and results of *P. destructans* test during the most recent hibernacula survey at the seven sites monitored. COTO = Townsend's big-eared bat; MYCI = western small-footed myotis; MYLU = little brown myotis; MYEV = long-eared myotis; MYSP = unidentified myotis.

ID	Date	Species observed (individuals present)	*P. destructans* PCR results
121	3/18/2004	COTO (8)	Negative
392	3/25/2014	COTO (2), MYCI (1)	Not tested
407	4/4/2014	COTO (2), MYCI (2)	Negative
133	4/15/2014	COTO (5), MYCI (4), MYSP (9)	Negative
91	1/7/2015	COTO (3)	Not tested
71	1/15/2015	COTO (11), MYCI (15), MYLU (6), MYEV (12), MYSP (24)	Negative
40	1/29/2015	COTO (47), MYCI (2), MYEV(2)	Negative

Table 2. Conditions at Site 71 at two exterior and three interior locations from 8/27/2012 to 2/8/2013. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and range of temperature and humidity. Data taken within the hibernation zone are in bold.

Site 71	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior 1	-0.59	10.06	-31.72	28.61	75.48	26.18	6.6	113.28
Exterior 2	-1.04	9.98	-31.8	28.58	74.42	23.87	7.19	105.66
Entrance Passage	0.4	1.95	-5.49	2.55	98.42	20.75	26.21	115.08
Below Upper Passage	**2.18**	**0.53**	**1.03**	**2.54**	**109.5**	**0.54**	**107.47**	**111.39**
X Roads	**2.73**	**0.5**	**1.57**	**4.09**	**116.26**	**0.69**	**114.12**	**118.56**

Table 3. Conditions at Site 407 at two exterior and one interior locations from 3/21/2013 to 4/13/2014. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 407	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior 1	7.38	11.73	-27.17	39.09	59.87	22.52	5.38	106.09
Exterior 2	7.03	11.49	-27.1	33.62	60.43	24.10	6.60	112.11
Rear of Cave	**7.07**	**0**	**7.07**	**7.07**	**107.55**	**0.56**	**104.30**	**109.25**

Table 4. Conditions at Site 133 at one exterior and three interior locations from 5/4/2012 to 4/15/2014. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 133	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior	7.96	11.05	-27.72	39.55	56.44	25.72	5.67	112.68
First room	**5.24**	**1.26**	**2.1**	**7.62**	**96.93**	**3.95**	**87.05**	**104.84**
Before Climb	**4.72**	**0.27**	**4.12**	**5.08**	**102.6**	**2.19**	**94.69**	**106.89**
Last Chamber	**4.82**	**0.32**	**4.57**	**5.59**	**105.57**	**5.14**	**90.46**	**109.66**

Table 5. Conditions at Site 91 at two exterior and six interior locations from 4/25/2012 to 6/20/14, with a gap in monitoring from 4/25/2014 to 8/13/2013. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 91	Temperature (^{o} C)				Humidity (%)			
	Avg.	STD	Min	Max	Average	STD	Min	Max
Exterior 1	4	10.31	-29.04	31.6	58.44	24.7	3.55	115.83
Exterior 2	6	10.74	-29.76	33.1	55.07	23.77	4.38	106.72
First Chamber	2.55	0.03	2.05	3.04	95.39	2.86	85.6	100.55
Upper Passage	-0.14	2.25	-14.02	2.56	89.26	16.29	40.89	107.68
S of Tight Crawl	0.05	1.31	-7.04	1.61	88.01	14.22	44.98	104.67
S Large Chamber	2.46	0.22	2.04	3.05	91.47	3.5	81.03	97.78
Rat Turd Hill	**2.6**	**0.18**	**2.05**	**3.05**	**92.32**	**6.02**	**79.82**	**105.28**
N Large Chamber	**3.16**	**0.34**	**2.58**	**3.58**	**94.68**	**4.16**	**84.13**	**103.48**

Table 6. Conditions at Site 392 at one exterior location and three interior locations (two for temperature) from 6/19/2013 to 3/25/2014. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 392	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior	6.66	11.32	-27.64	30.59	53.87	24.31	3.48	103.63
First Chamber	**8.2**	**2.75**	**5.07**	**14.1**	**65.13**	**14**	**29.09**	**98.45**
Small Chamber	**8.57**	**4.95**	**2.06**	**17.09**	**58.45**	**14.08**	**22.76**	**99.6**
Last Fork	**6.91**	**2.18**	**4.12**	**11.14**				

Table 7. Conditions at Site 121 at two exterior sites and four interior sites from 12/25/2012 to 5/6/2014. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 121	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior 1	5.08	10.88	-29.14	35.58	58.04	22.07	**7.73**	**104.03**
Exterior 2	3.84	10.85	-30.19	36.65	64.86	23.22	4.2	107.59
Dark Zone	**4.75**	**0.74**	**2.53**	**6.04**	**73.56**	**16.05**	**32.77**	**100.09**
Guano Room	**4.29**	**0.51**	**3.09**	**5.1**	**77.51**	**17.59**	**28.06**	**102.07**
Spread Eagle	**5.58**	**0**	**5.58**	**5.58**	**73.26**	**13.28**	**48.2**	**95.48**
Disney Room	**5.5**	**0**	**5.5**	**5.5**	**70.25**	**14.37**	**34.9**	**91.76**

Table 8. Conditions at Site 40 at one exterior site and four interior sites. For the exterior site and two internal sites (Little Red Buddha and Big Fissure), monitoring occurred from 3/1/2013 to 1/29/15. For the interior data logger at the before crawl location, monitoring was from 3/1/2013 to 6/19/2014. For the interior data logger at the first room location, monitoring was from 6/19/14 to 1/29/2015. Average temperature (^{o} C) and relative humidity (%; with standard deviation) and temperature and relative humidity range. Data taken within the hibernation zone are in bold.

Site 40	Temperature (^{o} C)				Humidity (%)			
	Average	STD	Min	Max	Average	STD	Min	Max
Exterior 1	8.29	13.32	-30.69	45.61	64.42	26.11	3.97	107.39
First Room	**6.36**	**6.53**	**-9.01**	**15.56**	**73.8**	**11.91**	**32.77**	**101**
Before Crawl	**4.94**	**0.56**	**3.62**	**6.13**	**65.07**	**13.81**	**22.22**	**101**
Big Fissure	**8.59**	**0.01**	**8.57**	**8.59**	**58.93**	**16.15**	**23.62**	**87.75**
Little Red Buddha	9.33	0.24	9.07	9.57	53.64	9.95	30.1	69.02

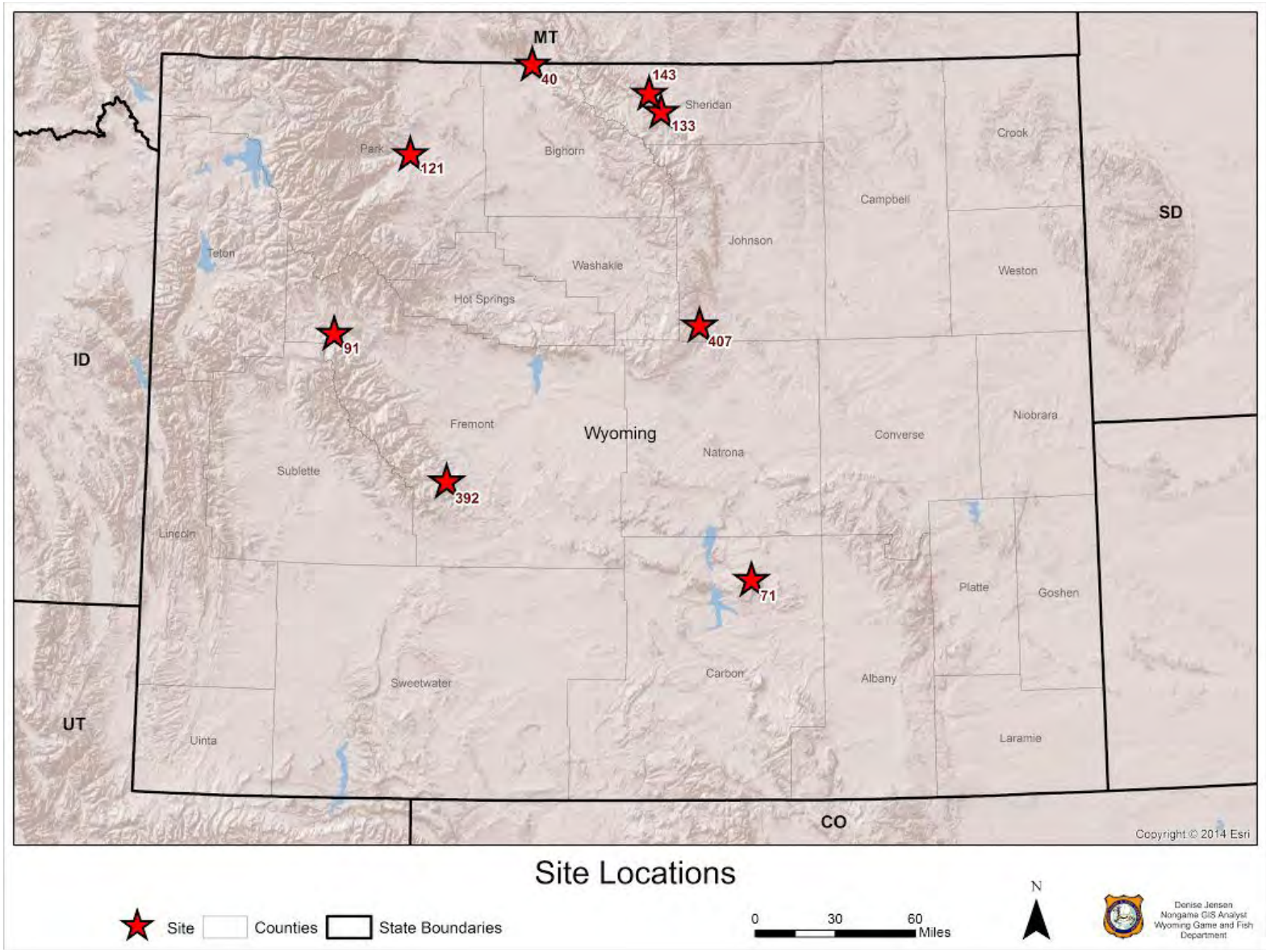

Figure 1. Map of sites monitored with temperature/humidity data loggers.

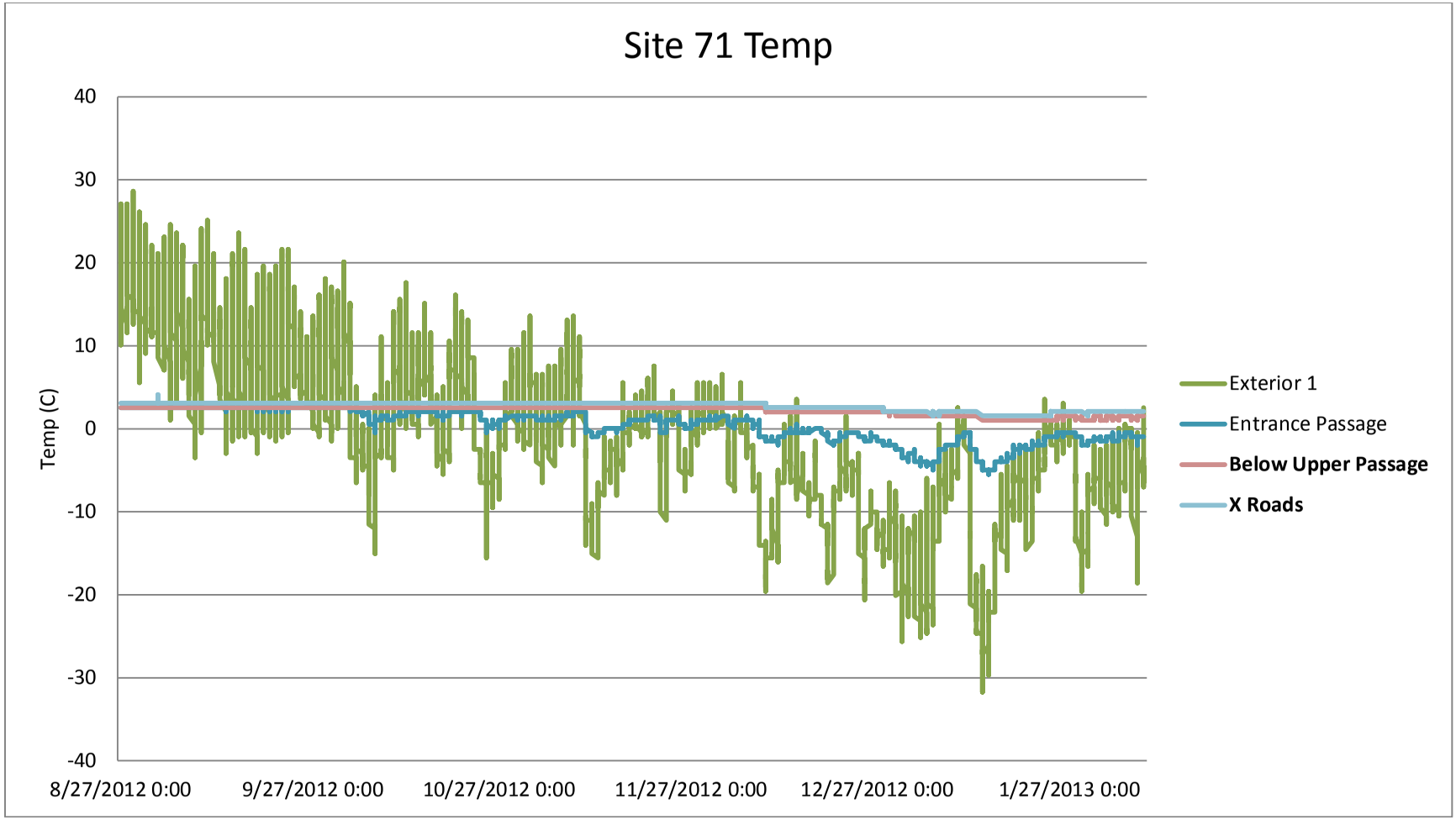

Figure 2. Temperature at Site 71, recorded at one exterior and three interior locations from 8/27/2012 to 2/8/2013. Names of data logger locations within the hibernation zone are in bold.

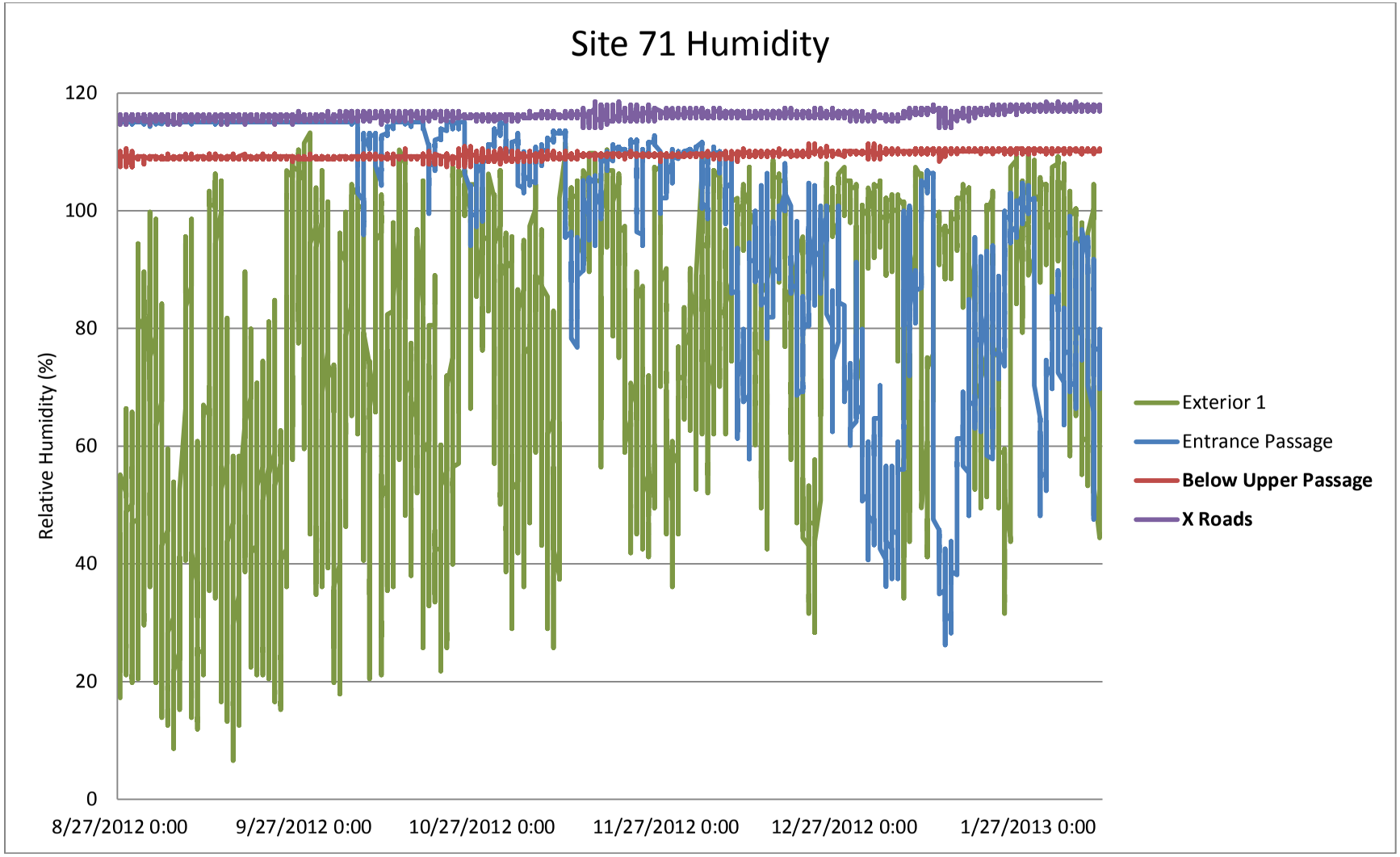

Figure 3. Relative Humidity at Site 71, recorded at one exterior and three interior locations from 8/27/2012 to 2/8/2013. Names of data logger locations within the hibernation zone are in bold.

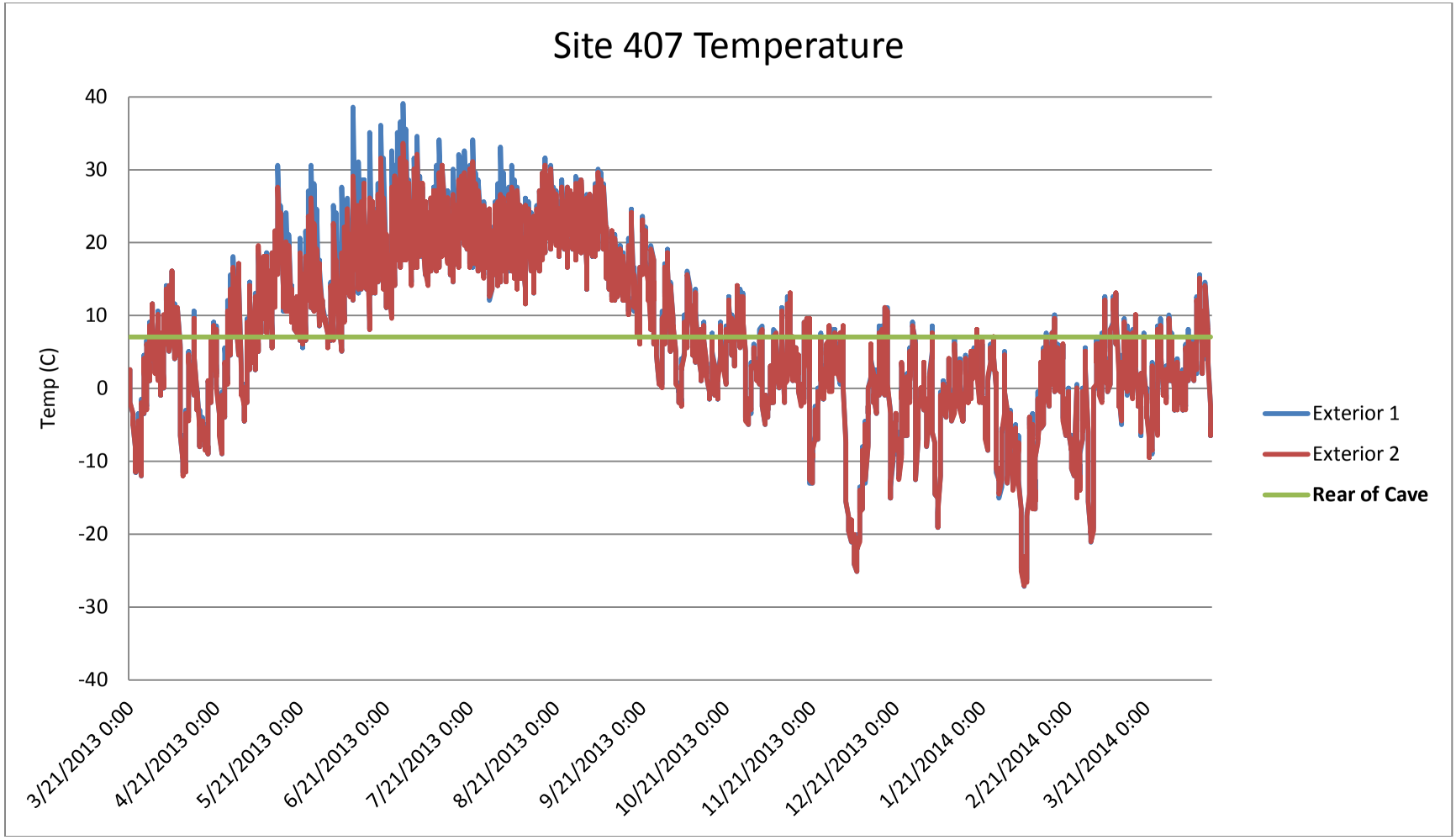

Figure 4. Temperature at Site 407 recorded at two exterior and one interior location from 3/21/2013 to 4/13/2014. Names of data logger locations within the hibernation zone are in bold.

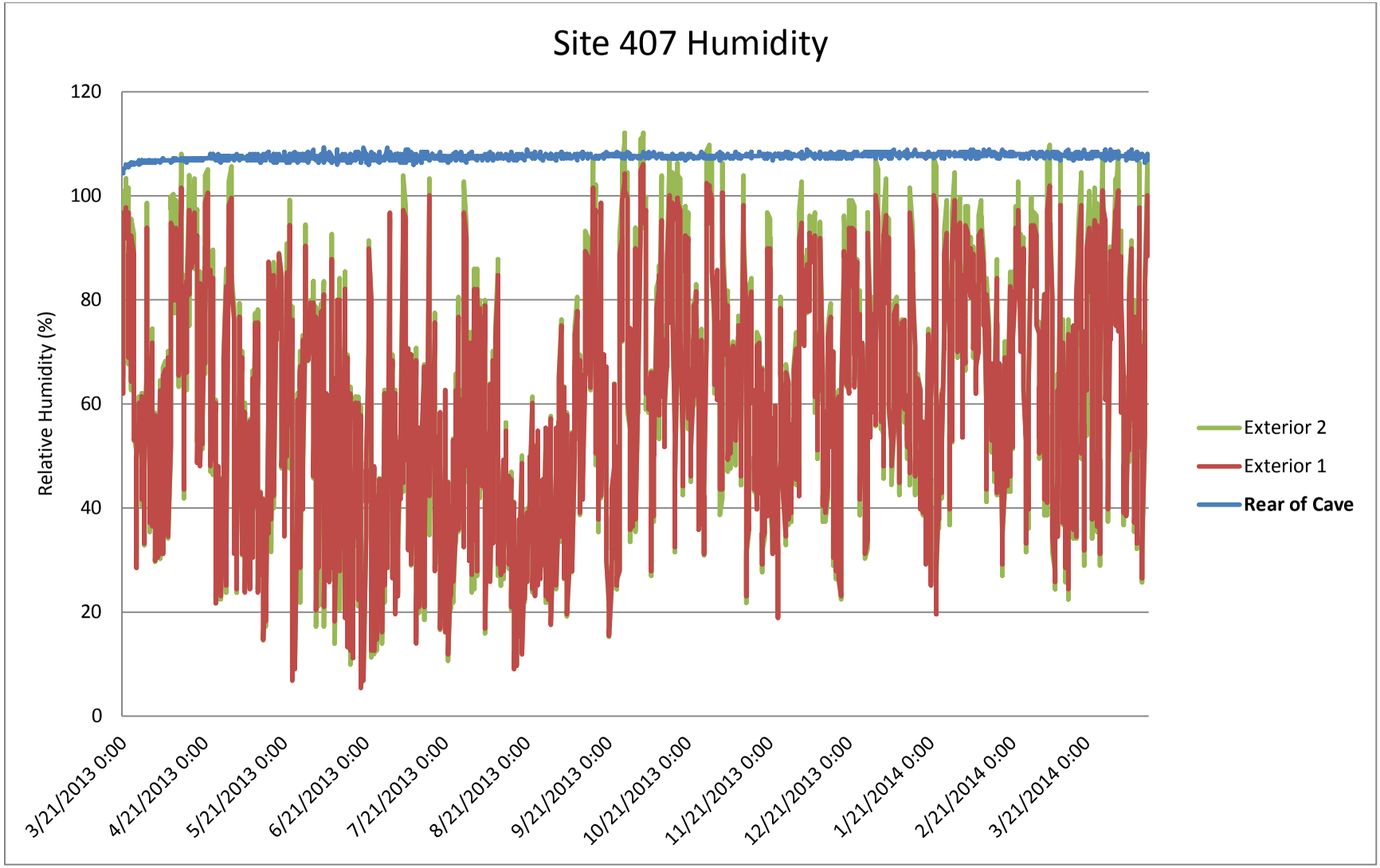

Figure 5. Relative humidity at Site 407 recorded at two exterior and one interior location from 3/21/2013 to 4/13/2014. Names of data logger locations within the hibernation zone are in bold.

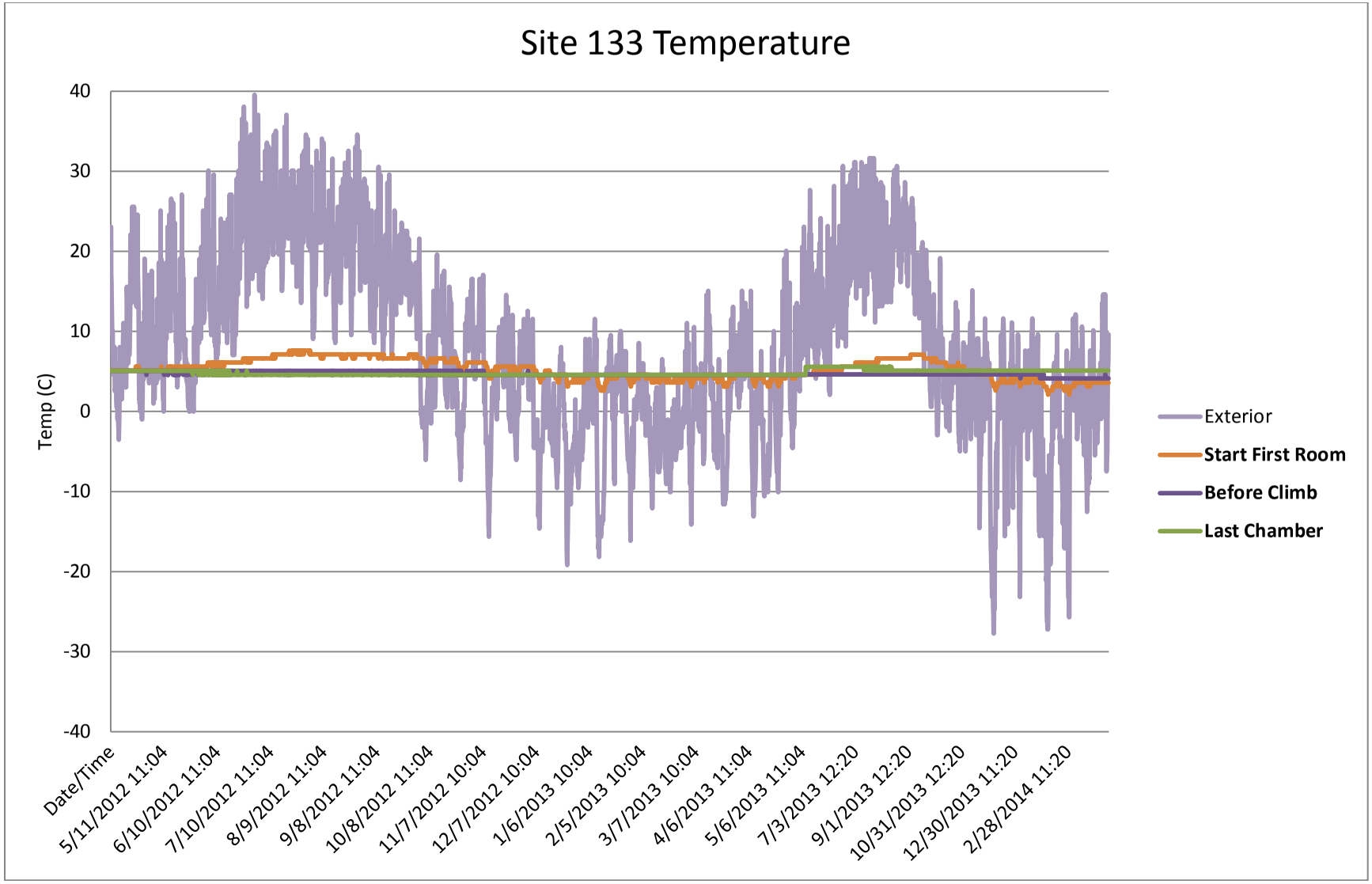

Figure 6. Temperature at Site 133 at one exterior and three interior locations from 5/4/2012 to 4/15/2014. Names of data logger locations within the hibernation zone are in bold.

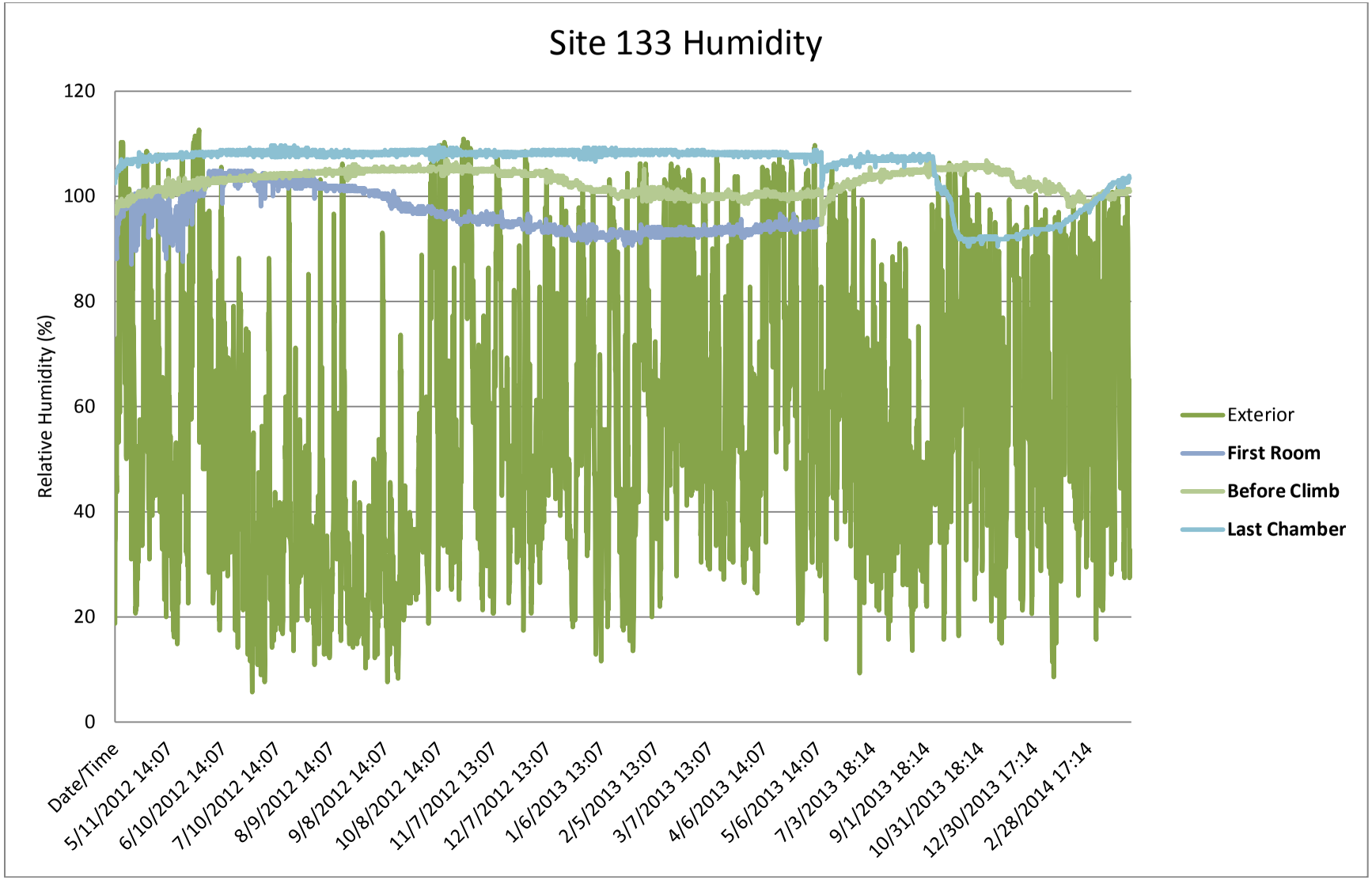

Figure 7. Relative humidity at Site 133 at one exterior and three interior locations from 5/4/2012 to 4/15/2014. Names of data logger locations within the hibernation zone are in bold.

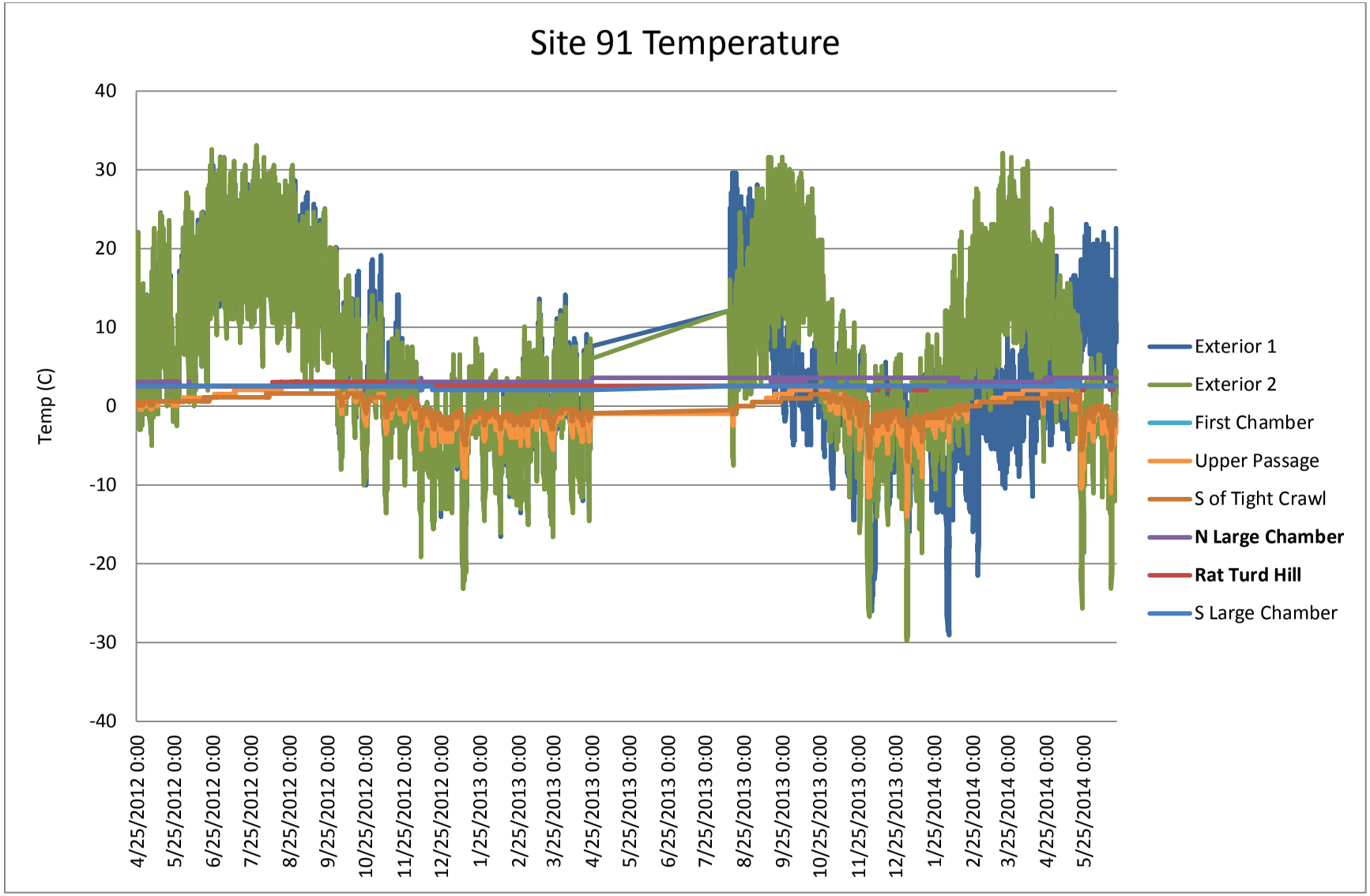

Figure 8. Temperature at Site 91 at two exterior and six interior locations from 4/25/2012 to 6/20/14, with a gap in monitoring from 4/25/2014 to 8/13/2013. Names of data logger locations within the hibernation zone are in bold.

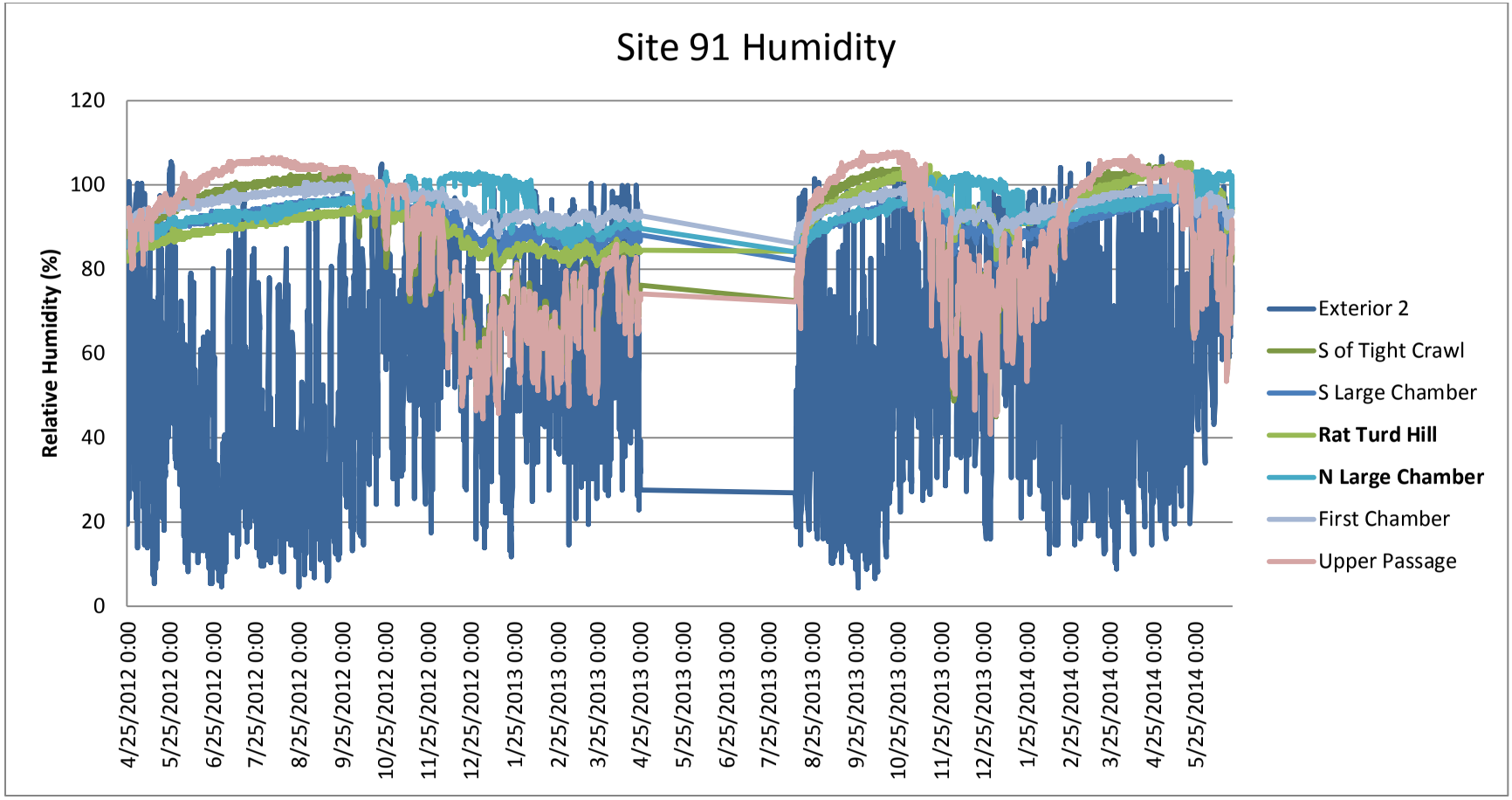

Figure 9. Relative humidity at Site 91 at two exterior and six interior locations from 4/25/2012 to 6/20/14, with a gap in monitoring from 4/25/2014 to 8/13/2013. Names of data logger locations within the hibernation zone are in bold.

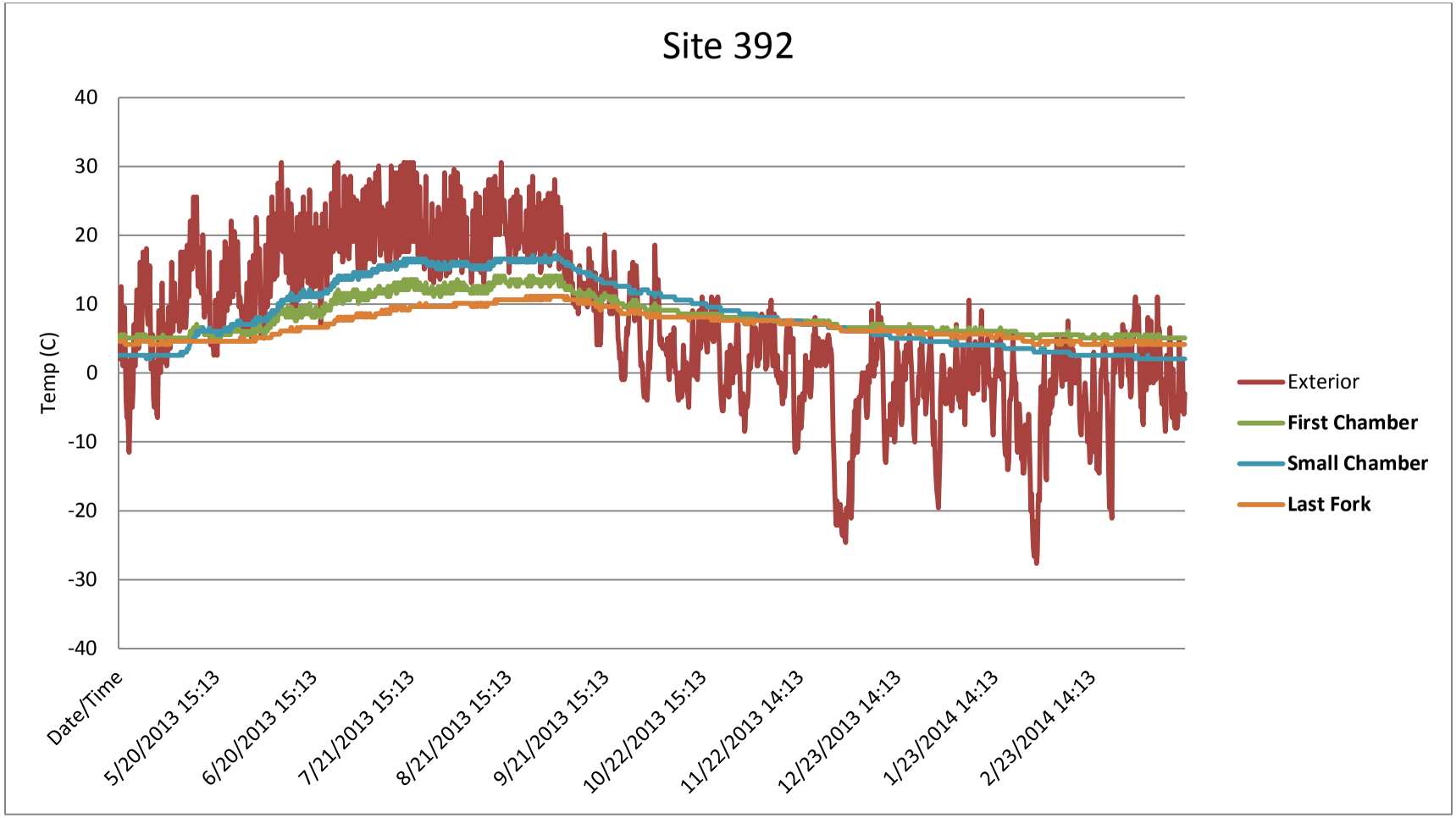

Figure 10. Temperature at Site 392 at one exterior location and three interior locations from 6/19/2013 to 3/25/2014. Names of data logger locations within the hibernation zone are in bold.

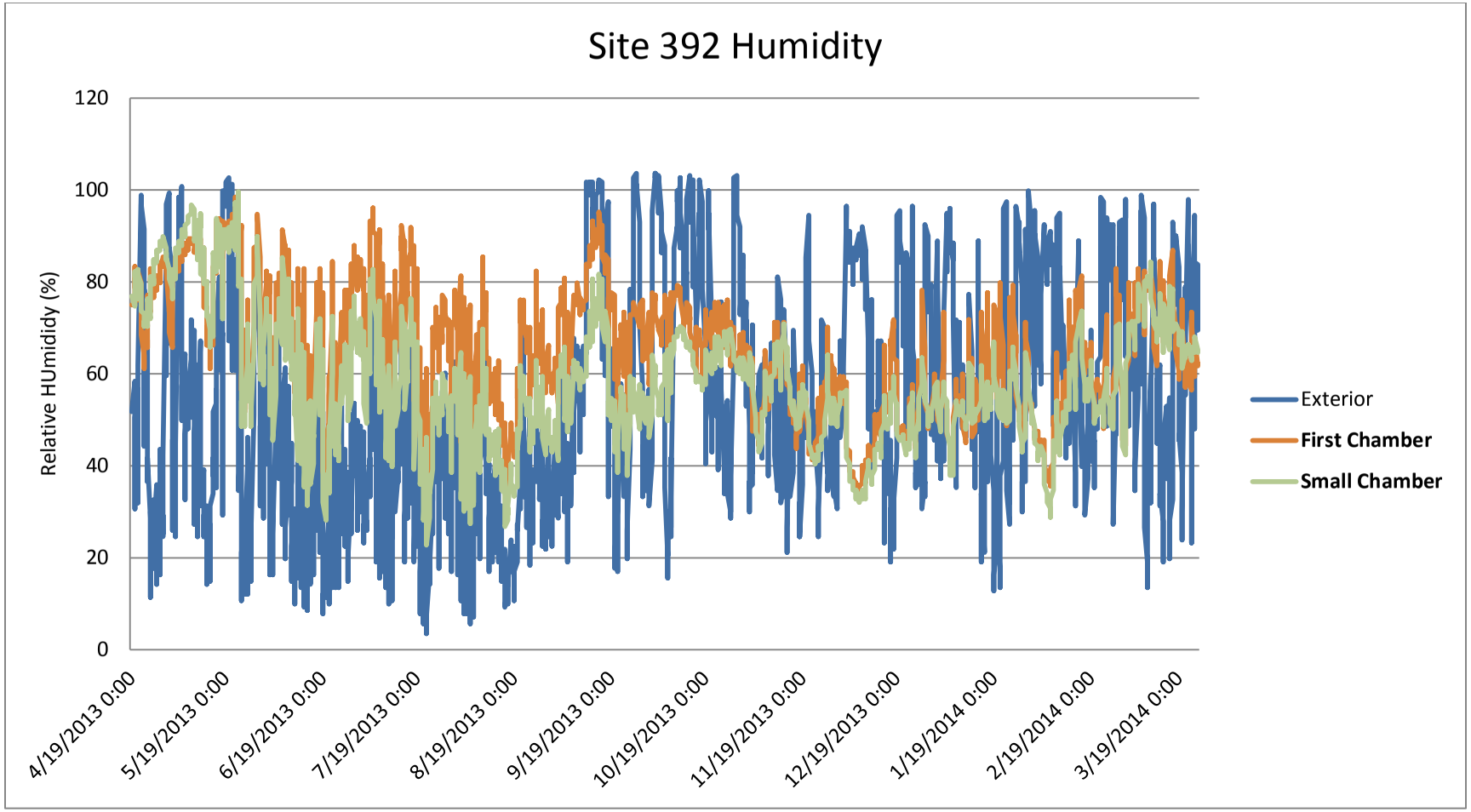

Figure 11. Relative humidity at Site 392 at one exterior location and two interior locations from 6/19/2013 to 3/25/2014. Names of data logger locations within the hibernation zone are in bold.

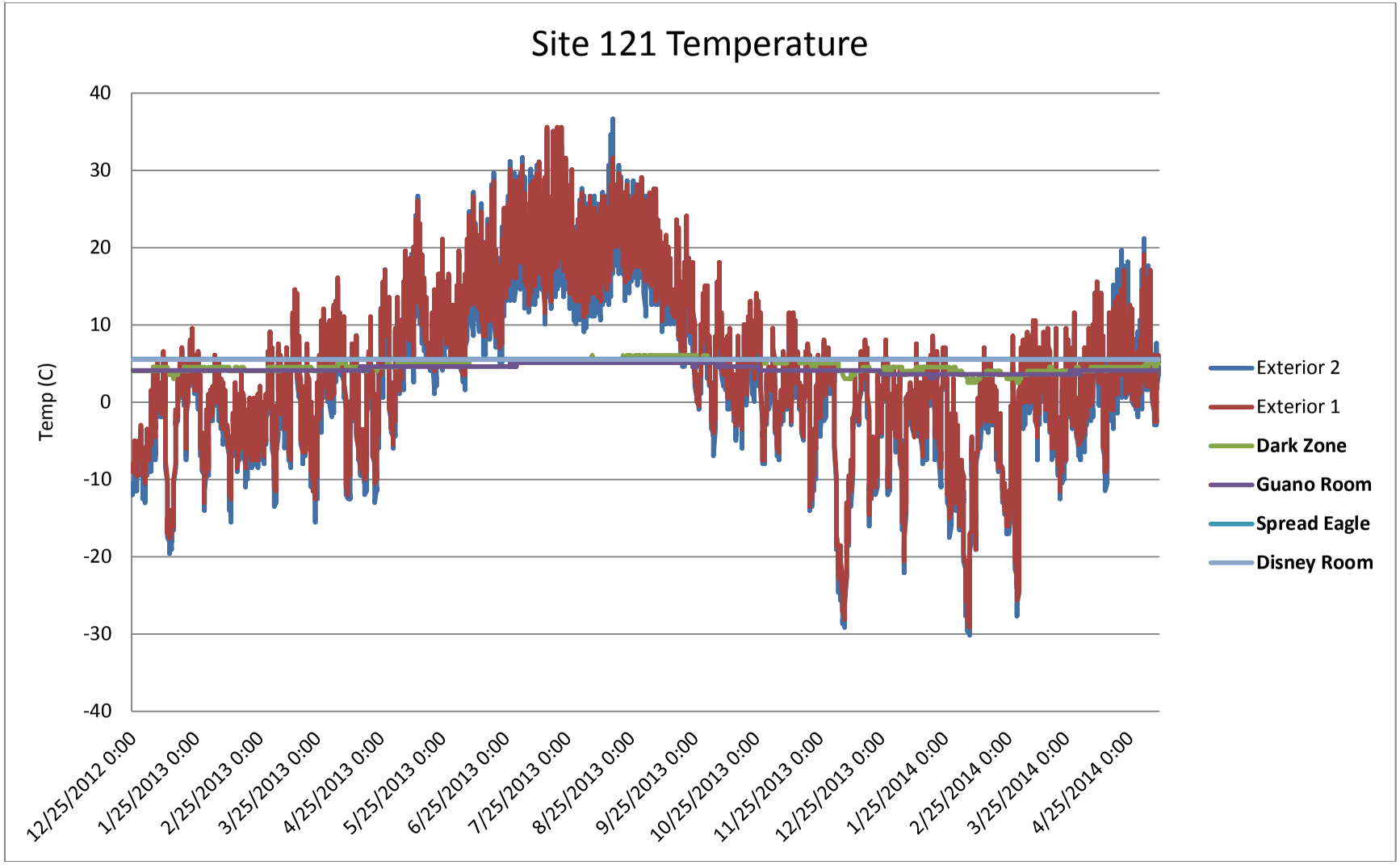

Figure 12. Temperature at Site 121 at two exterior sites and four interior sites from 12/25/2012 to 5/6/2014. Names of data logger locations within the hibernation zone are in bold.

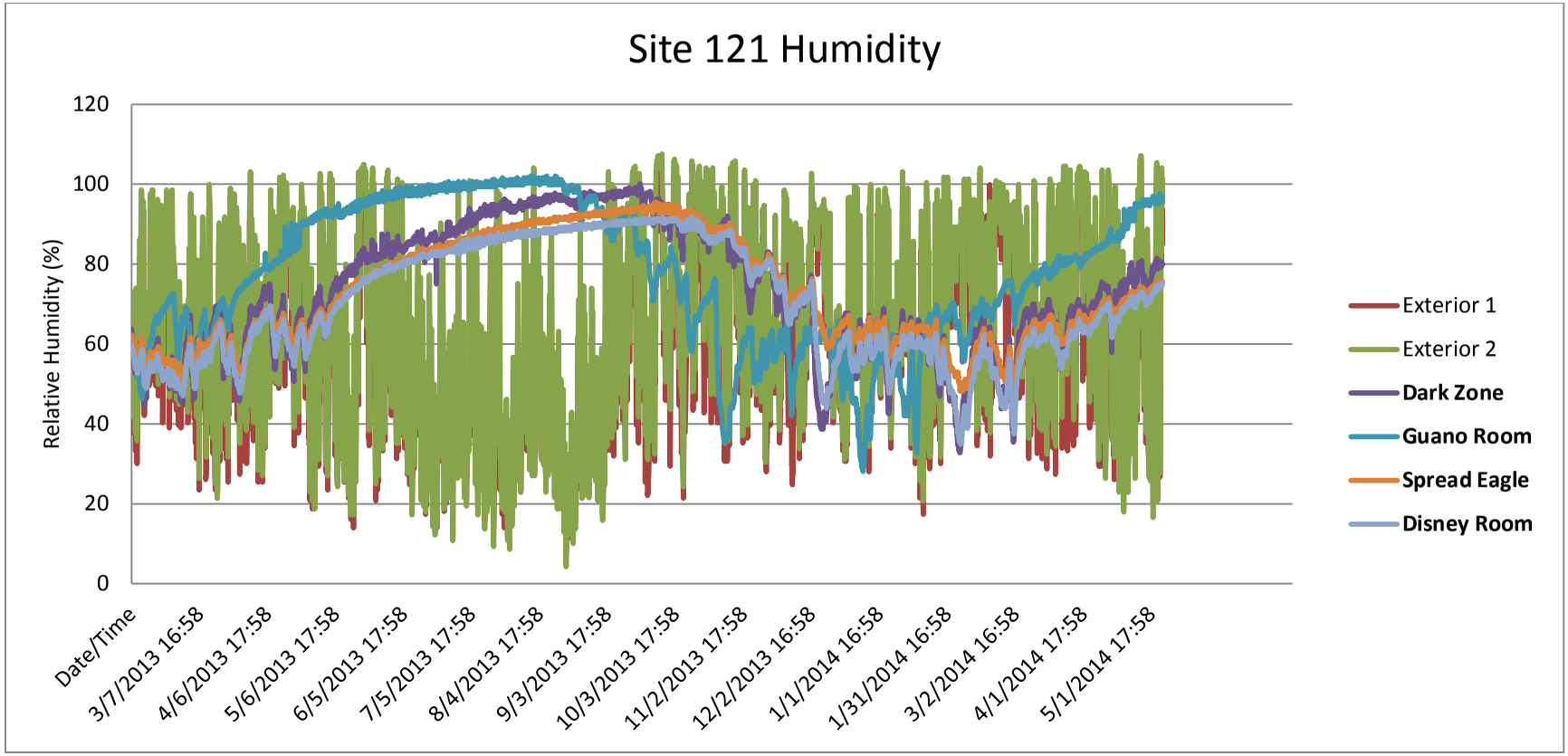

Figure 13. Relative humidity at Site 121 at two exterior sites and four interior sites from 12/25/2012 to 5/6/2014. Names of data logger locations within the hibernation zone are in bold.

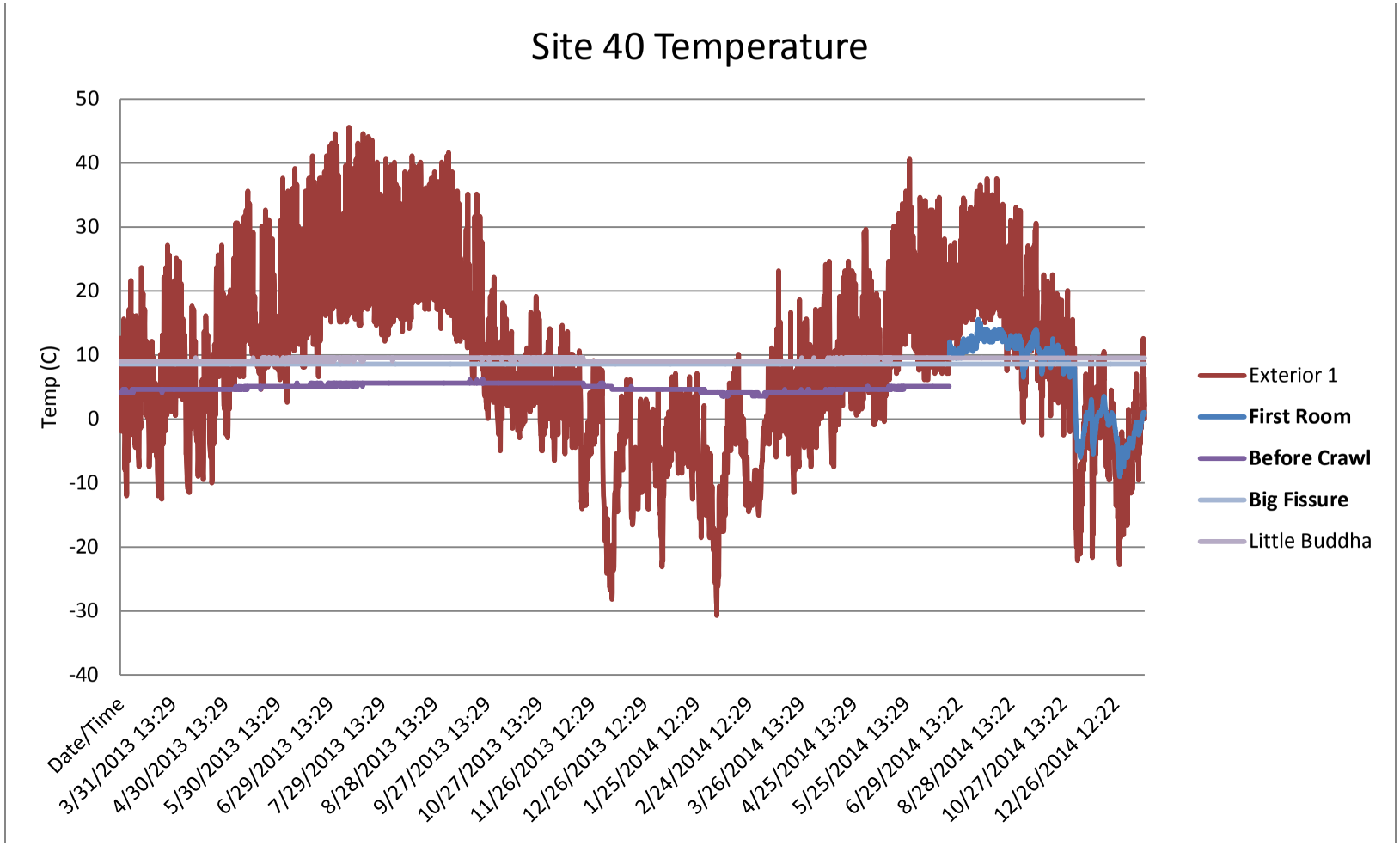

Figure 14. Temperature at Site 40 at one exterior site and four interior sites. For the exterior site and two internal sites (Little Red Buddha and Big Fissure), monitoring occurred from 3/1/2013 to 1/29/15. For the interior data logger at the before crawl location, monitoring was from 3/1/2013 to 6/19/2014. For the interior data logger at the first room location, monitoring was from 6/19/14 to 1/29/2015. Names of data logger locations within the hibernation zone are in bold.

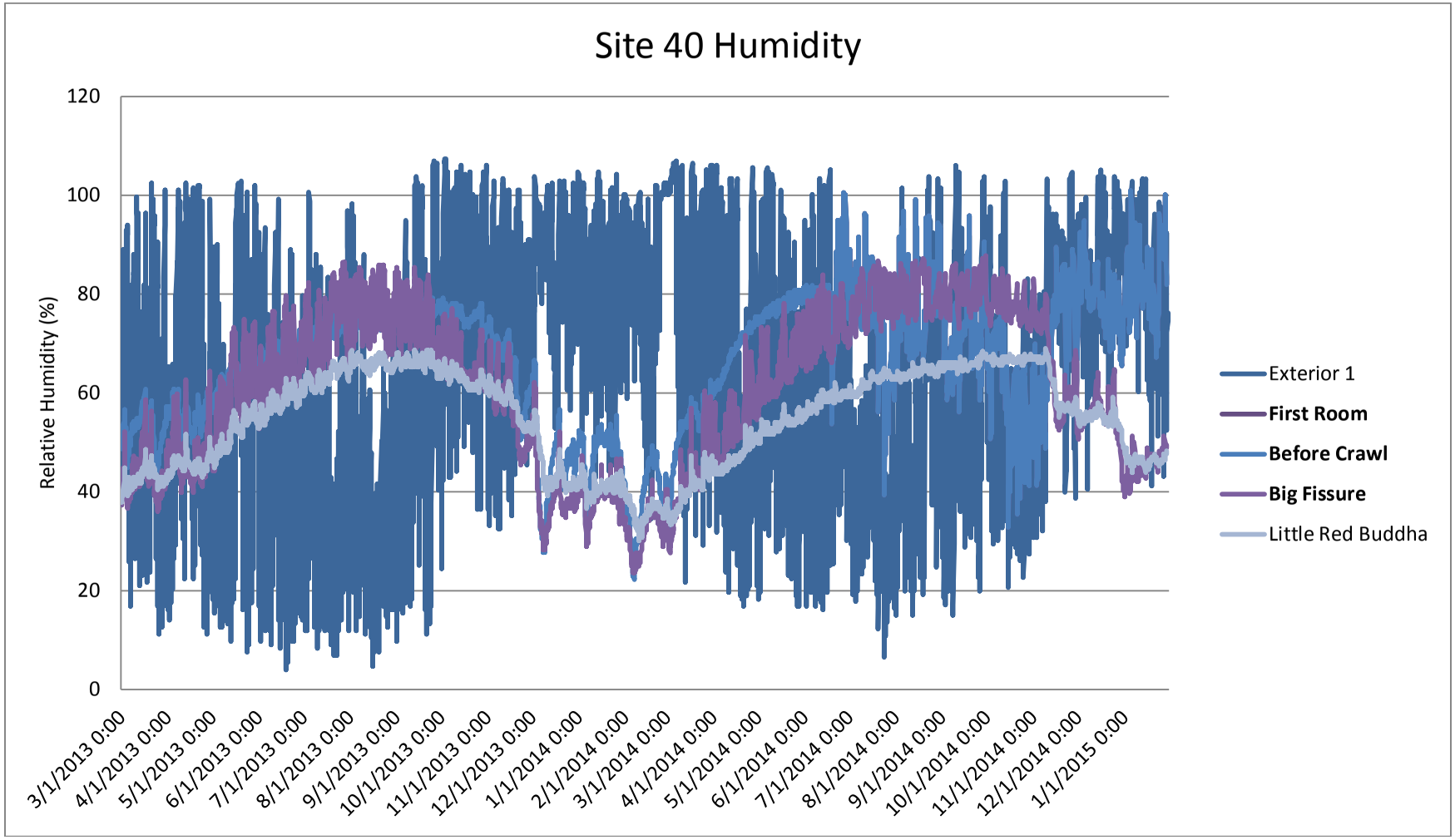

Figure 15. Relative humidity at Site 40 at one exterior site and four interior sites. For the exterior site and two internal sites (Little Red Buddha and Big Fissure), monitoring occurred from 3/1/2013 to 1/29/15. For the interior data logger at the before crawl location, monitoring was from 3/1/2013 to 6/19/2014. For the interior data logger at the first room location, monitoring was from 6/19/14 to 1/29/2015. Names of data logger locations within the hibernation zone are in bold.

DOCUMENTING DISTRIBUTION AND HABITAT ATTRIBUTES OF NORTHERN FLYING SQUIRRELS (*GLAUCOMYS SABRINUS*) IN TETON COUNTY, WYOMING

STATE OF WYOMING

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

FUNDING SOURCE: Meg and Bert Raynes Wildlife Fund
Wyoming State Legislature General Fund Appropriations

PPCAS PROJECT CODE: NASW0FSS0512

PROJECT DURATION: 1 June 2014 –1 August 2014

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Laurie Van Fleet, Nongame Biologist

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 4 June and 22 July 2014, we used remote infrared cameras and enclosed bait tubes at 12 plots to estimate occupancy and update the current distribution of northern flying squirrels in Teton County. Additionally, we evaluated important habitat components that could be used to predict presence of flying squirrels. We recorded 13 unique detections (i.e., photographs of flying squirrels >1 hr apart) on seven plots. Understory cover varied among sites, although saplings were found most frequently in occupied plots ($\bar{X}$ = 2.95% ± 0.25) and less frequently in unoccupied plots ($\bar{X}$ = 0.25% ± 0.75; t_{10} = 3.72; P = 0.003). Conversely, we detected a greater amount of shrubs in unoccupied plots ($\bar{X}$ = 66.50% ± 2.73) than in occupied plots ($\bar{X}$ = 33.36% ± 4.78; t_{10} = -3.08, P = 0.005). Both lichen and witches' broom were present only in occupied plots. 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 surveys consider characterizing availability of mycorrhizal fungi, which may affect occupancy of flying squirrels.

INTRODUCTION

The northern flying squirrel (*Glaucomys sabrinus;* flying squirrel) generally occupies boreal and north temperate conifer, mixed conifer-hardwood, and northern hardwood forests of the northern United States and Canada (Weigl 2007). These cool and moist habitats support old-growth and mature forests that have a well-developed canopy and an abundance of snags, downed wood, and organic materials. Old-growth stands provide the most suitable habitats for the flying squirrel, which relies on these stands to facilitate locomotion, nesting, and forage for wood-borne fungi and lichens (Carey et al. 1999). The flying squirrel is important to ecosystem processes since it consumes and transports 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). The flying squirrel is also an important prey base for nocturnal raptors and mammalian carnivores associated with old-growth forests (Martin 1994). In Wyoming, the flying squirrel occurs primarily in montane and subalpine forests of the western mountain ranges, although there are isolated populations in the xeric and lower montane forests of the Black Hills and Sweetwater County (WGFD 2010). In Wyoming, habitat loss is the most limiting factor for populations of flying squirrels (WGFD 2010). The species is susceptible to declines as a result of large-scale habitat manipulation projects that destroy or remove suitable habitat (e.g., logging, prescribed fire) with both short- and long-term consequences (Holloway and Smith 2011). The flying squirrel is also vulnerable to habitat loss due to climate change (e.g., mountain pine beetle kill, drought, fire), which may cause their range to contract or fragment (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 (SGCN) by the Wyoming Game and Fish Department (Department; NSS4, Tier 2; WGFD 2010).

In 2012 and 2013, Department biologists developed a baseline occupancy model to monitor trends for flying squirrels in the Wyoming Range as part of a long-term monitoring program (Van Fleet et al. 2014). Although surveys were conducted in the Wyoming Range, other areas in the northwest were not surveyed due to time constraints and limited equipment. This left a dearth of information on flying squirrel occupancy in other areas of northwestern Wyoming, including Teton County. Our objectives were to follow established guidelines and use remote cameras (PC800 Reconyx, Holmen, WI) and enclosed bait tubes (EBTs) to document flying squirrels and establish a baseline for long-term surveillance in Teton County. Additionally, we evaluated important components of habitat that could be used to predict presence of flying squirrels.

METHODS

Our study area was located in the Bridger-Teton National Forest in northwestern Wyoming (Fig. 1). Dominant forest trees included Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), and sub-alpine fir (*Abies lasiocarpa*), with elevation ranging from 2049 m to 2367 m. Specifically, we conducted our surveys within the Fall Creek and Shadow Mountain areas.

We completed surveys between 4 June and 22 July 2014. 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 a pre-selected plot was not accessible due to impassable or closed roads, 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 to a tree with a bungee cord approximately 1.5 m above ground. We attached each EBT to a tree ≤2 m from the camera and baited the EBT with a mixture of oatmeal, peanut butter, and bacon grease to lure flying squirrels within camera range. We re-baited EBTs at each station in the late afternoon for five consecutive days. We programmed cameras to take pictures 24 hrs a day 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 distinguished photos of flying squirrels from red squirrels (*Tamiasciurus hudsonicus*) and chipmunks (*Neotamias* spp.) by the presence of a patagium, large eyes, and a square, flat tail. We recorded all locations for flying squirrels and non-target species.

In conjunction with the camera surveys, we randomly selected three survey stations within each 4-ha survey plot and collected data for several habitat variables based on published studies of northern flying squirrels (Wells-Gosling and Heaney 1984; Rosenberg and Anthony 1992; Waters and Zabel 1995, Pyare and Longland 2002). We used 7-m radius circular plots at each location with the bait tree as our center point. In each cardinal direction, we placed one transect, 7 m in length, dividing each habitat-sampling plot into quadrants (i.e., northwest, northeast, etc.). Along each transect at 4 m from the bait station, we recorded the percentage of overstory cover using a convex densiometer (Forestry Suppliers Inc., Jackson, MS). In each 7-m quadrant, we visually estimated the percent, type, and distance of primary understory (i.e., shrub, seedling, and sapling) ≤2 m in height and recorded if mushrooms were present (Pyare and Longland 2002). Within 360° of the bait tree, we determined the basal area factor (BAF) of trees (>10 cm DBH) using a wedge prism (BAF 10; Forestry Suppliers Inc., Jackson, MS) and recorded presence of lichen, witches' broom, and natural or excavated tree cavities within the plot. All dead standing trees were assigned to a snag class from 1 to 5 (Ganey and Vojta 2007, Pyare and Longland 2002). We also recorded the total number of logs (≥20 cm DBH) and number of "class 3", or heavily decayed coarse woody debris (CWD), within the 7-m radius plot (Ganey and Vojta 2010). Finally, to account for the influence of microtopography on flying squirrels, we measured slope, aspect, and elevation at each bait tree. We summarized all data for each plot and provide averages ± standard error for each value per plot. We used t-tests to compare habitat variables between occupied and unoccupied plots.

RESULTS

We surveyed 12 plots for a total of 960 camera nights (Fig. 1). We recorded 13 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 7 plots. Presence of flying

squirrels was greater in the Fall Creek area along the western slopes of the Jackson valley (Fig. 1). On average, plots occupied by flying squirrels had a predominantly southeastern aspect of 148°, while unoccupied plots had a western aspect of 268°. All observations of flying squirrels and non-target species were entered into the Department's Wildlife Observation System database (Table 1).

We did not observe any flying squirrel mortalities, and none of our EBTs were damaged or destroyed. One camera, however, sustained a puncture in the lens from a grizzly bear (*Ursus arctos*). Since this incident happened during the last morning of the survey, the total number of camera nights was not affected.

We sampled 332 live trees and 71 snags at 37 stations within 12 plots (one plot contained 4 habitat survey stations). Although our sample size was relatively small, occupied sites tended to be characterized by live trees with larger DBH and lower basal area, and included some element of Engelmann spruce (Table 2). Understory cover varied among sites, although saplings were found more frequently in occupied plots ($\bar{X}$ = 2.95% ± 0.25) than unoccupied plots ($\bar{X}$ = 0.25% ± 0.75; t_{10} = 3.72; P = 0.003). Conversely, we detected a greater amount of shrubs in unoccupied sites ($\bar{X}$ = 66.50% ± 2.73) than in occupied sites ($\bar{X}$ = 33.36% ± 4.78; t_{10} = -3.08, P = 0.005). Other ground cover (mushrooms, grass, and CWD) and habitat (slope, canopy cover, and tree cavities) components did not differ significantly between occupied and unoccupied sites, potentially due to small sample size. Other habitat components were not significant.

Occupied sites appeared positively associated with the presence of lichen and witches' broom on trees within the plots. On the seven occupied sites, lichen was observed at six sites (86%) while witches' broom was observed at four sites (57%). The five unoccupied plots contained no lichen or witches' broom. Observations of mushrooms were similar between occupied (n = 3) and unoccupied (n = 2) plots.

DISCUSSION

Flying squirrels detected during our surveys seemed to have no aversion to entering the EBTs. 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 has proven highly successful at detecting flying squirrels (>80%) in other areas of Wyoming (Van Fleet et al. 2014). Our lower detection rate in the Jackson valley may be attributed to the time of year the survey was conducted. Krueger (2004) and Vernes (2004) reported low live-capture success in May and June with greater success occurring in summer and fall months. In 2012 and 2013, we also observed lower detection rates for flying squirrels during late spring and early summer compared to late summer and early fall surveys (Van Fleet et al. 2014). This time period coincides with females having young, which may cause them to be more cautious, preferring to forage closer to the nest tree (Krueger 2004). Additionally, females with young forage less often and typically only leave the nest for short intervals during this season (Wells-Gosling 1985). Therefore, we recommend that future monitoring should be conducted in the late summer and fall seasons to optimize detections of flying squirrels.

We failed to detect a significant difference in stand characteristics between sites that were occupied by flying squirrels and those that were not. Although we had a small sample size, results suggest that flying squirrels may be selecting for stands with lower basal area of live trees and larger DBH of live trees and snags. Results are similar to surveys the Department conducted in the Wyoming Range, where stands typically consisted of larger, older trees in late succession (Van Fleet et al. 2014). Older trees provide greater thermal insulation, denning sites, reduced predation risk, and greater biomass of lichen important for flying squirrels (Meyer et al. 2005, Smith 2007). Flying squirrels were detected in several plots that contained some quantity of Engelmann spruce, which occur in areas favored by adequate soil moisture, cool temperatures, and shade (NCRS 2000). Perhaps flying squirrels are not only selecting for larger, older trees, but also for the micro-climate these areas provide, rather than Engelmann spruce itself.

Flying squirrels were found in plots that contained more saplings and fewer shrubs than unoccupied plots, similar to studies conducted by Holloway and Malcom (2007). This is contradictory to several investigators who suggest that flying squirrels utilize understory cover with a higher density of shrubs to avoid predators or to feed on other food items (e.g., insects, buds, seeds; Pyare and Longland 2002, Smith 2007). While opinions differ on the composition of understory needed for flying squirrels, the diversity and abundance of lichen and mycorrhizal fungi may be a limiting factor and may explain the lack of agreement on ground cover. Lichen, or old man's beard, was found consistently on trees in occupied sites. Lichen is not only an important winter food item, but may also be used as cavity nest material (Maser et al. 1985, 1986; Hayward and Rosentreter 1994). We also detected witches' broom at several occupied sites, which flying squirrels use for both caching and denning sites (Garnett et al. 2006, Mowry 2008). Perhaps flying squirrels are selecting for cool micro-habitats within the forests that promote lichen and organic soils, which are important for fungal growth (Gomez et al. 2005, Meyer et al. 2005, Weigl 2007). Gomez et al. (2005) found a direct correlation between flying squirrel density and abundance of mycorrhizal fungi. Due to time constraints and limited personnel, we were unable to quantify availability of this important food item. We recommend that future surveys consider characterizing availability of mycorrhizal fungi, which may affect occupancy of flying squirrels.

Initially, we intended on using program PRESENCE (Hines 2010) to evaluate occupancy and develop an encounter history for each plot, however our sample size was too small to statistically evaluate occupancy. This method is in place however, and can easily be incorporated with previous work from the Wyoming Range. We recommend incorporating a subset of these plots with future trend monitoring in the Wyoming Range.

We consider our results to be a success in the Jackson valley by enhancing our knowledge of this secretive SGCN. We continue to adjust our habitat data techniques to better evaluate important components of habitat that could be used to predict presence of flying squirrels. 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 remove mature trees. Our results over the past several years suggest that the persistence of flying squirrels may be more complex than previously believed.

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Table 1. Number of detections (i.e., photographs >1 hr apart) for northern flying squirrel (*Glaucomys sabrinus*) and non-target species from remote cameras and enclosed bait tubes. Surveys were conducted during June and July 2014 in the eastern and western mountains of the Jackson valley, Bridger-Teton National Forest, Teton County, Wyoming.

Species	Drainage		Total	Proportion of total detections
	Eastern	Western		
Black bear (*Ursus americanus*)	0	2	2	0.12
Chipmunk (*Neotamias* spp.)	5	21	26	0.15
Coyote (*Canis latrans*)	0	1	1	0.01
Downy woodpecker (*Dryobates pubenscens*)	0	1	1	0.01
Elk (*Cervus canadensis*)	1	4	5	0.03
Grizzly bear (*Ursus arctos*)	1	0	1	0.01
Moose (*Alces alces*)	0	13	13	0.08
Mouse (*Peromyscus* spp.)	2	1	3	0.02
Mule deer (*Odocoileus hemionus*)	12	37	49	0.29
Northern flying squirrel (*Glaucomys sabrinus*)	2	11	13	0.08
Red fox (*Vulpes vulpes*)	0	1	1	0.01
Red squirrel (*Tamiasciurus hudsonicus*)	32	19	51	0.30
Unknown species	2	1	3	0.02
Total	57	112	169	1.10

Table 2. Species of live trees and snags measured for all occupied plots and unoccupied plots surveyed for northern flying squirrels (*Glaucomys sabrinus*) from June to July 2014 (n = 12) in Teton County, Wyoming. We present total number of live trees and snags, and mean number diameter at breast height (DBH; cm), basal area factor (BAF), and standard error (SE) per species for plots. Mean BAF of all live trees and snags were significantly different for occupied sites and those where we failed to detect flying squirrels (P <0.001).

Occupied Plots

Tree species	*n*	DBH (cm)	SE	BAF	SE
Subalpine-fir (*Abies lasiocarpa*)	41	21.36	2.77	7.68	1.59
Lodgepole pine (*Pinus contora*)	144	25.86	1.54	8.26	1.55
Engelmann spruce (*Picea engelmannii*)	52	26.07	3.13	8.37	1.54
Unknown	2	29.35	0.96	5.00	0
All live trees	239	25.66	1.81	7.33	1.26

Unoccupied Plots

Tree species	*n*	DBH (cm)	SE	BAF	SE
Subalpine-fir (*Abies lasiocarpa*)	13	24.62	2.85	9.62	1.18
Lodgepole pine (*Pinus contora*)	161	23.03	2.57	8.17	1.55
Engelmann spruce (*Picea engelmannii*)	0	0	0.00	0.00	0.00
Unknown	0	0	0.00	0.00	0.00
All live trees	174	23.83	1.06	8.90	1.01

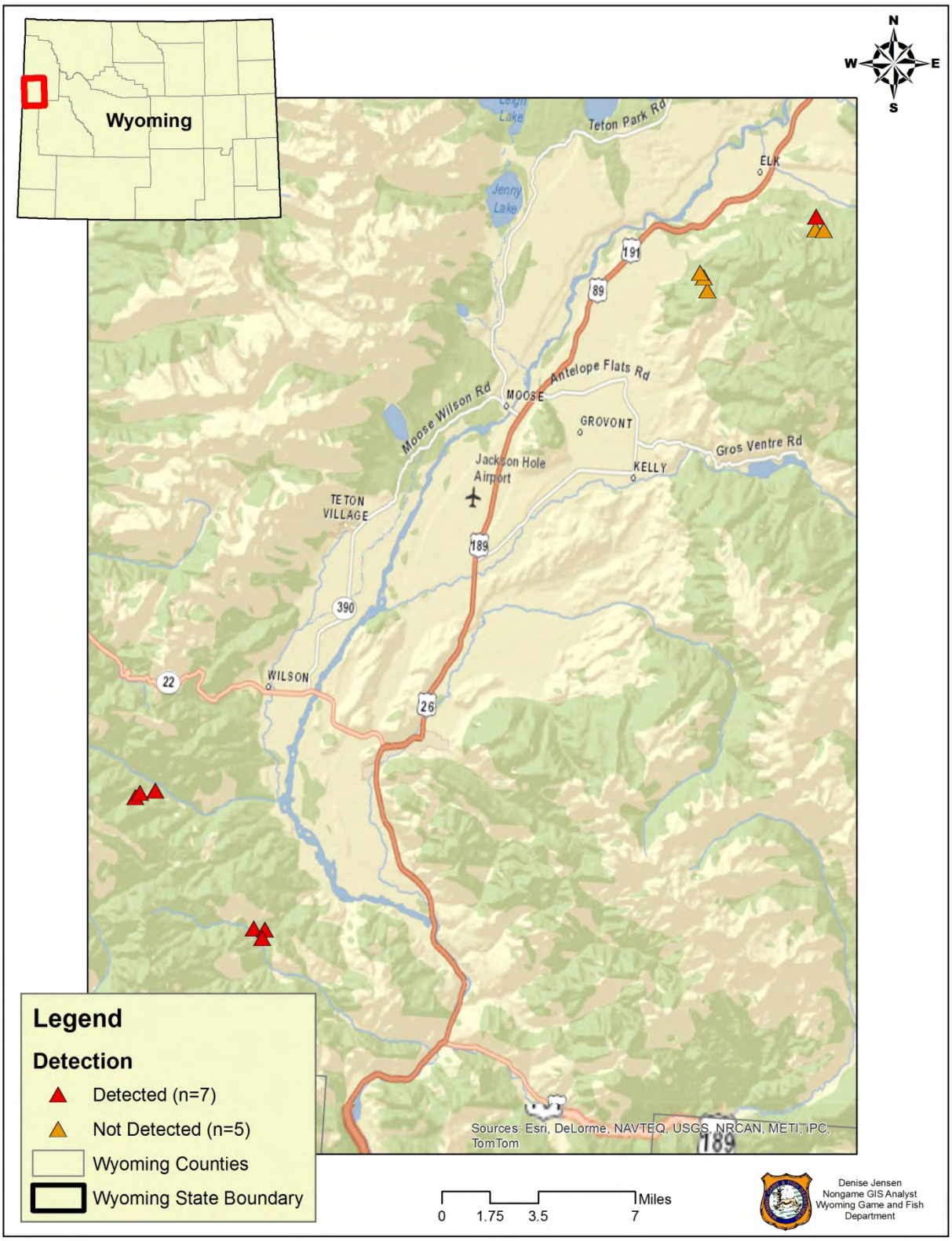

Figure 1. Study area, locations of survey plots, and detections of northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from 4 June to 22 July 2014 in the Bridger-Teton National Forest, Teton County, Wyoming.

DISTRIBUTION AND HABITAT REQUIREMENTS OF NORTHERN FLYING SQUIRRELS (*GLAUCOMYS SABRINUS*) IN THE BLACK HILLS NATIONAL FOREST, WYOMING

STATE OF WYOMING

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

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

PROJECT DURATION: 1 July 2014 – 31 January 2015

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Laurie Van Fleet, Nongame Biologist
Jesse Boulerice, Nongame Biologist

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 12 August and 13 October 2014, we used remote infrared cameras and enclosed bait tubes at 23 plots to estimate occupancy and update the current distribution of northern flying squirrels in the Black Hills National Forest. Additionally, we evaluated important components of habitat that could be used to predict presence of flying squirrels. We recorded 351 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 20 plots. We found covariates of number of class 3 logs (heavily decayed; $\beta = 3.889$, SE = 2.821) and aspect ($\beta = 1.131$, SE = 1.895) to have a positive effect, and greater distance to saplings ($\beta = -0.423$, SE = 0.689) to have a negative effect on occupancy of squirrels. Across all grids, probability of occupancy averaged 0.870 (95% CI; 0.664-0.958). 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. Finally, we recommend that future surveys consider characterizing availability of class 3 logs, distance to saplings, mycorrhizal fungi, and arboreal lichen, which may affect occupancy of flying squirrels.

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, flying squirrels are also important to ecosystem functioning by consuming and transporting 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 functioning and health (Carey 2000). In Wyoming, flying squirrels are primarily restricted to the western mountains, although isolated populations occur in the Uinta Mountains and Black Hills (WGFD 2010). Because their habitat is naturally patchy and susceptible to natural and anthropogenic disturbances, northern flying squirrels are classified as a Species of Greatest Conservation Need (SGCN) in Wyoming (NSS4, Tier 2; WGFD 2010).

Typically considered an inhabitant of old-growth forests, flying squirrels in the Black Hills are instead associated with xeric and lower montane forest habitat types due to the drier forests present in this area (Krueger 2004, Gabel et al. 2010). Annual moisture in the Black Hills ranges from less that 40 cm near the periphery to 70 cm in the Lead/Deadwood area (Trimarchi 1997, Gabel et al. 2010). Elevations range from 1200 m to 2207 m, with forested regions extending to 2102 m (Froiland 1990). Ponderosa pine (*Pinus ponderosa)* is found throughout the Black Hills and is the most abundant tree species, dominating 83% of the landscape (USDA Forest Service, 2005). Additionally, ponderosa pine roots are colonized by mychorrizal fungi fruiting bodies or truffles, an important food item for flying squirrels (Maser et al. 1985, Hough and Dieter 2009*a*). Other tree species in the Black Hills include bur oak (*Quercus macrocarpa*), aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and white spruce (*Picea glauca*) (Klutsch et al. 2012). Deciduous trees provide flying squirrels with both natural and excavated cavities for both denning and nesting, while conifers are primarily used for external drey nests (Carey et al. 1997, Hough and Dieter 2009*b*).

Although some work has been done to evaluate habitat of flying squirrels in the Black Hills (e.g., Krueger 2004, Hough and Dieter 2009*a*,*b*,*c*, Gabel et al. 2010), these studies were localized and none were conducted in Wyoming, resulting in a dearth of data on this sensitive species. Additionally, only two records for flying squirrels in the Black Hills are listed in the Wyoming Game and Fish Departments' (Department) Wildlife Observation System (WOS).

Our objectives were to follow established guidelines and use remote cameras (PC800 Reconyx, Holmen, WI) and enclosed bait tubes to document flying squirrels and establish a baseline for long-term surveillance in the Black Hills. Additionally we evaluated important components of habitat that can be used to predict presence of flying squirrels as outlined in the Wyoming State Wildlife Action Plan (WGFD 2010).

METHODS

Our study was located in the Black Hills National Forest (BHNF) in northeastern Wyoming (Fig. 1). Specifically, we conducted surveys in the Bear Lodge Mountains and the Wyoming segment of the Black Hills, with elevations ranging from 1365 m to 1862 m in the Bear Lodge Mountains and 1391 m to 1907 m in the Black Hills.

We used camera-trapping protocols established by Van Fleet and Grenier (2012) and outlined in Cudworth et al. (2013) to conduct surveys. We used GIS (ArcGIS 10.1, ESRI, Redlands, CA) to create a grid of 4ha cells (hereafter, "plots") over the Black Hills and Bear Lodge Mountains. We randomly selected plots for survey that contained ponderosa pine to maximize our detection probabilities for flying squirrels. If a pre-selected plot was not accessible due to impassable or closed roads, we selected a suitable replacement site within the same drainage. We completed surveys between 12 August and 13 October 2014 to coincide with juvenile dispersal in an attempt to, again, maximize detection probabilities (Kreuger 2004, Van Fleet et al. 2014).

In conjunction with camera surveys, we randomly selected three survey stations within each 4-ha survey plot and collected data for several habitat variables based on protocols established by Van Fleet and Grenier (2012; Table 1). Additionally, we recorded presence of arboreal lichen (*Bryoria* spp.; lichen), mushrooms, witches' broom, distance to water, and natural or excavated tree cavities within the plot, which may influence occupancy of flying squirrels (Pyare and Longland 2002, Hough and Dieter 2009*a*, Van Fleet 2015).

We evaluated the probability of occupancy of flying squirrels at our study sites based on habitat variables we collected. All analyses were conducted by using program PRESENCE (Hines 2010). We first completed univariate analysis to estimate the effect of each habitat covariate independently on occupancy while detection was held constant. We compared the Akaike Information Criterion weight (AIC weight; Burnham and Anderson 1998) of each of these models to the constant model psi(.)p(.). All variables found during the univariate analysis to have an AIC weights less that of model psi(.)p(.) were considered to have no significant effect on occupancy and were removed from subsequent analyses. We then generated a model set where occupancy was allowed to vary as a function of all multivariate combinations of those remaining habitat covariates and where detection was either constant or varied by time. No additional detection covariates were considered in this analysis. We used weight-model averaging based on AIC weights to determine the effect sizes for the top five models.

RESULTS

We surveyed 23 plots (11 in the Bear Lodge Mountains, 12 in Black Hills) for a total of 1,808 camera nights (Fig. 1). We lost 32 camera nights to camera malfunctions or human error. We recorded 351 unique detections (i.e., photographs of flying squirrel >1 hr apart) on 20 plots (8 in the Bear Lodge Mountains and 12 in Black Hills). We sampled 1,595 live trees and 312 snags at 69 stations. All sites had varying amounts of ponderosa pine, and sites near water sources contained patches of aspen and paper birch. Bur oak was found at all sites in the Bear Lodge Mountains. Plots occupied by flying squirrels had a predominantly south or southwest mean aspect of 192°, while unoccupied plots had a mean southeastern aspect of 119°. All observations of flying squirrels and non-target species were entered into the Department's Wildlife Observation System database.

During univariate analysis, we found the habitat variables of number of heavily decayed, class 3 logs (Ganey and Vojta 2010), aspect, and distance to sapling to have a significant effect on occupancy [i.e., AIC weights greater the model psi(.)p(.)]. We generated a multivariate model set based on these three occupancy covariates and found model psi(Class3 + SapDist)p(Time) to be the top rank model based on AIC weight (AIC weight = 0.295). The averaged probability of occupancy derived from this top model for all of our sites was 0.870 (95% CI 0.664-0.958). Top five models, AIC weights, and covariate effect sizes are shown in Table 2.

Based on modeling averaging of the top five models, we found covariates of number of class 3 logs ($\beta = 3.889$, SE = 2.821) and aspect ($\beta = 1.131$, SE = 1.895) to have a positive effect, and greater distance to saplings ($\beta = -0.423$, SE = 0.689) to have a negative effect on occupancy of flying squirrels. Values for top five models are listed in Table 2. Models that allowed detection to vary with time consistently outranked those models where detection remained constant. The effect of time on detection is graphed in Figure 2.

DISCUSSION

Prior to our surveys in the Black Hills, observations of flying squirrels were rare throughout the region, likely due to the nocturnal activity patterns of this species. Our camera surveys documented the presence of squirrels at 20 out of 23 sites, suggesting that this SGCN is relatively common in the Black Hills. Results in the Wyoming Range were similar with 33 of 48 sites occupied by flying squirrel (Van Fleet et al. 2014). Our survey effort has proven to be highly effective at establishing a baseline for evaluating long-term population trends in Wyoming, as we recorded high rates of occupancy and detection using a straightforward and non-invasive technique that can be easily repeated during future surveys.

Even within the relatively small number of sites surveyed, we found extensively decayed or class 3 logs to have significant strong positive effect on occupancy of flying squirrels. Class 3 logs are important structural and functional components in forest ecosystems; providing cover from predators and absorbing and retaining water, which are important for fungi growth (Maser and Trappe 1984, Pyare and Longland 2002). Although mychorrizal fungi are associated with live hosts, studies found fungi more prevalent closer to heavily decayed logs that provided the moist sites needed for mychorrizal fruiting bodies (Waters et al. 1997, Carey et al. 1999). Flying squirrels in the Black Hills may be selecting for these sites that offer both protection from predators and food availability.

The mean aspect (192°) was also significant in our ability to detect flying squirrels. In fact, previous studies in the Wyoming Range also had a mean southwest aspect of 192° (Van Fleet et al. 2014). Whether this is coincidence or significant is unclear. Previous analysis conducted in the Black Hills suggested that flying squirrels were less likely to occur in areas with a southern aspect (Hough and Dieter 2009*b*). Additionally, a southwest aspect contradicts what is known about flying squirrel habitats, which are considered to be cool, moist areas with an abundance of mature trees, decayed logs, large snags, and lichen (Weigl 2007). However, Daniels et al. (1999) reported that as elevation increases, aspect plays a smaller role in

determination of forest type. Flying squirrels may be selecting for the cool, micro-habitats that occur throughout the forest, including the southwest aspect. Further investigation into the significance of aspect is warranted.

Interestingly, the increased distance to saplings from the bait tree was found to have a slightly negative effect on occupancy of flying squirrels. This may be a function of predator avoidance while foraging on the forest floor, or soil moisture and composition more conducive for sapling growth. Another hypothesis may be that saplings are acquiring nutrients the mychorrizal fungi are providing to the mature ponderosa pine tree where the enclosed bait tube was located. The hyphae of these underground fungi form associations with tree roots, greatly increasing their surface area for the absorption of water and minerals (Maser and Maser 1998). According to Weigl (2007), many tree species grow poorly or not at all without mycorrhizae, and Gomez et al. (2005) found a direct correlation between flying squirrel density and abundance of mycorrhizal fungi. Due to time constraints and limited personnel, we were unable to quantify availability of this important food item. We recommend that future surveys consider characterizing availability of mycorrhizal fungi and distance to saplings, which may affect occupancy of flying squirrels.

In our efforts to evaluate the important habitat component for flying squirrels, we failed to detect a significant difference in occupancy as a function of habitat variables [slope, diameter at breast height (DBH), basal area, canopy cover, and snags] and micro-habitat components (mushrooms, lichen, witches' broom, tree cavities, and distance to water) that we anticipated could be important to habitat selection for flying squirrels in the Black Hills region based on previous literature (Krueger 2004, Hough and Dieter 2009*a*,*b*,*c*, Gabel et al. 2010). However, our study was hindered by both a relatively small number of sites and a lack of variation across sites in many of the habitat variables we measured. Both of these issues can make it difficult to accurately ascertain the effect sizes of covariates, as well as reduce statistical power. Therefore, we believe that certain habitat features that we frequently observed at occupied sites, such as the presence of lichen, may be an important determinant in habitat selection for flying squirrels, even though our modeling approach failed to detect a measurable effect. For example, in the Black Hills, lichen was detected on 90% of trees in occupied plots, with similar results in Teton County (85%; Van Fleet 2015). Lichen is often used by flying squirrels as denning and nesting material but is also an important winter food source when snow depths prevent foraging for truffles on the forest floor (Maser et al. 1986, Waters et al. 2000). Flying squirrels may be selecting these sites due to the availability of lichen; this merits further investigation.

Based on the statistical limitations we encountered in this study, we recommend that future efforts to measure the influence of habitat components on occupancy of flying squirrels consider a study design that increases the number of surveyed sites and captures greater variation in habitat variables thought to be important to habitat selection. Specifically, we suggest two major modifications that are likely to increase the statistical power in assessing habitat components. First, based on the high rate of detections we observed, we believe that the number of camera stations per grid could be reduced from 16 to 8-12, which would still produce a sufficiently high rate of detection across sites. By freeing up cameras to be deployed at additional sites, this modification would enable a greater number of sites to be surveyed without a substantial increase the amount of effort (i.e., manpower). Second, we suggest that study

design include a subset of sites that contain a diversity in macro- and micro-habitat attributes and/or that are expected to be less likely to be occupied by flying squirrels based on habitat components (i.e., shelterwood sites that remove snags and logs). Importantly, we acknowledge that these modifications may only be appropriate for the conditions we experienced within the Black Hills region, and surveys in other regions should consider the usefulness of these changes on a case-by-case basis.

Our survey method has proven to be an effective method for detecting flying squirrels. During the past three summers, we have been able to revise the known distribution for this secretive species and develop a baseline occupancy model for future monitoring efforts in the Wyoming Range and the Black Hills (Van Fleet et al. 2014, Van Fleet 2015). Although the flying squirrel appears to be more common than previously believed (WGFD 2010), this SGCN is still vulnerable to population declines due to fire, logging, and pine beetle kill that removes mature trees, snags, and logs. 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.

ACKNOWLEDGEMENTS

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Table 1. Description of habitat variables collected within three 7-m radius habitat sampling stations at 23 plots in the Black Hills National Forest, Crook County, Wyoming, 2014.

Habitat variables	Description
Elevation	Taken at bait tree in meters
Aspect	Direction of slope from bait tree
Slope	Degree of gradient from bait tree
Basal area	Mean basal area (m^2/ha) of station
DBH	Average of trees and snags with DBH >10 cm
Snag class	Rating of 1-5 based on Ganey and Vojta (2007)
Logs	Sum of downed logs ≥20 cm, 7-m radius of bait tree
Logs in "class 3"	Sum of heavily decayed, downed logs, 7-m radius of bait tree
Overstory cover	Mean percentage canopy cover at 4 m in each cardinal direction
Primary understory	% of sapling, shrub, forb, other in each quadrant
Distance to cover	Distance to understory cover in meters in each quadrant
Distance to stream	Distance to water in meters
Mushrooms	Presence of mushroom, 7-m radius of bait tree
Lichen	Presence of lichen
Witches' broom	Presence of witches' broom
Tree cavity	Presence of natural or excavated cavities

Table 2. Values for top five models of occupancy of northern flying squirrels (*Glaucomys sabrinus*) derived from capture histories obtained during surveys conducted at 23 plots in the Black Hills National Forest, Crook County, Wyoming, 2014. We also provide the model averaged estimates from these top five models.

Model	AIC	Delta AIC	AIC weight	β MClass3	SE MClass3	β aspect	SE aspect	β SapD	SE aspect
psi(MClass3+SapD),p(Time)	124.38	0	0.295	3.241	1.046	0	0	-1.210	0.992
psi(MClass3+Aspect),p(Time)	124.5	0.12	0.278	4.881	3.376	2.413	1.936	0	0
psi(MClass3),p(Time)	124.84	0.46	0.235	3.202	0.997	0	0	0	0
psi(MClass3+Aspect+SapD),p(Time)	125.27	0.89	0.189	4.302	4.699	2.424	3.156	-0.346	0.5061
psi(MClass3),p(.)	135.49	11.11	0.001	3.202	0.999	0	0	0	0
Model averaged				3.889	2.821	1.131	1.895	-0.423	0.689

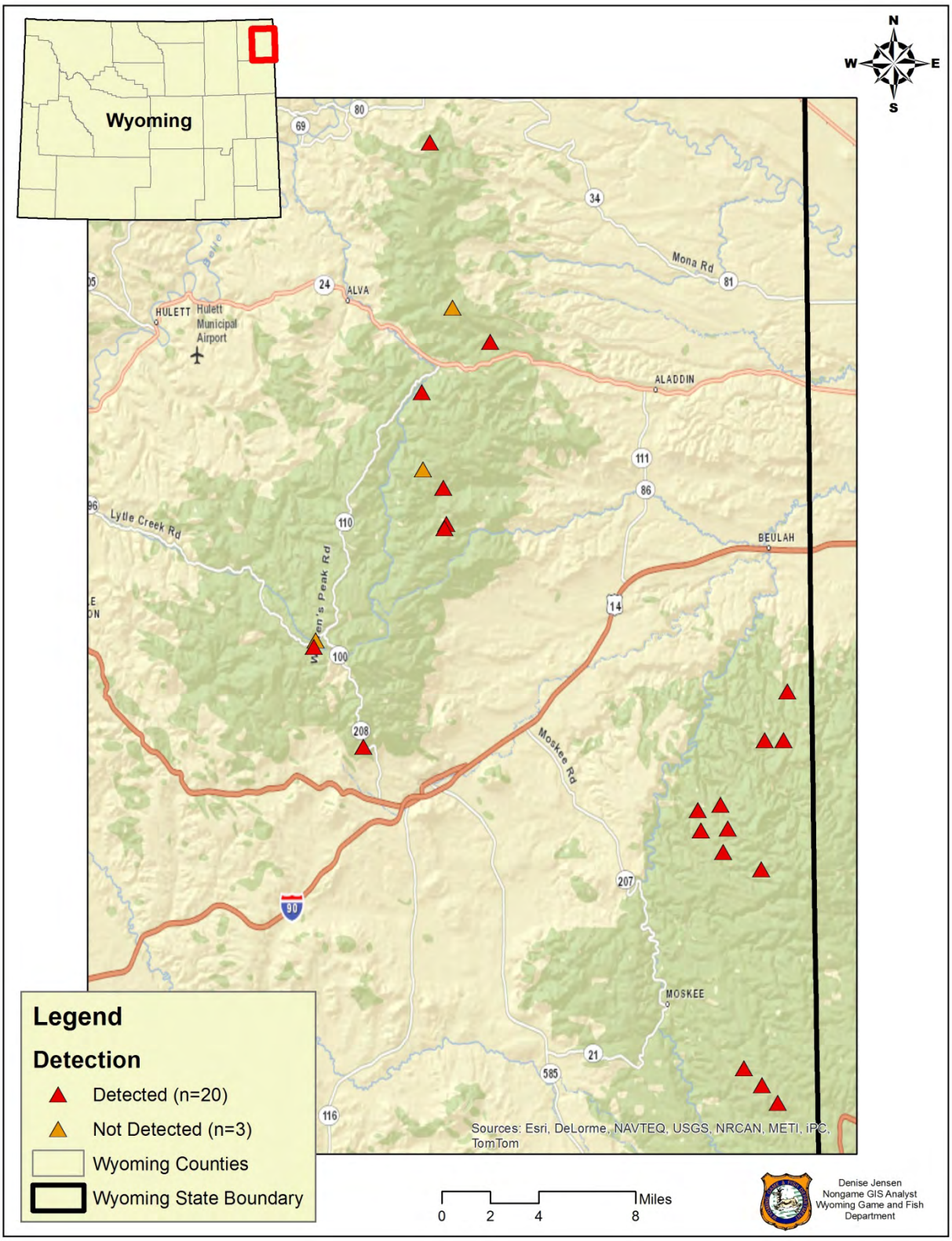

Figure 1. Study area, locations of survey plots, and detections of northern flying squirrels (*Glaucomys sabrinus*). Surveys were conducted from 12 August through 13 October 2014 in the Black Hills National Forest, Crook County, Wyoming.

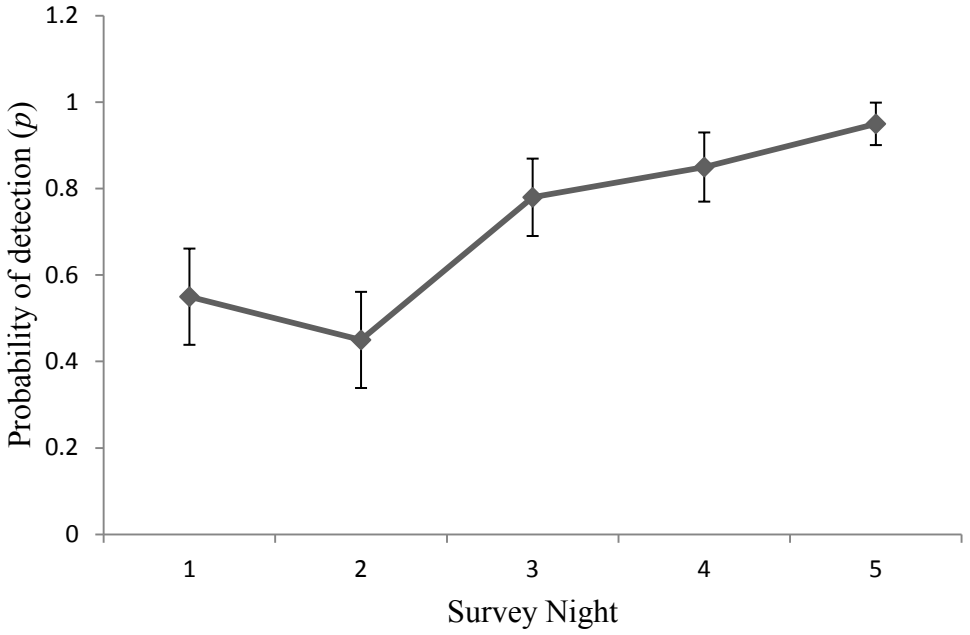

Figure 2. Average probability of detection by survey night ($p \pm$ SE) of northern flying squirrels (*Glaucomys sabrinus*) for all plots from August-October 2014 (n = 23) in the Black Hills National Forest, Wyoming.

ASSESSING TRENDS OF WATER VOLE (*MICROTUS RICHARDSONI*) IN THE BIG HORN MOUNTAINS OF WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Water Vole

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

PROJECT DURATION: 1 July 2013 – 30 June 2015

PERIOD COVERED: 1 June 2014 – 31 October 2014

PREPARED BY: Brian M. Zinke, Nongame Biologist

ABSTRACT

Historic glaciation cycles have left remnant populations of species restricted to mountain top refugias. Small mammals are particularly susceptible to such isolation due to their limited long-distance mobility. The water vole (*Microtus richardsoni*) is a habitat specialist constrained to subalpine streams, increasing its risk of isolation and small population sizes. Due to its vulnerability to local extinction in the Big Horn Mountains of Wyoming, the water vole has been listed as a Sensitive Species by the US Forest Service and a Species of Greatest Conservation Need by the Wyoming Game and Fish Department. We conducted a live-trapping survey for water vole in the Big Horn Mountains to increase distributional records and to form a baseline for future trends. Of the 22 sites surveyed, we captured water voles at 4 locations. The two habitat types in which we detected water voles were mountain big sagebrush and subalpine meadows. Lodgepole pine, clearcut conifer, and mixed grass prairies were also surveyed, but we detected no water voles in these habitat types. Stream and vegetation characteristics that were significantly different between habitat types in which water voles were detected and not detected were bankfull width/depth ratio, bankfull width, wetted width, stream slope, and thallophyte and litter cover. Within the habitat types in which water voles were detected, thallophyte cover and stream slope were significant factors between sites of detection and non-detection. As a result of our low detection rates, coupled with the species' vulnerability to local extinction, future studies should continue to increase the known distribution of water vole. Other factors that might affect the water vole's distribution and that warrant further investigations include livestock grazing, soil properties, and interactions with other species.

INTRODUCTION

Numerous species have been restricted to mountain top refugias following the recession of the Pleistocene glaciers, including American pika (*Ochotona princeps*; Hafner and Sullivan 1995, Smith 1999), snowshoe hare (*Lepus americanus*; Murray 1999), and montane vole (*Microtus montanus*; Jannett 1999). The water vole (*Microtus richardsoni*) is another such species (Hoffman and Koeppl 1985), occurring at elevations between 914 to 3,201 m in the US (Ludwig 1984). Over the extent of its distribution, the water vole occupies a highly discontinuous range of mountainous habitat (Ludwig 1981, Hoffman and Koeppl 1985, Klaus et al. 1999). The water vole is a habitat specialist, typically restricted to linear stretches of habitat alongside alpine and subalpine streams (Pattie 1967, Hooven 1973, Anderson et al. 1976, Clark and Stromberg 1987, Ludwig 1988). These areas are generally characterized as having narrow stream channels, a well-developed soil substratum, 5° slope, and gravel bottoms (Pattie 1967, Anderson et al. 1976, Ludwig 1981, Getz 1985, Reichel 1986, Blankenship 1995). Additionally, these areas are primarily composed of mid- to late seral stage vegetation composed of willows, sedges, grasses, and forbs (Pattie 1967, Anderson et al. 1976, Ludwig 1981, Getz 1985, Reichel 1986, Blankenship 1995).

Due to the water vole's narrowly defined habitat preferences and the patchy distribution of its suitable habitat, movement between populations and habitat patches is limited (Klaus et al. 2001, Klaus and Beauvais 2004). Habitat and geomorphic features, including large expanses of coniferous forests, valleys, and high-sloped mountainsides, present physical barriers to dispersal for the water vole (Brown 1971, Ludwig 1988). Where water voles do occur, they live in groups of 8-40 individuals, with population densities remaining low (Hooven 1973, Anderson et al. 1976, Clark and Stromberg 1987, Ludwig 1988). Despite possessing the characteristics associated with high reproductive capabilities that other microtine rodents share (Hasler 1975, Brown 1977, Jannett et al. 1979), water vole populations remain small and do not exhibit the characteristic population cycles associated with other microtines (Anderson et al. 1976, Pattie 1967, Klaus 2003).

The combination of the water vole's habitat specificity, small population sizes, limited dispersal abilities, low colonization rates, and high extinction rates results in low population densities that are subject to habitat degradation and local extinction within the state (Brown 1971, Ludwig 1988, Friedlander 1995, Klaus et al. 1999, Kenaith et al. 2003, Klaus 2003). As a result, the water vole has been listed as a sensitive species (Friedlander 1995) in the Forest Service's Region 2 and a Species of Greatest Conservation Need (SGCN) in the state of Wyoming (WGFD 2010).

The objectives of this study were to: 1) increase the records of known occurrences of water voles in the Big Horn Mountains; 2) estimate occupancy of water voles throughout the Big Horn Mountains to provide a baseline with which to monitor trends; 3) collect opportunistic records of other SGCN; and 4) analyze and update species distributions in the Wildlife Observation System, State Wildlife Action Plan, and the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming.

METHODS

The Big Horn Mountains are located in north-central Wyoming and are geographically isolated from the Rocky Mountains to the west. Within the Big Horn Mountains, we selected sampling locations based on suitable habitat for water vole. We defined suitable habitat as areas: ≥2400 m in elevation, located within 0.5 km of a first or second order stream, and located within 0.5 km of roads for accessibility. In selecting sampling locations, we excluded the Cloud Peak Wilderness Area, as well as any privately owned land. We laid a 1.6 km × 1.6 km grid system over the Big Horn Mountains, and grid cells with less than 50% suitable habitat were excluded from further selection. We then sorted grid cells by slope, with the target slope being 8% (~5°) or less. Cells with less than 8% of the area having the target slope were excluded to narrow down potential sites. Of the remaining 93 grid cells, we randomly selected 35 cells, with 28 as the study sites and 7 as alternates, if needed.

We trapped each site for four consecutive nights, with two sites being trapped simultaneously. We placed a trapping transect, consisting of approximately 200 Sherman live-traps (Model #339A; H. B. Sherman Traps, Inc., Tallahassee, FL), parallel to one edge of the stream. We positioned the traps within 5 m of the stream and 3 m apart. Each transect was approximately 600 m long, based on the number of traps set. We baited traps with a mixture of peanut butter and oats, wrapped in wax paper with holes poked in it to release the scent. We also supplied traps with Poly-fil bedding to reduce temperature-related fatalities. We left traps open all day and checked them twice, once in the morning and once in the evening. Trapping intervals were calculated following the method outlined by Klaus (2003).

When an individual was captured, we removed it from the trap by using a Ziploc bag. For all captured individuals, we recorded species, mass, sex, age, reproductive condition, and whether it was dead or alive. For vole species (*Microtus* spp.), we measured the hind foot, tail, and body lengths. To determine if it was a water vole, the hind foot had to be ≥25 mm and the tail ≥70 mm (for adults only; Clark and Stromberg 1987). If the captured individual was a water vole, we scanned it to determine if it had been previously caught and tagged with a passive integrated transponder tag (PIT tag; AVID Microchip I.D. Systems, Folsom, LA) during our study. If tagged previously, we recorded the unique identifying number. If not tagged previously, we sedated the individual in the Ziploc bag by using isoflurane. Once the animal was sedated, we injected a PIT tag and recorded the unique identifying number. We followed the guidelines on capture and handling techniques outlined by Cudworth et al. (2013).

We assigned each small mammal trapping station a number, starting upstream with number one and working downstream. We selected 15 random trap station numbers at which to conduct vegetation sampling. At each selected station, sampling was conducted 1 m to the non-stream side of the trap station to reduce trampling of the vegetation. We dropped a 50 × 50 cm Daubenmire frame at each sampling location (Daubenmire 1959). We recorded aerial cover for grasses, forbs, shrubs, sedges and rushes, ferns, thallophytes, horsetails, trees, water, bare ground, litter, and standing dead vegetation. We also placed a 1.5 m cover pole, which consisted of alternating-color 5 cm bands, at each sampling location. We took readings at a distance of 4 m and height of 1 m, recording the lowest band that was at least half visible (Robel et al. 1970). Two cover pole readings were taken at each sampling location, one upstream and one downstream of the cover pole.

For stream sampling, we used 10 of the random trap station numbers previously selected for the vegetation sampling. At each of the selected trap stations, we sampled the stream cross-section. Several of the techniques we used were modified from Rosgen and Silvey (1998). At each cross-section, we measured the water and bankfull depths on the left side, center, and right side of the stream. Left and right sides were designated as looking upstream. We also measured the width of the stream at water and bankfull levels. We conducted pebble counts at each cross-section, consisting of 10 substrate samples which we measured and categorized into groups. Additionally, we characterized each stream by walking the length of the trapping transect and recording the character of the stream (pool, riffle, run) at each trap station. We measured stream slope by using a Suunto PM-5/360 PC clinometer (Suunto, Vantaa, Finland), taking readings at trap stations 1, 100, and 200. We then averaged the three readings to obtain the average slope of the stream segment. Finally, we used the above information to determine the Rosgen class for each stream sampled.

We used *t*-tests to determine any significant differences in vegetation and stream characteristics between habitat types and sites where water voles were captured and not captured. For the aerial cover samples of vegetation, we chose to use the Benjamin and Yekutieli correction for multiple tests because it balances both Type 1 and Type 2 errors better than the Bonferroni correction (Narum 2006).

RESULTS

We surveyed 22 of the 35 randomly selected sites, which consisted of mountain big sagebrush, subalpine meadow, lodgepole pine, clearcut conifer, and mixed grass prairie habitat types, and averaged 668 trap intervals per trapping session (Table 1; Figs. 1-2). We captured water voles at four of the sites surveyed (Table 2). Water voles were captured in mountain big sagebrush and subalpine meadow habitat types, which together exhibited lower slopes, bankfull width/depth ratios, mean bankfull widths, and mean wetted widths than the combined mixed grass prairie, lodgepole pine, and clearcut conifer habitat types (Table 3). When sites within the mountain big sagebrush and subalpine meadow habitat types were separated based on captures of water vole, slope was marginally significantly lower where voles were captured (Table 4). The streams at the sites where water voles were captured were classified as G or E on the Rosgen scale (Rosgen 1994), and had a dominant substrate of either pebble gravel or cobble (Table 1). Of the 16 total captures of water vole, there was no difference in stream character at trap stations where they were captured, as nine occurred at riffles, four at runs, and three at pools in the stream ($\chi^2_2 = 2.80$, $P = 0.25$).

The habitat types in which water voles were detected had significantly lower aerial cover of thallophytes and litter than habitat types in which they were not detected, but had marginally significantly higher cover of sedges and rushes (Table 3). Within the two habitat types in which water voles were captured, thallophytes was the only cover type that was significantly higher at sites where water voles were captured compared to sites of non-capture (Table 4). The difference in visual obstruction was marginally significant between habitat types, with mountain big sagebrush and subalpine meadows having slightly taller vegetation structure (Table 3).

There was no difference in visual obstruction between sites where water voles were captured and not captured within mountain big sagebrush and subalpine meadow habitats (Table 4).

Of our 774 total captures, we had 758 captures of 11 non-target species. The non-target species we captured, in order of most captures, were southern red-backed vole (*Clethrionomys gapperi*, *n* = 158), water shrew (*Sorex palustris*, *n* = 73), least chipmunk (*Neotamias minimus*, *n* = 53), western jumping mouse (*Zapus princeps*, *n* = 23), montane vole (*Microtus montanus*, *n* = 19), red squirrel (*Tamiasciurus hudsonicus*, *n* = 18), masked shrew (*Sorex cinereus*, *n* = 12), dusky shrew (*Sorex monticolus*, *n* = 9), ermine (*Mustela erminea*, *n* = 1), long-tailed vole (*Microtus longicaudus*, *n* = 1), and Dark-eyed Junco (*Junco hyemalis*, *n* = 1). We also captured a large number of voles (*Microtus* spp.), deer mice and white-footed mice (*Peromyscus* spp.), and shrews (*Sorex* spp.), of which we were not able to identify (*n* = 230, 114, 15, respectively). One capture of water shrew updated that species' known distribution in the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming in latilong five (Orabona et al. 2012; Table 5).

DISCUSSION

Our captures contributed new records to the known distribution of water vole in the Big Horn Mountain range. We did not detect any water voles below 44.6° latitude, despite the historic and predicted ranges indicating their presence there. Although we sampled 22 sites, we detected water voles at only 4 sites. Our low capture rates were not unexpected, though, as water voles are less abundant in the Bighorn National Forest compared to the nearby Shoshone National Forest (Klaus 2003, Klaus and Beauvais 2004). With so little detection, occupancy modeling was not a viable option.

Water voles are most often associated with alpine or subalpine meadows, but can also be found in other habitat types, such as old growth forests (Doyle 1987). We surveyed multiple habitat types, but water voles were only captured in mountain big sagebrush and subalpine meadow habitats. Stream characteristics that were significantly different between habitat types in which water voles were detected and not detected were bankfull width/depth ratio, bankfull width, and wetted width. However, within the mountain big sagebrush and subalpine meadow habitats, none of the stream characteristics differed between sites where water voles were captured and not captured. This supports the results of Ludwig (1981), which found that water depth and width in subalpine streams was not a good predictor of water vole presence. Further, water voles typically inhabit streams with an 8% (~5°) slope or less; however, we detected water voles only at streams with a slope of 2% (~1°) or less. This indicates that stream gradient might be more restrictive than previously thought. Overall, the Rosgen classification (G and E) and dominant substrate (pebble gravel and cobble) of the streams at which we detected water voles align well with the results of Klaus (2003).

Thallophyte and litter cover were higher in the three habitat types in which water voles were not captured. Two of these three (lodgepole pine, and clearcut conifer) are forest-type habitats, which typically have a more prevalent litter layer and higher presence of thallophytes. Although the mountain big sagebrush and subalpine meadow habitat types had lower thallophyte

cover than the other three habitats, the sites in which water voles were captured had higher cover of thallophytes than sites where water voles were not captured. Thallophytes are not known to be a food source for water vole (Anderson et al. 1976, Ludwig 1981), yet Klaus (2003) has shown water vole presence to be associated with thallophyte cover. Our data suggest that, within the Big Horn Mountains, thallophyte cover might only be a good predictor of water vole presence within the mountain big sagebrush and subalpine meadow habitat types.

Livestock grazing of riparian zones is detrimental to water voles for multiple reasons, including the compaction of soil, widening of stream channels, changes in soil moisture, and increased erosion (Klaus 2003). Another result of grazing is the reduction of plant cover, which influences predation, habitat security, and food resources of voles (Birney et al. 1976). Our visual obstruction measurements of the vegetation exhibited marginal differences between habitat types and no difference between sites where water voles were captured and not captured. This suggests that, although grazing influences water vole presence, it seems that the height of the vegetative structure is not the driving factor.

It is critical to note that one of the major identifying characteristics of water voles, according to many field guides, is not always true. Many sources, including the species account of *Microtus richardsoni*, state that there are five pads on the sole of the hind foot (Ludwig 1984, Reid 2006). However, Klaus and Beauvais (2004), as well as our own observations during this study, refute this characteristic as an identifying feature, as water voles can have six pads on the hind foot. Thus, we recommend not using the number of foot pads as a distinguishing characteristic of water vole.

Little is known about the water vole in the Big Horn Mountains. Because the water vole in the Big Horn Mountains has small population sizes and is isolated from populations in other mountain ranges, it is at risk of local extinction (Klaus 2003, Klaus and Beauvais 2004). Future studies should continue to update the known distribution of water vole within the Big Horn Mountains, as well as factors affecting its distribution, including but not limited to livestock grazing, soil properties, and interactions with other species (e.g., beaver). We have selected sites that should be given priority for subsequent water vole surveys (Fig. 4). These selections are based on our original site selection criteria, plus the exclusion of habitat types in which we did not detect water voles in this study, with one exception. We included the mixed grass prairie habitat type as a habitat that is suspected to be used by water vole, based on historic sightings. Based on these criteria, there are 45 sites which should be given priority, including 35 subalpine meadows, two mountain big sagebrush, and eight mixed grass prairie sites. About half of these sites are below 44.6° latitude and would help determine if the water vole still occurs in the southern portion of the Big Horn Mountains. The Cloud Peak Wilderness Area has no records of water vole due to its difficulty of access, and surveys there would likely prove very beneficial to fill in gaps in the water vole's distribution, as well. Further, many small mammal species in the Big Horn Mountains are designated as subspecies, including the American pika (*O. princeps obscura*), montane vole (*Microtus montanus zygomaticus*), snowshoe hare (*L. americanus seclusus*), and least chipmunk (*N. minimus confinis*). It is possible, with its isolation, that the water vole in the Big Horn Mountains might be a subspecies, as well, and this warrants further investigating.

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Table 1. Stream and site data for locations surveyed for water vole (*Microtus richardsoni*) in the Big Horn Mountains of Wyoming, 2014.

Stream Name	Dates trapped	GPS (Zone 13T)		Elevation		Rosgen class	Dominant substrate	Habitat type
		Upstream	Downstream	Upstream	Downstream			
North Fork Crazy Woman Creek	6/24-6/28	0343710E 4890705N	0343902E 4890713N	2,470	2,467	B4a	Pebble Gravel	Clearcut Conifer
Bull Creek	8/25-8/29	0325083E 4891479N	0324750E 4891850N	2,709	2,696	G4	Pebble Gravel	Subalpine Meadow
Willow Creek	6/24-6/28	0346106E 4895735N	0346061E 4895426N	2,491	2,481	G4	Pebble Gravel	Clearcut Conifer
West Tensleep Creek	6/30-7/04	0321522E 4899211N	0321818E 4898942N	2,649	2,639	B3a	Cobble	Lodgepole Pine
West Tensleep Creek	8/25-8/29	0322453E 4901697N	0322591E 4901385N	2,710	2,709	B4	Pebble Gravel	Lodgepole Pine
Middle Tensleep Creek	6/30-7/04	0323425E 4903123N	0323420E 4902574N	2,759	2,748	B2a	Boulder/ Cobble	Lodgepole Pine
Buckskin Ed Creek	7/07-7/11	0317792E 4905169N	0317414E 4905130N	2,742	2,716	A4	Pebble Gravel	Clearcut Conifer
Middle Paint Rock Creek	7/07-7/11	0316820E 4907288N	0316309E 4907239N	2,735	2,702	A3	Cobble	Clearcut Conifer
Unnamed	7/14-7/18	0301986E 4944220N	0302016E 4943819N	2,701	2,691	G4	Pebble Gravel/ Silt/Clay	Mountain Big Sagebrush
West Fork/Unnamed	7/14-7/18	0301796E 4945052N	0301775E 4944559N	2,716	2,715	G4	Pebble Gravel	Mountain Big Sagebrush
East Fork/ Mohawk Creek	7/28-8/01	0309942E 4944442N	0309556E 4944365N	2,805	2,800	E4	Pebble Gravel	Subalpine Meadow

Table 1. Continued.

Stream Name	Dates trapped	GPS (Zone 13T)		Elevation		Rosgen class	Dominant substrate	Habitat type
		Upstream	Downstream	Upstream	Downstream			
Prospect Creek/ Unnamed	7/14-7/18	0300731E 4946738N	0301010E 4946361N	2,774	2,739	A4	Pebble Gravel	Subalpine Meadow
West Fork/Bruce Creek	7/14-7/18	0303395E 4946598N	0303257E 4947029N	2,710	2,708	E4	Pebble Gravel	Mountain Big Sagebrush
Graves Creek	7/28-8/01	0308705E 4948186N	0308313E 4948240N	2,724	2,724	E4	Pebble Gravel	Lodgepole Pine
Owen Creek	7/21-7/25	0301959E 4954179N	0301906E 4953294N	2,584	2,566	G2	Boulder/ Cobble	Subalpine Meadow
Unnamed Branch	8/18-8/22	0309958E 4953993N	0309567E 4953814N	2,630	2,570	G4	Pebble Gravel	Clearcut Conifer
Copper Creek	7/21-7/25	0305307E 4954179N	0305424E 4954530N	2,536	2,532	E4	Pebble Gravel	Subalpine Meadow
Big Willow Creek	8/11-8/14	0297437E 4957355N	0297453E 4957769N	2,500	2,493	G4	Pebble Gravel	Subalpine Meadow
Prune Creek	8/18-8/22	0307411E 4958683N	0307143E 4959008N	2,468	2,446	G4	Pebble Gravel	Lodgepole Pine
Big Willow Creek	8/11-8/15	0298789E 4959849N	0298892E 4960388N	2,449	2,438	E3	Cobble	Subalpine Meadow
Porcupine Creek	8/04-8/08	0274541E 4968177N	0274134E 4968492N	2,674	2,659	G3	Cobble	Mixed Grass Prairie
Big Tepee Creek	8/04-8/08	0271625E 4974828N	0271195E 4974640N	2,524	2,507	A4	Pebble Gravel/ Cobble	Mixed Grass Prairie

Table 2. Location, date, habitat type, age class, sex, reproductive condition, and morphometric measurements of water voles (*Microtus richardsoni*) captured in the Big Horn Mountains of Wyoming, 2014.

Site and survey date	Habitat type	Species	Age[a]	Sex	Reproductive	Mass (g)	Hind foot (mm)	Tail (mm)	Total length (mm)
West Fork/Unnamed									
15-July	Mountain Big Sagebrush	*M. richardsoni*	Class I	F	No	25	25	45	136
16-July	Mountain Big Sagebrush	*M. richardsoni*	Class II	M	No	56	29	63	183
16-July	Mountain Big Sagebrush	*M. richardsoni*	Class I	F	No	29	29	44	117
17-July	Mountain Big Sagebrush	*M. richardsoni*	Adult	M	Yes	149	29	87	232
17-July	Mountain Big Sagebrush	*M. richardsoni*	Class I	F	No	29	28	50	136
West Fork/Bruce Creek									
17-July	Mountain Big Sagebrush	*M. richardsoni*	Adult	M		111	27	80	234
17-July	Mountain Big Sagebrush	*M. richardsoni*	Class II	F	Yes	73	26	56	182
19-July	Mountain Big Sagebrush	*M. richardsoni*	Class I	F	No	46	27	60	166
18-July	Mountain Big Sagebrush	*M. richardsoni*	Adult	F	Yes	105	26	86	225
East Fork/Mohawk Creek									
29-July	Subalpine Meadow	*M. richardsoni*	Adult	M	No	120	28	76	146
30-July	Subalpine Meadow	*M. richardsoni*	Class II	F	No	50	26	55	
30-July	Subalpine Meadow	*M. richardsoni*	Adult	F	Yes	109	26	82	
1-August	Subalpine Meadow	*M. richardsoni*	Class II	F	No	50	26	62	
1-August	Subalpine Meadow	*M. richardsoni*	Class I	F	No	48	26	56	
1-August	Subalpine Meadow	*M. richardsoni*	Class I	F		44	27	56	
Big Willow Creek									
14-August	Subalpine Meadow	*M. richardsoni*	Class II	M	Yes	58	27	65	185

[a]Age classes follow those outlined by Klaus et al. (1999).

Table 3. Comparison of stream and vegetation characteristics of habitat types in which water voles (*Microtus richardsoni*) were captured (mountain big sagebrush/subalpine meadows) and not captured (mixed grass prairie/lodgepole pine/clearcut conifer) in the Big Horn Mountains of Wyoming, 2014. Stream, aerial cover, and visual obstruction measurements follow the methods outlined by Rosgen and Silvey (1998), Daubenmire (1959), and Robel et al. (1970), respectively.

Site characteristics	Mountain Big Sagebrush/ Subalpine Meadow	Mixed Grass Prairie/Lodgepole Pine/Clearcut Conifer	*t*	df	*P*-value
Number of Sites	10	12			
Stream					
Slope (%)	2.32	3.87	2.380	19.62	0.028[b]
Width/Depth Ratio	6.02	11.72	3.033	12.68	0.010[b]
Mean Bankfull Depth[a] (cm)	45.46	50.80	0.987	18.89	0.336
Mean Bankfull Width[a] (cm)	273.50	643.78	2.525	11.83	0.027[b]
Mean Wetted Depth[a] (cm)	23.53	28.17	0.957	17.30	0.352
Mean Wetted Width[a] (cm)	193.57	532.98	2.322	11.89	0.039[b]
Vegetation					
Mean Aerial Cover (%)					
Grasses	16.27	13.31	-0.639	19.35	0.530
Forbs	32.96	28.03	-1.120	19.80	0.276
Shrubs	13.80	5.82	-1.986	13.69	0.067
Sedges/Rushes	19.59	11.60	-2.288	19.16	0.034
Thallophytes	2.18	7.59	3.378	12.19	0.005[c]
Horsetails	2.73	1.33	-0.774	11.05	0.456
Bare Ground	7.44	10.55	1.537	16.53	0.143
Litter	4.46	18.78	3.709	12.42	0.003[c]
Standing Dead Vegetation	0.20	0.24	0.179	14.79	0.860
Water	0.24	1.23	1.432	13.76	0.175
Trees	0.00	2.29	2.010	11.00	0.070
Visual Obstruction					
Mean Obstruction[d]	5.65	4.13	-1.849	20.00	0.079

[a]Mean of means ($n \geq 10$).
[b]Significant at $\alpha=0.05$ level.
[c]Difference between means is significant at $\alpha=0.01656$ level, based on the Benjamin and Yekutieli correction for alpha (Narum 2006).
[d]Mean of means ($n \geq 30$); lowest band at least half visible.

Table 4. Comparison of stream and vegetation characteristics at sites in which water voles (*Microtus richardsoni*) were captured and not captured within mountain big sagebrush and subalpine meadow habitat types in the Big Horn Mountains of Wyoming, 2014. Stream, aerial cover, and visual obstruction measurements follow the methods outlined by Rosgen and Silvey (1998), Daubenmire (1959), and Robel et al. (1970), respectively.

Site characteristics	Captured	Not Captured	*t*	df	*P*-value
Number of Sites	4	6			
Stream					
Slope (%)	1.50	2.86	2.242	6.32	0.064
Width/Depth Ratio	6.87	5.45	-1.429	6.02	0.203
Mean Bankfull Depth[a] (cm)	46.52	44.75	-0.297	7.91	0.774
Mean Bankfull Width[a] (cm)	317.91	243.90	-1.429	7.68	0.192
Mean Wetted Depth[a] (cm)	22.88	23.96	0.221	7.91	0.831
Mean Wetted Width[a] (cm)	233.25	167.11	-1.131	6.38	0.299
Vegetation					
Mean Aerial Cover (%)					
Grasses	17.84	15.21	-0.434	6.06	0.680
Forbs	30.21	34.79	0.677	3.83	0.537
Shrubs	12.84	14.45	0.244	7.28	0.814
Sedges/Rushes	21.57	18.26	-0.718	6.55	0.498
Thallophytes	3.24	1.48	-4.194	7.27	0.004[b]
Horsetails	1.09	3.82	0.911	6.40	0.396
Bare Ground	7.38	7.48	0.055	8.00	0.957
Litter	5.75	3.60	-0.975	4.06	0.384
Standing Dead Vegetation	0.10	0.26	1.078	6.51	0.319
Water	0.00	0.41	1.051	5.00	0.342
Trees					
Visual Obstruction					
Mean Obstruction[c]	5.92	5.46	-0.333	3.89	0.756

[a]Mean of means ($n \geq 10$).
[b]Difference between means where water voles were captured and not captured is significant at α=0.01656 level, based on the Benjamin and Yekutieli correction for alpha (Narum 2006).
[c]Mean of means ($n \geq 30$); lowest band at least half visible.

Table 5. Updated distribution of water shrew (*Sorex palustris*) in the Wyoming Game and Fish Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming. The updated status of b = animals were observed and, due to limited mobility, breeding is assumed (Orabona et al. 2012). The individual was captured by using a Sherman live-trap in the Big Horn Mountains of Wyoming in June 2014.

Species	Latilong	Current status	Updated status
Sorex palustris	5	No record	b

a)

b)

Figure 1. Images of a) mountain big sagebrush and b) subalpine meadow habitats that were surveyed for water vole (*Microtus richardsoni*) in the Big Horn Mountains of Wyoming in 2014. Water voles were detected at both of the specific sites shown.

a)

b)

c)

Figure 2. Images of a) lodgepole pine, b) clearcut conifer, and c) mixed grass prairie habitats that were surveyed for water vole (*Microtus richardsoni*) in the Big Horn Mountains of Wyoming in 2014. The mixed-grass prairie shown in c was bordered by a spruce-fir stand. Water voles were not detected at any of the sites within these three habitat types.

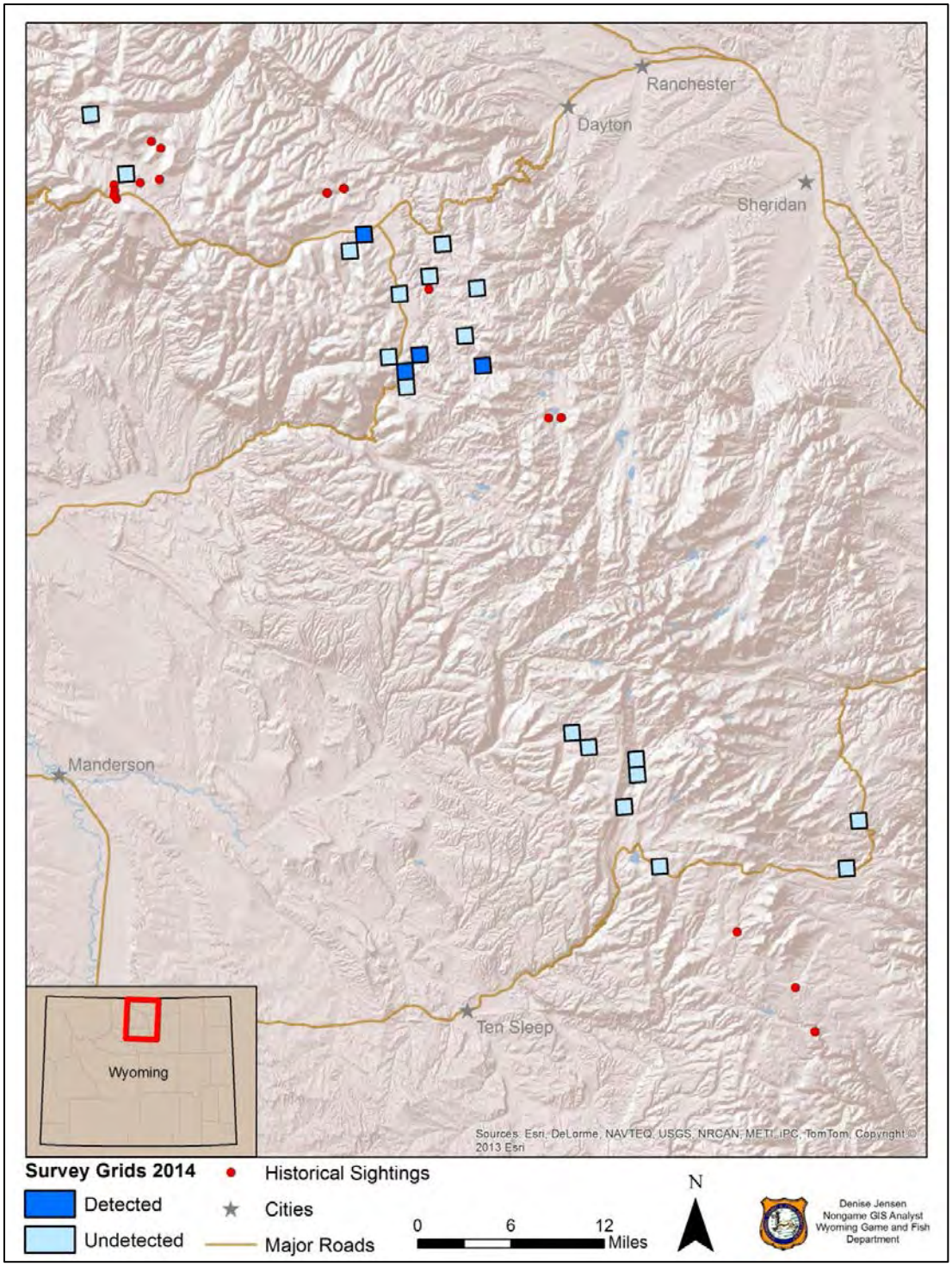

Figure 3. Survey grids in which the water vole (*Microtus richardsoni*) was detected (dark blue) and undetected (light blue) in the Big Horn Mountains of Wyoming in 2014. Historic sightings of water vole are indicated by red dots.

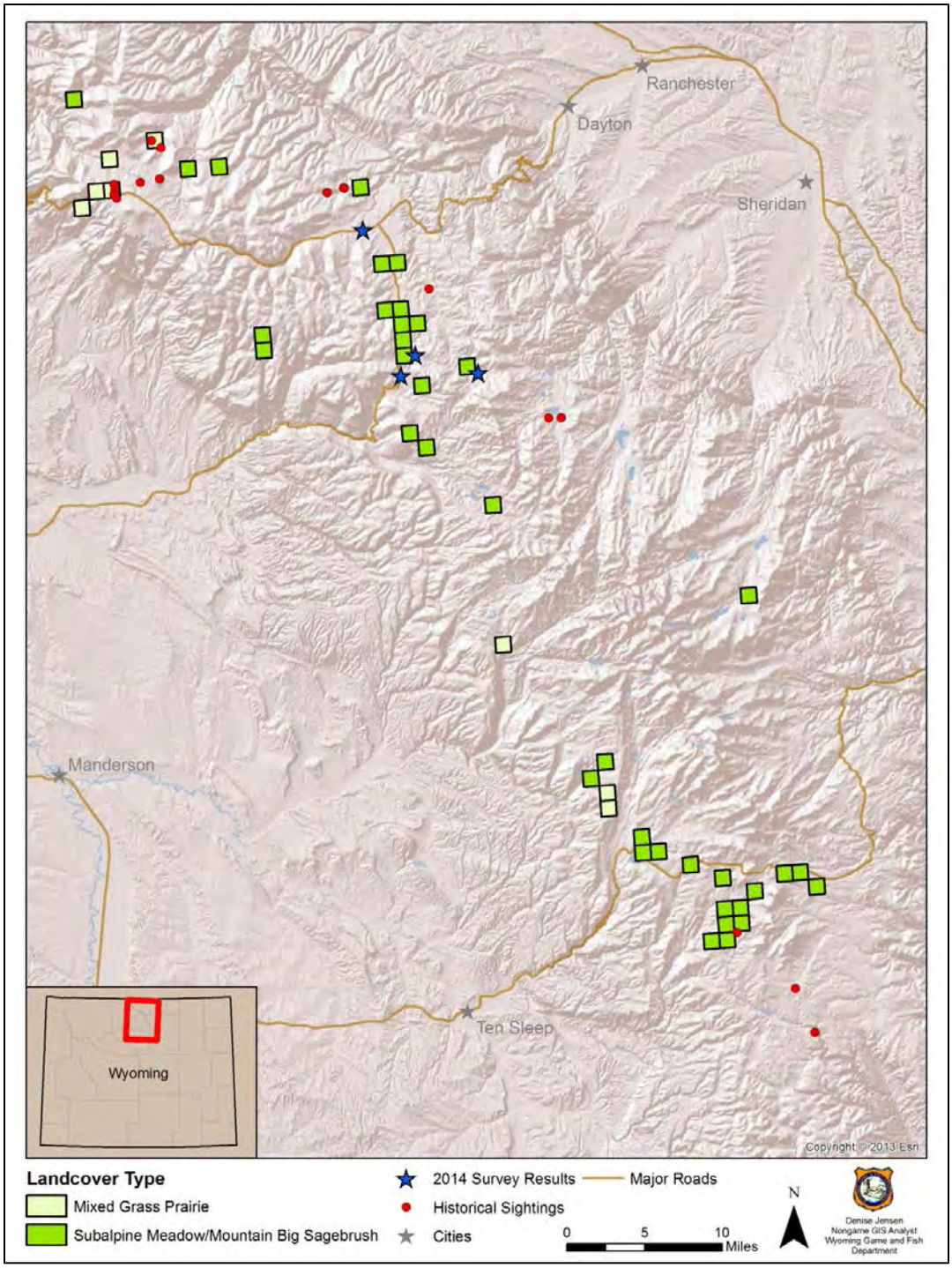

Figure 4. Suggested areas of priority for future surveys of water vole (*Microtus richardsoni*) in the Big Horn Mountains of Wyoming as selected by the following criteria: ≥2,400 m in elevation, located within 0.5 km of a first or second order stream, located within 0.5 km of roads for accessibility, ≤8% slope, and within the two habitat types (dark green) in which water voles were captured in 2014 (blue stars). Mixed grass prairie (light green) is suspected to be suitable habitat for water vole because many of the historical sightings (red dots) occur within that habitat type.

EVALUATING THE STATUS OF FISHERS (*PEKANIA PENNANTI*) IN WYOMING: FINAL REPORT

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: December 2012 – April 2014

PERIOD COVERED: December 2012 – April 2014

PREPARED BY: Jesse Boulerice, Nongame Project Biologist

ABSTRACT

As a result of overharvesting and habitat loss, populations of fisher (*Pekania pennanti*) have experienced significant declines in distribution and abundances across much of North America. Such declines have accentuated the fisher as a species of conservation concern, resulting in a warranted but precluded finding under the Endangered Species Act (ESA) for the West Coast Distinct Vertebrate Population Segment (DPS). Similarly, the Northern Rockies DPS, a designation that includes Wyoming, has been repeatedly petitioned for listing and these efforts are expected to continue. Currently, fishers are classified as a Native Species Status Unknown (NSSU, Tier III) in Wyoming, due to insufficiencies in the information necessary to assign conservation status. Given the data gap for this species in Wyoming and the implications of listing under the ESA, Wyoming Game and Fish Department biologists conducted occupancy surveys for fishers throughout northwestern Wyoming during 2012-2014. In addition, we evaluated landscape-level habitat attributes to determine the suitability of habitat for fishers. Surveys failed to document the presence of fisher at nearly 100 survey locations, adding to the body of evidence suggesting that populations may be extirpated from the state, except for the possibility of exploratory movements of transient males. Habitat analysis suggested that size of habitat patches available to fishers may be inadequate to support long-term persistence of a fisher population in Wyoming. Given the predicted future impact of threats to montane forest communities (climate change, forest fires, pine beetles, etc.) and the results of this effort, we recommend a reclassification of the native species status for fishers from NSSU to NSS1.

INTRODUCTION

The fisher (*Pekania pennanti*, formerly *Martes pennanti*) is a medium-sized mustelid historically occurring throughout the northern forests of the Rocky, Appalachian, and Pacific Coast mountain ranges (Powell 1981). Today, the distribution of the fisher is a patchwork of this former area, as habitat loss and overharvesting have led to contracted ranges and reduced abundances across North America (Gibilisco 1994, Zielinski et al. 1995). Such declines have qualified fisher as a candidate species for listing under the Endangered Species Act. In 2004, The US Fish and Wildlife Service (USFWS) determined that listing of the West Coast Distinct Vertebrate Population Segment (DPS) of fishers to be warranted but precluded (USFWS 2004). The Northern Rockies DPS of fisher, a designation including Montana, Idaho, and Wyoming, was recently re-petitioned in 2013 after listing was found to be not warranted in 2011 (USFWS 2011). Given the continuing decline in habitat for fisher in the Northern Rockies, additional listing attempts for this DPS are expected to occur in the near future.

In Wyoming, the fisher is currently classified as a Species of Greatest Conservation Need (SGCN) with a Native Species Status Unknown (NSSU, Tier III; WGFD 2010). By definition, the NSSU classification refers to species for which "obtaining a greater understanding regarding population numbers and distributions of these species is necessary in determining their conservation status, including responding to petitions for listing under the Endangered Species Act" (WGFD 2010). Information pertaining to fishers in Wyoming is extremely sparse, impeding a proper assignment of conservation status and, thus, appropriating the NSSU classification (WGFD 2010). Fishers are thought to have historically existed at relatively low abundances in Wyoming, although no information is available regarding the current or historical breeding status of the species. The predicted distribution of the fisher, based mainly on extrapolation of observations outside of Wyoming, is predicted to extend only into the mountainous regions of the northwestern portion of the state (WGFD 2010). By some reports, fishers were thought to be close to extirpation in Wyoming in the 1950s (Thomas 1954, Hagmeier 1956). Nearly no effort has been made to assess populations of this species within Wyoming in several decades, and only six observations of fisher have been reported to the Wildlife Observation System (WGFD 2010). With the nearest documented population of breeding fishers occurring nearly 200 km from the Wyoming border in the Bitterroot Mountains of Montana/Idaho, the status of this mustelid in Wyoming is unclear, and uncertainty exists as to whether a population of fisher remains extant in Wyoming.

Fishers are frequently described as habitat specialists occurring in old-growth forest (Powell 1981). Specifically, fishers routinely select for forest types with large tracts of continuous canopy closure in western states including Montana and Idaho, comprised of mature stands of dense coniferous tree species (Powell and Zielinski 1994, Jones and Garton 1994, Schwatz et al. 2013). Open exposed areas, even within otherwise dense forest, are typically avoided or traversed at high speed (Powell 1981, Wier and Harestad 2003, Schwartz et al. 2013). This affinity to overhead cover is likely due to a combination of associated benefits to fisher, including protection from predators; abundance or vulnerability of prey; and avoidance of soft, deep snow that makes locomotion difficult for fisher during winter months (Powell and Zielinski 1994, Wier and Harestad 2003). Unlike other western regions with documented populations of fisher, such as the Bitterroot Mountains or northern California, the montane and subalpine forests within Wyoming where large contiguous tracts of coniferous tree species would likely occur are instead primarily regionally fragmented (WGFD 2010). These regions in the northwest are

better characterized as disjoined patches of forest separated by exposed rocky ridges and sagebrush steppes. As these landscape-level habitat attributes likely represent poor habitat for fishers, it is unknown if enough suitable habitat is available in Wyoming to support the long-term persistence of a population of fishers.

Interspecific competition with another SGCN mustelid, the American marten (*Martes caurina*; NSS4, Tier II, formerly *Martes americana*), may also influence populations of fisher where the two species co-occur (WGFD 2010). Although a fisher is roughly three times the size of a marten, these two forest carnivores occupy similar habitat and display significant dietary overlap (Powell and Zielinski 1994, Zielinski and Duncan 2004). Competition over food resources may be minimized via prey partitioning in regions where larger-bodied prey items (e.g., lagomorphs, porcupines) are available to fishers or where a diverse and abundant array of prey reduces foraging pressures on these generalist carnivores (Powell and Zielinski 1994, Zielinski and Duncan 2004). However, some research suggests landscape-level habitat selection by fisher and marten is inversely related to the presence of the other competitor, leading to partitioning of space (Fisher et al. 2013). Competitive interactions between fisher and marten have thus far been impossible to measure in Wyoming due to the limited data on fisher. Therefore, whether spatial distribution and resource selection of each mustelid species is influenced by competition with the other remains unresolved. As a result of the fragmented nature of optimal habitat in the region, additional stresses such as competition are likely to have significant effects on populations of fisher.

Given the paucity of information for the region and the implications of listing of the Northern Rockies DPS for fisher, the Nongame Program conducted surveys for this SGCN across the predicted distribution of the species in northwestern Wyoming during 2012-14. The primary objective of this project was to evaluate the status of fisher in Wyoming, and relate findings to availability of optimal habitat and presence of competing species (i.e., martens). To do so, we completed occupancy surveys for fisher throughout the expected range of the species in Wyoming. Additionally, we evaluated the landscape-level habitat attributes throughout the region, compared to the nearest documented population of fisher in the Bitterroot Mountains. Our results enabled the Department to update the status of fisher in the state.

METHODS

We established a study area that encompassed the predicted range of fisher in Wyoming based on habitat models in the Wyoming State Wildlife Action Plan (WGFD 2010; Fig. 1). We excluded land contained within national parks and a small portion of land west of the Teton Mountains due to the difficulties in accessing these areas. Using ArcGIS 10, we divided the remaining study area into a grid of 25.7 km^2 square cells. Cell size represented the best available estimate of average home range size of an adult fisher (Heinemeyer 1993, Zielinski and Duncan 2004). We then selected cells for survey that contained at least 6.4 km^2 (25% of cell size) of appropriate habitat, defined as forest with tree canopy closure $\geq$40%.

During December through April of 2012-2013 and 2013-2014, we conducted surveys for fisher within those cells selected for survey. We installed one camera within each 6.4 km^2

quadrant of a cell which could be traversed safely given the terrain and weather conditions at time of deployment. Within each quadrant, cameras were positioned within accessible patches of forest. We baited each camera with approximately 2 kg of game meat wrapped in chicken wire, and two tablespoons of scent lure (Caven's Gusto Lure or O'Gorman's Main Fisher Call Lure, F&T Fur Harvesters Alpena, MI). We attached bait combinations at breast height to a tree approximately 6 m in front of the camera. Cameras were positioned to capture the image contained within 2 m of the base of the bait tree to 1 m above the bait. We programmed cameras to record a series of three photographs each time the internal motion sensors were activated for a period of at least 480 consecutive hours (20 days) with no delay between activations. After retrieving cameras, we reviewed photos to generate detection histories for all species detected during surveys.

Additionally, we completed a series of spatial analyses using ArcGIS10.1 to compare the landscape-level habitat attributes of the predicted range of fisher in Wyoming to the nearest documented breeding population of fisher in the Bitterroot Mountains of the Idaho/Montana border. First, we established two sampling units of the same total size centered on the predicted range in Wyoming and on the Bitterroot population (Fig. 2). We defined a habitat patch at both units as clusters of canopy cover >40% separated by less than 200 m. Specifically, we designed all 30 m^2 raster cells $\geq$40% canopy cover as habitat and all <40% as non-habitat based on the National Landcover Database 2011 USFS Tree Canopy raster. We employed the Landscape Fragmentation Analysis 2.0 tool to determine total area of each patch of habitat using a 100 m buffer for edge length for both the Wyoming and Bitterroot units (Vogt et al. 2007). Because the vast majority of forest in our region of interest (northwestern Wyoming) is comprised primarily of coniferous tree species, we did not differentiate between forest types, and defined habitat solely as >40% canopy cover regardless of tree species composition. We then defined 125 km^2 as the minimum patch size which would potentially allow for long-term persistence of a population of fisher, based on an average home range size of 25 km^2 and a minimum of five fishers to maintain a population (Reed and Bryant 2000, Olson et al. 2014).

RESULTS

Over two winters, we surveyed 98 quadrants within 27 cells (Fig. 1). In total, we recorded 88,224 camera hours across all camera sites, for an average of 900 hours per camera (Range = 480-2256 hrs, Median = 696 hr). We collected 43,466 images of wildlife summarized by species in Table 1. We failed to detect fisher during our surveys. We did, however, routinely detect American marten during our surveys in 61 quadrants (62%) and 25 cells (93%). Distribution of marten detections are presented in Figure 1. Additional Species of Greatest Conservation Need detected as part of this study include wolverine (n = 2; NSS3, Tier II) and moose (n = 10; NSS4, Tier II).

In our analysis of landscape-level habitat attributes, we found two patches to be >125 km^2 in northwestern Wyoming, compared to eight patches >125 km^2 within the Bitteroot population. The distribution of patch sizes for each study unit is mapped in Figure 2 and graphed in Figure 3.

DISCUSSION

Although our survey efforts encompassed a significant portion of the predicted distribution of fisher in Wyoming outside of the National Parks, we failed to detect the presence of fisher at nearly 100 survey stations over a 2-year period. Few techniques guarantee a 100% rate of detection even when the target species is abundant (MacKenzie et al. 2002, 2005). Therefore, surveying for locally uncommon species such as fisher inherently accrues a risk of false absences, or failing to detect a species when presence. However, the baited camera technique employed here is well documented to be effective and reliable at detecting the presence of fisher in other regions, and has been promoted as the standard technique for surveying fishers and other forest carnivore species (Zeilinski and Kucera 1995). As such, this technique was specifically chosen to reduce the probability of false absences for fisher in Wyoming. In addition, our surveys successfully recorded the presence of two other forest carnivore species while located in presumably the best habitat available to fisher in Wyoming outside of Yellowstone and Grand Teton National Parks. These observations included detections of wolverines, one of the most uncommon and notoriously difficult species to detect, as well as the American marten at nearly two thirds of all survey locations. Based on these factors, we believe that the probability of false absence during our survey effort was insignificant, thereby supporting the conclusion that the areas we surveyed were truly unoccupied by fisher at the time of survey.

Our comparison of landscape-level habitat attributes suggested that the availability of optimal habitat may be extremely low for fisher in Wyoming. Specifically, we found only two patches of habitat to be a suitable size for sustaining a population of fisher (patch size of 125 km^2 or greater, population size $\geq$5 individuals) in the entire predicted distribution of fisher in Wyoming. These two patches were separated by nearly 30 km, which would likely represent a significant challenge to dispersal for this agoraphobic species (Figs. 2 and 3). In contrast, eight patches were found to be of suitable size within the Bitteroot population, combined with several slightly smaller patches (100-125 km^2) interspersed throughout the region to form a landscape more amenable to long-term persistence of a viable fisher population (Figs. 2 and 3). The differences between these two regions suggest that the current distribution and availability of forest types characterized by high canopy closures may be insufficient for supporting fisher in Wyoming.

The current disjointed and patchy nature of the coniferous forest throughout northwestern Wyoming is similar to historic conditions for the region, and may partially explain why fishers have presumably always been uncommon in the state. In recent decades, natural causes including wildfires, logging, pine beetle, etc. are likely to have further reduced the size and quality of habitat patches. These conditions are predicted to become exponentially worse throughout the next century, as the synergistic impact of mountain pine beetle, forest fires, and climate change are anticipated to drastically reduce montane forest communities of the Rocky Mountains through direct habitat loss and upslope migration (WGFD 2010, Wasserman et al. 2012). Therefore, the habitat conditions necessary to supporting a population of fishers are unlikely to improve in the foreseeable future, increasing the likelihood of extirpation of fishers in Wyoming to a near certainty.

In addition to low availability of habitat, interspecific competition with marten may also be acting to lessen the probability of persistence of a fisher population and impeding the establishment of a population through immigration. We observed an extremely high rate of occupancy for marten throughout all of our cells while surveying in the best available habitat for fisher. If any degree of spatial segregation between fisher and marten due to competition occurs in Wyoming, the limited amount of habitat available to fisher would be further reduced as a result of this competitive interaction with an abundance and well-dispersed population of marten occurring within the same patches. Likewise, competition over shared prey species, den sites, etc. may also reduce the availability of these resources for fisher across a landscape occupied by marten to further challenge the persistence and/or establishment of fisher populations in Wyoming. However, at this time, we have no evidence to support that competition is currently occurring, or would occur in the future, as the nature of this interaction between fisher and marten appears to vary regionally (e.g., Powell and Zielinski 1994, Zielinski and Duncan 2004, Fisher et al. 2013). We recommend that if efforts to introduce fisher into Wyoming develop in the future, the relationship between fisher and marten be further explored.

The results of our occupancy surveys for fisher, combined with our landscape-level habitat analysis, support the hypothesis that a population of fisher capable of long-term persistence is likely not a reality within the boundaries of Wyoming. In addition, our results provide further evidence that a population of fisher may not currently be extant in Wyoming. Whether Wyoming was ever has supported a resident population of fisher remains unresolved (Thomas 1954, Hagmeier 1956). The Wyoming Game and Fish Department (Department) continues to occasionally receive reports of fisher observations from across the state. Most all of these reports remained unconfirmed and may be misidentifications at the species level. However, we acknowledge the possibility of exploratory movements into Wyoming from external source populations, as male fishers have been documented to occasionally make long-distances dispersals (Aubry and Raley 2006, Schwartz et al. 2013). Notably, even these would have to be exceptionally long distance treks, as forested areas bordering Wyoming in Montana also are suspected to be devoid of fisher (B. Gidding, Montana Fish Wildlife and Parks, pers. comm.). We expect that these fisher reports will continue and, if identification is accurate, sightings represent transient males. We recommend that if a female fisher with kits is confirmed in Wyoming, efforts be made to determine whether a breeding population remains extant in the state.

We acknowledge a few limitations of our survey efforts that challenge our findings. Specifically, some areas within the expected distribution of fisher containing relatively large (>100 km^2) patches of habitat were not surveyed due to logistical restrictions associated with gaining safe access during winter weather conditions or other access restrictions. These unfortunately included both of the >125 km^2 patches potentially capable of supporting a fisher population in Wyoming. We recommend that future efforts to survey for fisher specifically target these patches. However, we believe that while these areas could be suitable for fishers, the likelihood that a population could persist long-term within these disjoined patches is low given the low number of fishers that could be supported (~5 per patch) and the distance between patches (~30 km). In addition, we acknowledge that our selection of landscape-level habitat attributes used to evaluated availability of habitat is rudimentary, and other attributes not

assessed here could have significant influence on fishers. For example, diameter at breast height (DBH) of trees was recently found to be a stronger predictor of fisher presence than canopy closure in one study of the Bitteroot population (Schwartz et al. 2013). While these relationships merit exploration when assessing the availability of habitat, we felt that, for the purpose of this study, a single simple analysis was appropriate, especially given that variables such as canopy cover, DBH, species composition, forest age, etc. are all likely to be correlated as a measure of "denseness" of the forest (e.g., Olson et al. 2014). Finally, we acknowledge that detection rates for species may be decreased due to declines in daily movements associated with cold temperatures and restricted locomotion during winter seasons (Krohn et al. 2005). We specifically chose to conduct these surveys during the winter for three reasons: 1) to reduce conflict with bear activity, 2) to enhance our ability to attract wildlife to bait given the reduced availability of natural food sources, and 3) to take advantage of snowpack for navigating difficult terrain. We believe these benefits outweigh the costs of conducting these surveys during a time of year when fisher movement patterns may correspond to higher detection rates.

Based on the results of this project, the NSSU status assigned to fisher in the 2010 State Wildlife Action Plan (SWAP) is no longer an appropriate designation for fisher in Wyoming. In particular, with our efforts to document fisher at nearly 100 locations specifically targeted to represent the best habitat for fisher, combined with data obtained from the Department's Wildlife Observation System database and consultation with other wildlife agencies, we have increased our understanding of population numbers and distribution of fisher to a sufficient level to appropriately assess conservation status of this species. Clearly, the population size and distribution of fisher in Wyoming is restricted and extirpation may have already occurred. Similarly, suitable habitat for fisher appears to be severely limited throughout the expected distribution of the species in Wyoming and such limitations are predicted to increase in severity as a result of significant threats to montane forest communities, including climate change, forest fires, pine beetles, etc. Given these conditions and in accordance with the 2010 SWAP Native Species Status Matrix, we recommend that the Native Species Status for fisher be updated to NSS1 (WGFD 2010).

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Table 1. Summary of detections by cell, quadrant, and image recorded from camera surveys in northwestern Wyoming from December through April of 2012-2013 and 2013-2014. One camera station was installed within each quadrant of a surveyed cell.

Common name	Scientific name	Cells N=27	Quadrants[1] N=98	Images N=43466
Fisher	*Pekania pennanti*	0	0	0
Marten	*Martes caurina*	25	61	22919
Wolverine	*Gulo gulo*	2	2	255
Red Fox	*Vulpes vulpes*	17	30	5362
Coyote	*Canis latrans*	9	15	174
Wolf	*Canis lupus*	2	2	27
Bobcat	*Lynx rufus*	4	4	35
Cougar	*Puma concolor*	5	5	174
Deer	*Odocoileus spp.*	9	16	2927
Elk	*Cervus canadensis*	3	5	1484
Moose	*Alces alces*	10	11	548
Rabbit	*Leporidae spp.*	17	22	548
Red Squirrel	*Sciurus vulgaris*	19	32	741
Bird[2]		26	46	6612

[1] Not all quadrants per cell were surveyed. Quadrants were not surveyed when terrain and weather conditions resulted in unsafe conditions.

[2] Species of birds included Black-billed Magpie (*Pica hudsonia*), Clark's Nutcracker (*Nucifraga columbiana),* Gray Jay (*Perisoreus canadensis*), and Stellar's Jay (*Cyanocitta stelleri*).

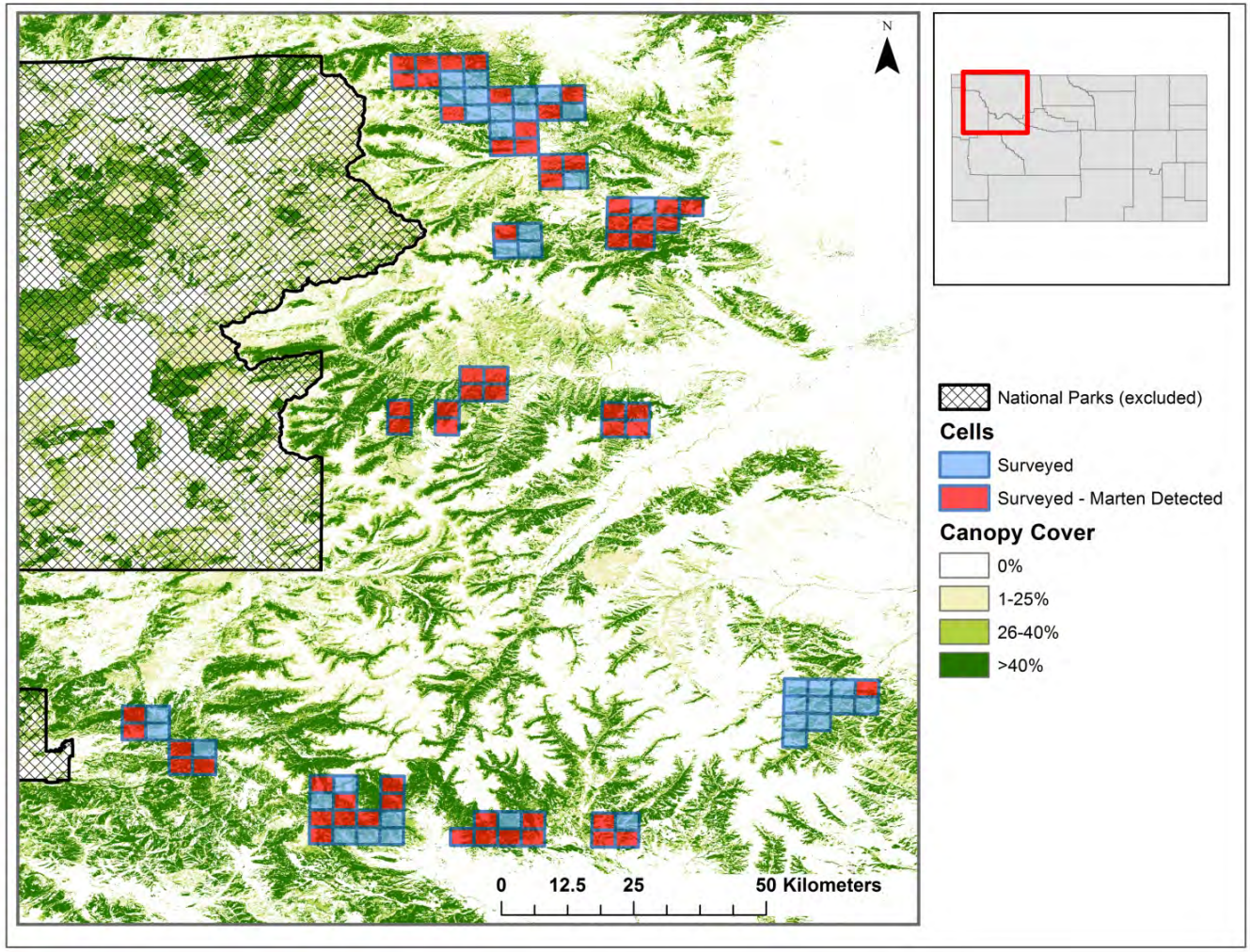

Figure 1. Map of the study area for surveys to assess the status of fisher (*Pekania pennanti*) in northwestern Wyoming conducted during winter months of 2012-2013 and 2013-2014. Boxes indicate locations of surveyed quadrants of cells in which one baited camera station was installed for a period of 900 hours, on average. Canopy cover indicates distribution of forest cover across the study area. Fishers generally select for large continuous tracts of forest cover, defined here as canopy cover >40%.

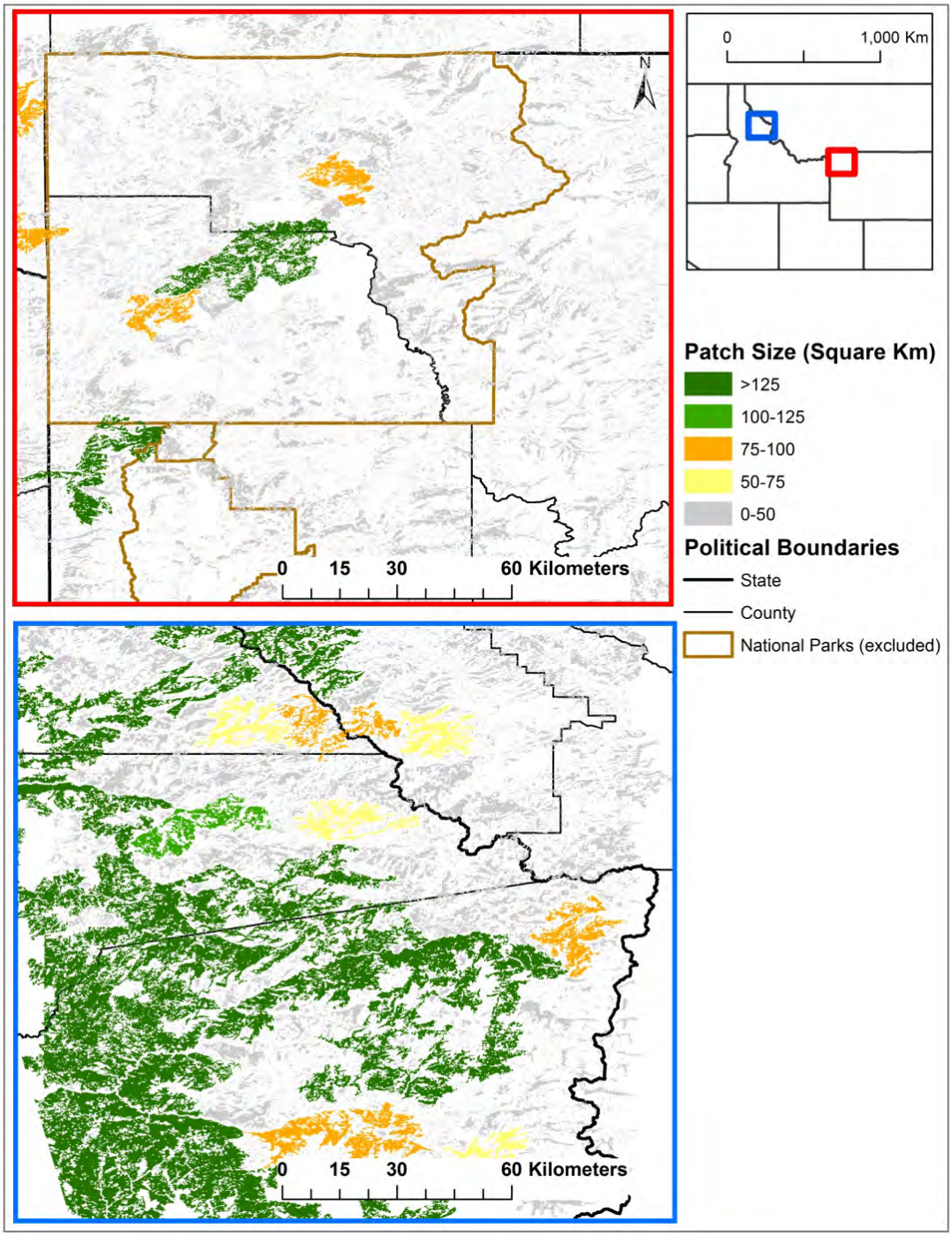

Figure 2. Distribution of habitat patches for fisher (*Pekania pennanti*). Red box indicates study site in northwestern Wyoming, blue box indicates the nearest documented population of fisher to Wyoming, in the Bitteroot Mountains of Idaho/ Montana. Habitat patch was defined as clusters of canopy cover >40% separated by less than 200 m. We defined 125 km^2 as the minimum patch size, which would potentially allow for long term persistence of a population of fisher based on an average home range size of 25 km^2 and a minimum of five fishers to maintain a population (Reed and Bryant 2000, Olson et al. 2014).

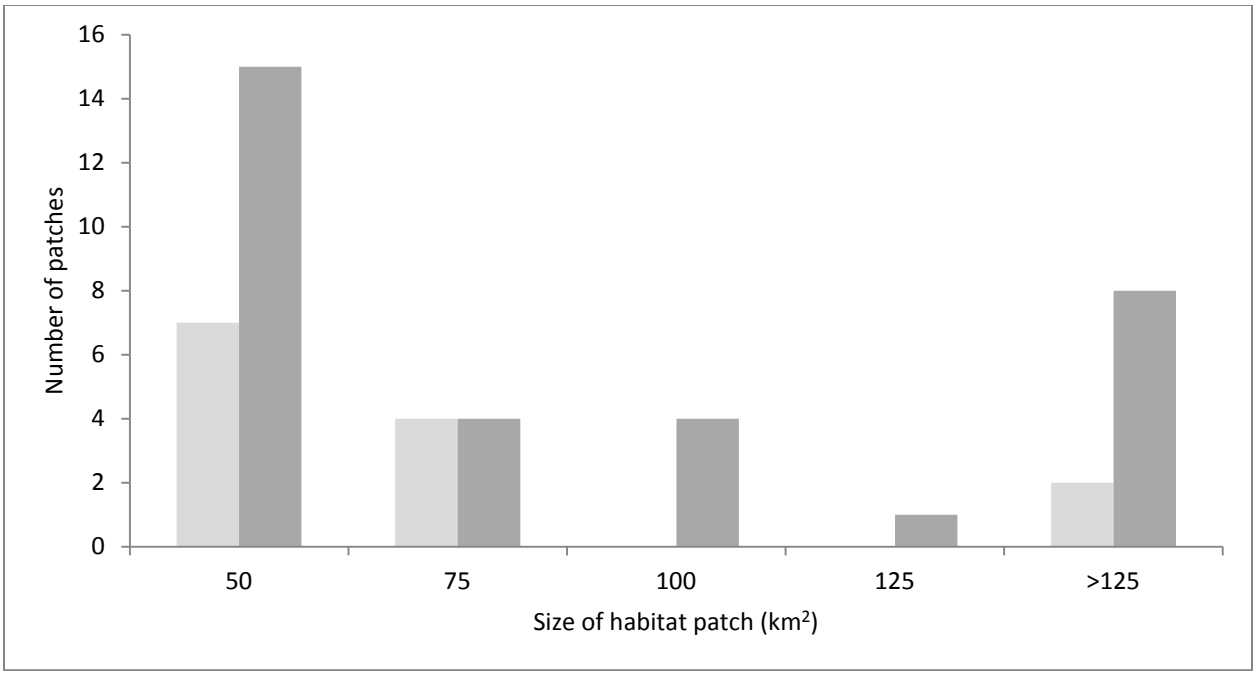

Figure 3. Size comparison of habitat patches for fisher (*Pekania pennanti*). Light bars indicate the habitat patches throughout northwestern Wyoming; dark bars indicate habitat patches at the nearest documented population of fisher to Wyoming, in the Bitteroot Mountains of Idaho and Montana. Habitat patch was defined as clusters of canopy cover >40% separated by less than 200 m. We defined 125 km^2 as the minimum patch size, which would potentially allow for long term persistence of a population of fisher based on an average home range size of 25 km^2 and a minimum of five fishers to maintain a population (Reed and Bryant 2000, Olson et al. 2014).

HARVEST REPORTS

HARVEST OF RAPTORS FOR FALCONRY

STATE OF WYOMING

NONGAME BIRDS: Raptors

FUNDING SOURCE: Wyoming Game and Fish Department
Bureau of Land Management Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2014 – 31 December 2014

PREPARED BY: Courtney Rudd, Nongame Biologist
Dillon Herman, Game Warden

SUMMARY

In 2014, the Wyoming Game and Fish Department issued 27 falconry capture licenses. The number of licenses issued represented a decrease from 2013 (33 licenses), but is similar to the number issued in 2011 and 2007 (30 each year). Licenses were issued for 19 residents and 8 nonresidents. Residents filled 6 of 19 licenses; nonresidents filled 5 of 8 licenses. While no Prairie Falcons (*Falco mexicanus*) were captured in 2013, it was the most commonly captured species during 2014, with 2 captures (one female, one male) taken by residents and the remaining 2 captures (two females) taken by nonresidents. Two female Red-tailed Hawks (*Buteo jamaicensis*) were captured by residents. Two male Northern Goshawks (*Accipiter gentilis*) were captured, one by a resident, the other by a nonresident. Although the Ferruginous Hawk (*Buteo regalis)* was the most commonly captured species in 2013, only two females were captured in 2014, both taken by nonresidents. A single female American Kestrel (*Falco sparverius*) was captured by a resident (Table 1). The total number of birds captured in 2014 (n = 11) was substantially less than the mean (±SE) number of captures from 1981-2013 (22.5 ± 1.50 birds). Additionally, capture success for 2014 (41%) was less than the mean (±SE) capture success from 1981-2013 (46.5% ± 2.23%; Table 2).

Table 1. Species and number of raptors captured by residents and nonresidents for falconry in Wyoming, 2014.

Species captured	Number of resident captures	Number of nonresident captures	Total captures
Cooper's Hawk	0	0	0
Northern Goshawk	1	1	2
Red-tailed Hawk	2	0	2
Ferruginous Hawk	0	2	2
American Kestrel	1	0	1
Merlin	0	0	0
Prairie Falcon	2	2	4
Great Horned Owl	0	0	0
Total	6	5	11

Table 2. Number of individuals captured and yearly capture success rate (%) for raptors taken for falconry in Wyoming, 1981-2014.

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
2014	11	41

OTHER NONGAME – BIRDS

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
Bureau of Land Management Cooperative Agreement
Bureau of Reclamation Cooperative Agreement
National Park Service Cooperative Agreement
United States Fish and Wildlife Service Cooperative Agreement
United States Forest Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Courtney Rudd, Nongame Biologist
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 2013, volunteers surveyed 60 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. 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-five 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 (USFWS)] and the Canadian Wildlife Service. This roadside survey methodology was field tested in 1965 and formally launched in 1966, with 600 routes established in the US east of the Mississippi River and in Canada(Sauer et al. 1997). In 1967, the BBS spread to the Great Plains states and Prairie Provinces. By 1968, approximately 2,000 BBS routes were set up across southern Canada and the contiguous 48 states, and more than 1,000 routes were surveyed annually. During the 1980s, the BBS expanded further into Alaska and Canada's Yukon and Northwest Territories, and additional routes were added in many states. Today, over 4,500 BBS routes are located across the continental US and Canada, including 108 active routes in Wyoming (Fig. 1).

The BBS was designed to provide a continent-wide perspective of population change. All routes have been randomly located in order to sample habitats that are representative of the entire region. Other requirements, such as consistent methodology, observer expertise, visiting the same stops each year, and conducting surveys under suitable weather conditions, are necessary to produce comparable data over time (Sauer et al. 1997). A large sample size (i.e., number of routes conducted) is needed to average local variations and reduce the effects of sampling error (i.e., variation in counts attributable to both sampling technique and real variation in trends).

The BBS provides an index of relative abundance rather than a complete count of breeding bird populations. Data can be used to estimate population trends and relative abundance of individual species at the continental, regional, statewide, and physiographic region scale. Relative abundance maps should be viewed with some caution, however, as species tend to be rare, locally distributed, and likely to be poorly represented along BBS routes at the edges of their ranges (Sauer et al. 1997). The most effective use of BBS data is to analyze population change on survey routes; however, these data do not provide an explanation for the causes of population trends. To evaluate population changes over time, BBS indices from individual routes are combined to acquire regional and continental estimates of trends (Sauer et al. 1997). Some species have consistent trends throughout the history of the BBS, although most do not due to stochastic effects that can affect populations.

Our objectives in 2014 were to add additional data to the BBS and interpret current large-scale trends of nongame breeding birds in Wyoming. While 2014 population trend analyses were not completed by publication time, analyses are available through 2013 for over 420 species of birds (Sauer et al. 2014). All raw data can be accessed on the BBS web site http://www.pwrc.usgs.gov/bbs/. Due to the unavailability of 2014 survey data for this report, analyses were performed using survey data through 2013 (Pardieck et al. 2014).

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 at 0.8 km intervals along the route. 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 count 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 2013, observers surveyed approximately 2,654 of 3,550 (75 %) active routes in the US. In Wyoming, observers attempted to survey 60 of the 108 (56%) active routes. We report results for 60 (56%) of the 108 available routes that were surveyed (Table 1). Since 1990, the number of routes surveyed in Wyoming has decreased by 0.83 routes per year ($P<0.001$; $R^2=0.5672$; Fig. 2). Consistent with this trend, the number of routes surveyed in 2013 (i.e., 60 routes) was less than the mean number of routes completed from 1990-2012 (65.0 ±1.64 routes).

Observers detected a total of 26,530 individual birds representing 181 species in Wyoming (Table 2). Since 1990, the number of individuals detected has decreased by 5.3 individuals per route per year ($P<0.001$; $R^2=0.620$; Fig. 3), but the number of species detected has increased by 0.17 species per route per year ($P<0.001$; $R^2=0.541$; Fig. 4). Consistent with these trends, the number of individuals detected per route in 2013 (i.e., 442.3 ±40.0 individuals) was less than the mean number of individuals detected per route between 1990–2012 (i.e., 533.4 ±9.4 individuals), but the number of species detected per route (i.e., 38.4 ±1.8 species) was similar to the mean number of species detected per route between 1990-2012 (i.e., 38.1 ±0.4 species).

DISCUSSION

A complete history of BBS observers and routes surveyed in Wyoming from 1968 through 2013 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. To address these problems, dangerous routes have been altered or

are no longer conducted, although 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 23 years. While 2013 recorded the sixth lowest number of routes completed since 1990 at 60 routes completed, this was an increase of 2 routes from 2012, keeping Wyoming in 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.

The uses of BBS data are manifold. Trend data are used by the USFWS, Canadian Wildlife Service, and Partners in Flight to assess bird conservation priorities. Data were instrumental in focusing research and management actions on Neotropical migratory birds in the late 1980s, and on grassland birds in the mid-1990s. State Natural Heritage programs and Breeding Bird Atlas projects use BBS data to enrich their databases. Data are used by educators as a tool to teach biological, statistical, and Geographic Information System concepts. Finally, BBS data have been used in over 450 scientific publications. Thus, the importance of recruiting and retaining qualified observers and ensuring that routes are conducted annually cannot be overstated.

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, 2013. Data are presented in numerical order by survey route. Late data are not included in analyses and, when applicable, are represented by 'not available'.

Route number and name	Latilong	Observer	Species	Individuals
1 – NE Entrance, YNP	1	Amanda Boyd	51	468
2 – Cody	2	Grace Nutting	54	435
3 – Otto	3	Observer needed		
4 – Basin	4	N/A – discontinued		
5 – Wyarno	5	John Berry	37	1046
6 – Clarkelen	6	N/A – discontinued		
7 – Sundance	7	Jennifer Adams	54	525
8 – Colter Bay	8	N/A – discontinued		
9 – Dubois	9	Jazmyn McDonald	54	320
10 – Midvale	10	Observer needed		
11 – Nowood	11	Donna Walgren	36	242
12 – Natrona	12	N/A – discontinued		
13 – Bill	13	Observer needed		
14 – Redbird	14	N/A – discontinued		
15 – Fontenelle	15	Carol Deno	51	489
16 – Elk Horn	16	Sid Johnson	Not conducted	Not conducted
17 – Bear Creek	17	Andrea Orabona	13	201
18 – Ervay	18	Jazmyn McDonald	38	255
19 – Brookhurst	19	Bruce Walgren	55	489
20 – Glenrock	20	N/A – discontinued		
21 – Dwyer	21	Martin Hicks	Not conducted	Not conducted
22 – Cumberland	22	Carol Deno	26	137
23 – McKinnon	23	N/A – discontinued		
24 – Patrick Draw		N/A – discontinued		
25 – Savery	25	Marie Adams	41	287
26 – Riverside	26	Steve Loose	46	707
27 – Buford	27	Suzanne Fellows	Not conducted	Not conducted
28 – Yoder	28	Gloria Lawrence	41	1070
29 – Canyon		N/A – discontinued		
30 – Mammoth, YNP	1	John Parker	64	676
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	Suzy Grimes	35	410
36 – Moose	8	Christine Paige	48	464
37 – Lovell	3	Observer needed		
38 – Meeteetse	3	Jazmyn McDonald	57	489
39 – Ten Sleep	4	C.J. Grimes	54	430
40 – Dayton	4	Tracey Ostheimer	59	713

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
41 – Bald Mountain	4	Observer needed		
42 – Crazy Woman	5	Grace Nutting	44	219
43 – Schoonover	5	Observer needed		
44 – Arvada	5	Donald Brewer	34	511
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	18	524
50 – Moskee		N/A – discontinued		
51 – Alpine	8	Susan Patla	52	438
52 – Wilson	8	Observer needed		
53 – Horse Creek	9	Eva Crane	49	343
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	55	327
59 – Arminto	11	Heather O'Brien	22	293
60 – Lysite	11	Greg Anderson	Not conducted	Not conducted
61 – Worland	11	C.J. Grimes	28	225
62 – Teapot Dome	12	Observer needed		
63 – Mayoworth	12	Observer needed		
64 – Sussex	12	Bill Ostheimer	44	430
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	27	621
70 – Raven	14	Nichole Cudworth	16	459
71 – Soda Lake	15	Observer needed		
72 – Buckskin Mountain	15	Lara Oles	Not conducted	Not conducted
73 – Daniel		N/A – discontinued		
74 – Boulder	16	Susan Patla	Not conducted	Not conducted
75 – Big Sandy	16	Susan Patla	38	239
76 – Farson	16	Sid Johnson	Not conducted	Not conducted
77 – Fiddler Lake	17	Eva Crane	37	206
78 – Sand Draw	17	Jazmyn McDonald	34	258
79 – Sweetwater	17	Stan Harter	Not conducted	Not conducted
80 – Gas Hills	18	N/A – discontinued		
81 – Bairoil	18	Greg Hiatt	22	216
82 – Lamont	18	Greg Hiatt	34	308
83 – Pathfinder	19	Laurie Schwieger	29	285

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
84 – Leo	19	Donna Walgren	36	245
85 – Shirley	19	Linda Drury	18	200
86 – Warbonnet	20	James Lawrence	Not conducted	Not conducted
87 – Fletcher Peak	20	Gloria Lawrence	53	392
88 – Shawnee	20	Observer needed		
89 – Meadowdale	21	Martin Hicks	Not conducted	Not conducted
90 – Lusk	21	Grant Frost	23	399
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	29	216
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	48	390
105 – Fox Park	26	Wendy Estes-Zumpf	32	401
106 – Ryan Park	26	Debbie Wagner	31	196
107 – Sybille Canyon	27	Ian Abernethy	50	953
108 – Rock River	27	Matt Carling	Not conducted	Not conducted
109 – Harmony	27	Doug Keinath	46	288
110 – Cheyenne	28	Chuck Seniawski	21	448
111 – Chugwater	28	Chuck Seniawski	24	325
112 – Pine Bluff	28	Chuck Seniawski	25	415
120 – Welch	20	Chris Michelson	40	376
123 – Flaming Gorge	23	Observer needed		
147 – Rozet	6	Observer needed		
148 – Seely 2	7	Mary Yemington	44	435
150 – Government Valley	7	Jennifer Adams	31	487
167 – Thunder Basin	13	Nichole Cudworth	18	307
173 – Rye Grass	15	Observer needed		
180 – Gas Hills 2	18	Courtney Rudd	17	268
192 – Carter	23	Observer needed		
195 – Seedskadee	23	Observer needed		
198 – Black Rock 2	24	Andrea Orabona	Not conducted	Not conducted
204 – Basin 2	4	Observer needed		
206 – Caballa Creek	6	Sandra Johnson	24	359
208 – Moran	8	Mikael Cejtin	54	455

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
212 – Bucknum	12	Larry Keffer	Not conducted	Not conducted
214 – Hampshire	14	Observer needed		
224 – Patrick Draw III		N/A – discontinued		
250 – Moskee 2	7	Jennifer Adams	59	579
524 – Patrick Draw VI	24	Laurie Van Fleet	21	355
900 – Hayden Valley		N/A – discontinued		
901 – Yellowstone, YNP	1	John Parker	60	2291
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, 2013. Data are presented in phylogenetic order. The 30 most abundant species detected on BBS routes in 2013 are denoted by an asterisk (note: Western Kingbird and Barn Swallow, with 177 individuals detected, are tied for the 30th placement).

Order	Species (common name)	Number detected	Relative abundance (%)
Anseriformes	Canada Goose*	1878	7.08
	Trumpeter Swan	2	0.01
	Wood Duck	2	0.01
	Gadwall	20	0.08
	American Wigeon	38	0.14
	Mallard	148	0.56
	Blue-winged Teal	3	0.01
	Cinnamon Teal	8	0.03
	Northern Shoveler	15	0.06
	Northern Pintail	2	0.01
	Green-winged Teal	10	0.04
	Canvasback	6	0.02
	Redhead	3	0.01
	Ring-necked Duck	2	0.01
	Lesser Scaup	55	0.21
	Bufflehead	5	0.02
	Barrow's Goldeneye	8	0.03
	Common Merganser	33	0.12
	Ruddy Duck	4	0.02
Galliformes	Chukar	6	0.02
	Gray Partridge	2	0.01
	Ring-necked Pheasant	101	0.38
	Ruffed Grouse	3	0.01
	Greater Sage-Grouse	49	0.18
	Sharp-tailed Grouse	2	0.01
	Wild Turkey	31	0.12
Podicipediformes	Pied-billed Grebe	1	0.00
	Eared Grebe	16	0.06
	Western Grebe	8	0.03
Suliformes	Double-crested Cormorant	68	0.26
Pelecaniformes	American White Pelican	72	0.27
	Great Blue Heron	24	0.09
Accipitriformes	Turkey Vulture	57	0.21
	Osprey	5	0.02
	Bald Eagle	6	0.02
	Northern Harrier	13	0.05
	Cooper's Hawk	3	0.01
	Northern Goshawk	1	<0.01
	Broad-winged Hawk	1	<0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
	Swainson's Hawk	17	0.06
	Red-tailed Hawk	58	0.22
	Ferruginous Hawk	14	0.05
	Golden Eagle	30	0.11
	Unidentified Buteo hawk	1	<0.01
Falconiformes	American Kestrel	54	0.20
	Peregrine Falcon	2	0.01
	Prairie Falcon	2	0.01
Gruiformes	Virginia Rail	1	<0.01
	Sora	10	0.04
	American Coot	21	0.08
	Sandhill Crane	58	0.22
Charadriiformes	Killdeer	123	0.46
	Mountain Plover	12	0.05
	American Avocet	50	0.19
	Spotted Sandpiper	65	0.25
	Willet	7	0.03
	Upland Sandpiper	33	0.12
	Long-billed Curlew	7	0.03
	Wilson's Snipe	123	0.46
	Wilson's Phalarope	10	0.04
	Ring-billed Gull	23	0.09
	California Gull	51	0.19
	Unidentified gull	1	<0.01
Columbiformes	Rock Pigeon	20	0.08
	Eurasian Collared-Dove	68	0.26
	Mourning Dove*	754	2.84
Strigiformes	Great Horned Owl	5	0.02
	Burrowing Owl	4	0.02
	Short-eared Owl	2	0.01
Caprimulgiformes	Common Nighthawk	114	0.43
Apodiformes	White-throated Swift	31	0.12
	Calliope Hummingbird	1	<0.01
	Broad-tailed Hummingbird	26	0.10
Coraciiformes	Belted Kingfisher	5	0.02
Piciformes	Red-headed Woodpecker	6	0.02
	Williamson's Sapsucker	2	0.01
	Red-naped Sapsucker	25	0.09
	Downy Woodpecker	3	0.01
	Hairy Woodpecker	21	0.08
	American Three-toed Woodpecker	8	0.03
	Unidentified woodpecker	3	0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Piciformes	Northern Flicker	169	0.64
Passeriformes	Olive-sided Flycatcher	14	0.05
	Western Wood-Pewee	175	0.66
	Willow Flycatcher	34	0.13
	Least Flycatcher	7	0.03
	Hammond's Flycatcher	33	0.12
	Gray Flycatcher	1	<0.01
	Dusky Flycatcher	85	0.32
	Cordilleran Flycatcher	16	0.06
	Unidentified Empidonax flycatcher	3	0.01
	Say's Phoebe	54	0.20
	Western Kingbird*	177	0.67
	Eastern Kingbird	67	0.25
	Loggerhead Shrike	50	0.19
	Plumbeous Vireo	10	0.04
	Warbling Vireo*	329	1.24
	Red-eyed Vireo	4	0.02
	Gray Jay	7	0.03
	Steller's Jay	1	<0.01
	Blue Jay	7	0.03
	Pinyon Jay	16	0.06
	Clark's Nutcracker	66	0.25
	Black-billed Magpie*	313	1.18
	American Crow	167	0.63
	Common Raven*	286	1.08
	Horned Lark*	1650	6.22
	Tree Swallow	101	0.38
	Violet-green Swallow	163	0.61
	Northern Rough-winged Swallow	49	0.18
	Bank Swallow	56	0.21
	Cliff Swallow*	1044	3.94
	Barn Swallow*	177	0.67
	Black-capped Chickadee	42	0.16
	Mountain Chickadee	124	0.47
	Red-breasted Nuthatch	70	0.26
	White-breasted Nuthatch	7	0.03
	Rock Wren*	229	0.86
	Canyon Wren	2	0.01
	House Wren	164	0.62

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	American Dipper	2	0.01
	Golden-crowned Kinglet	6	0.02
	Ruby-crowned Kinglet*	295	1.11
	Blue-gray Gnatcatcher	7	0.03
	Mountain Bluebird*	187	0.70
	Townsend's Solitaire	34	0.13
	Veery	16	0.06
	Swainson's Thrush	53	0.20
	Hermit Thrush	113	0.43
	American Robin*	1049	3.95
	Gray Catbird	27	0.10
	Sage Thrasher*	399	1.50
	Brown Thrasher	2	0.01
	European Starling*	395	1.49
	American Pipit	5	0.02
	Cedar Waxwing	18	0.07
	McCown's Longspur	21	0.08
	Ovenbird	78	0.29
	Orange-crowned Warbler	6	0.02
	MacGillivray's Warbler	40	0.15
	Common Yellowthroat	48	0.18
	American Redstart	58	0.22
	Yellow Warbler*	325	1.23
	Yellow-rumped Warbler*	412	1.55
	Black-throated Gray Warbler	2	0.01
	Wilson's Warbler	6	0.02
	Yellow-breasted Chat	27	0.10
	Green-tailed Towhee*	299	1.13
	Spotted Towhee	106	0.40
	Chipping Sparrow*	248	0.93
	Clay-colored Sparrow	20	0.08
	Brewer's Sparrow*	792	2.99
	Field Sparrow	2	0.01
	Vesper Sparrow*	1004	3.78
	Lark Sparrow*	196	0.74
	Sagebrush Sparrow*	230	0.87
	Lark Bunting*	1971	7.43
	Savannah Sparrow*	183	0.69
	Grasshopper Sparrow	110	0.41
	Fox Sparrow	13	0.05
	Song Sparrow	159	0.60

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	Lincoln's Sparrow	83	0.31
	White-crowned Sparrow	130	0.49
	Dark-eyed Junco	250	0.94
	Western Tanager	93	0.35
	Black-headed Grosbeak	48	0.18
	Blue Grosbeak	5	0.02
	Lazuli Bunting	32	0.12
	Dickcissel	2	0.01
	Bobolink	27	0.10
	Red-winged Blackbird*	1098	4.14
	Western Meadowlark*	3294	12.42
	Yellow-headed Blackbird	55	0.21
	Brewer's Blackbird*	678	2.56
	Common Grackle*	271	1.02
	Brown-headed Cowbird*	256	0.96
	Orchard Oriole	4	0.02
	Bullock's Oriole	62	0.23
	Pine Grosbeak	7	0.03
	Cassin's Finch	19	0.07
	House Finch	18	0.07
	Red Crossbill	77	0.29
	Pine Siskin	154	0.58
	American Goldfinch	113	0.43
	House Sparrow*	239	0.90
	Total Individuals	26530	
	Total Species	181	

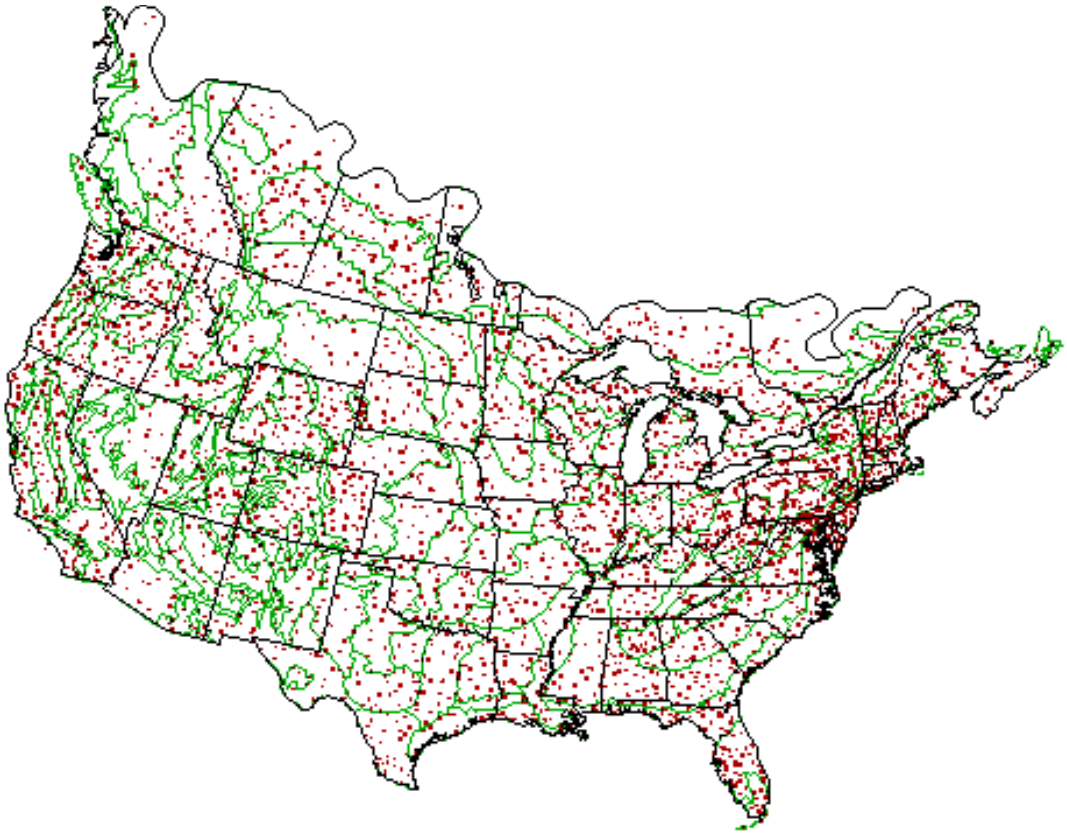

Figure 1. Location (red dots) of all Breeding Bird Survey routes in the United States and Canada (Sauer et al. 1997).

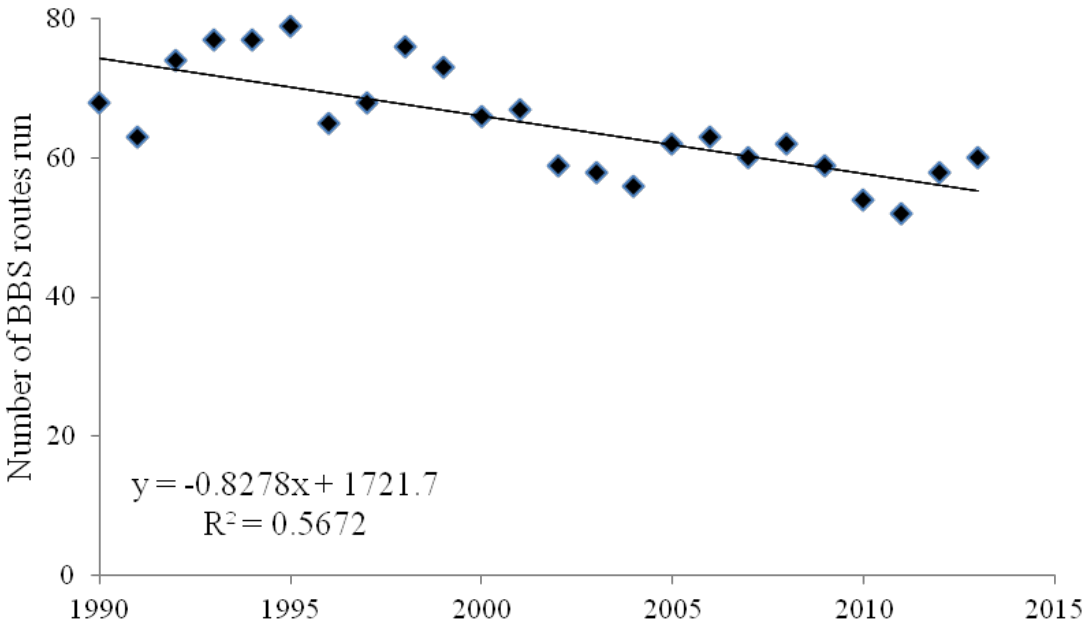

Figure 2. Number of Breeding Bird Survey routes completed in Wyoming, 1990-2013. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

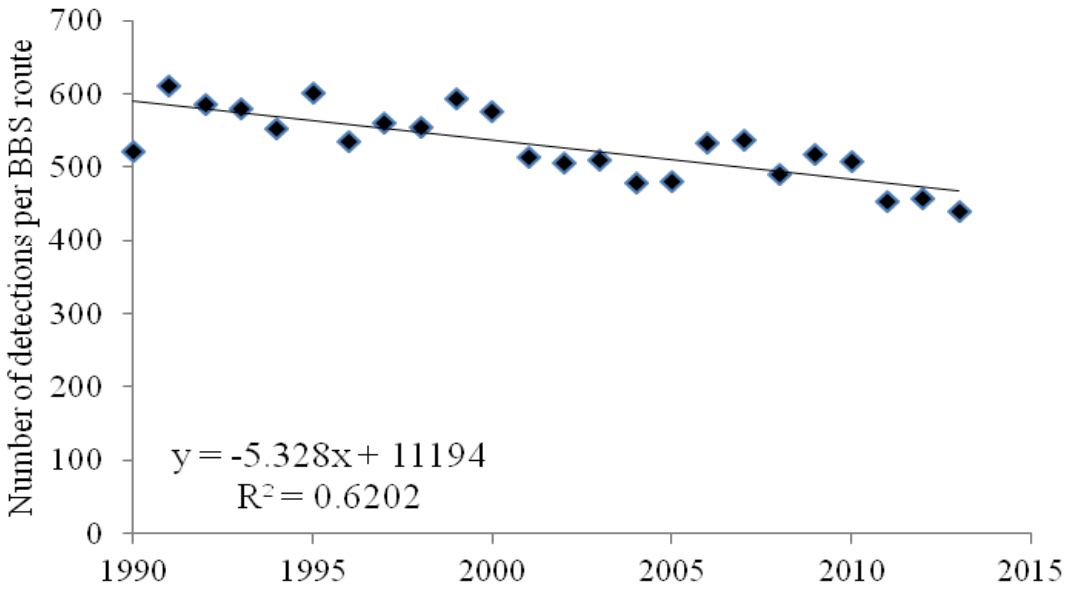

Figure 3. Average number of individual detections of birds per Breeding Bird Survey route in Wyoming, 1990-2013. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

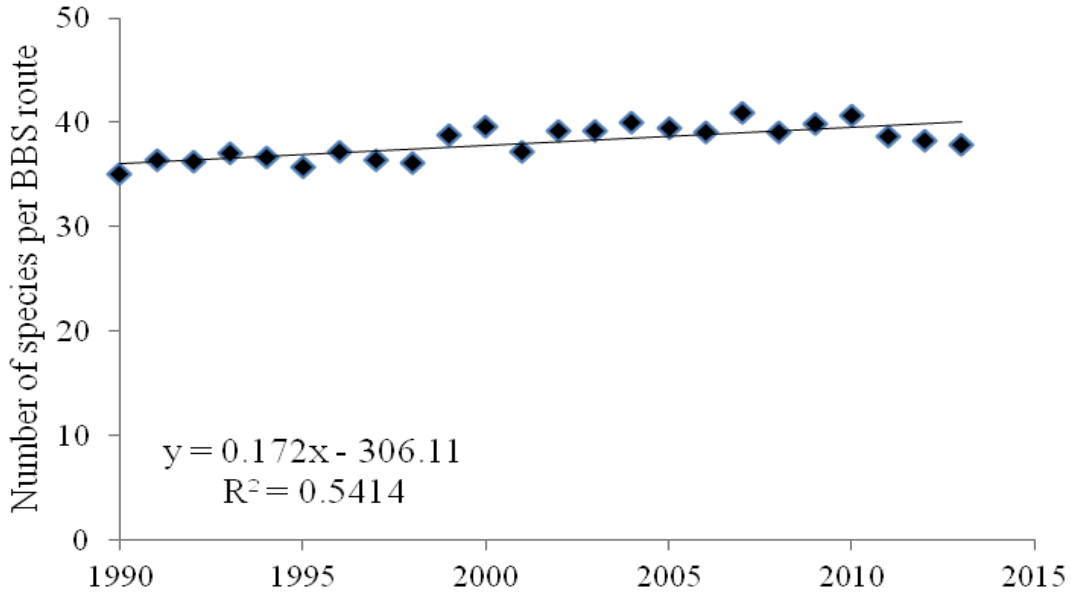

Figure 4. Average number of species detected per Breeding Bird Survey route in Wyoming, 1990-2013. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

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
National Park Service Cooperative Agreement
United States Fish and Wildlife Service State Wildlife Grants
United States Forest Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

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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 jointly implemented the Integrated Monitoring in Bird Conservation Regions program (formerly Monitoring Wyoming's Birds) through the Rocky Mountain Bird Observatory. Data gathered from this program allow us to estimate density, population size, occupancy, and detection probabilities for numerous avian species, including Species of Greatest Conservation Need (SGCN). In 2014, field technicians

completed 2,455 point counts on 190 of the 191 planned surveys (99.8%) within the 37 strata in the 5 Bird Conservation Regions in Wyoming, covering a total of 253,467 km^2. They detected 176 species, including 18 SGCN. Biometricians determined occupancy for 143 species (81.3%), including 15 SGCN. Data provided robust estimates for 92 species, including (52.3%), including 8 SGCN. Biometricians estimated density and population size for 150 species (85.2%), including 18 SGCN. Data provided robust estimates for 67 species (44.7%), including 6 SGCN. The Integrated Monitoring in Bird Conservation Regions design allows us to monitor trends of avian SGCN 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 (NPS), 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 populations of 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 14th consecutive year, biologists from the Department, RMBO, BLM, USFS, NPS, WYNDD, and Audubon Rockies 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. 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. 2014). The BLM, USFS, NPS, 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 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*), Burrowing Owl (*Athene cunicularia*), 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. With funding and guidance from the IMBCR partnership, RMBO oversees and implements the program, conducts data analyses, maintains the Rocky Mountain Avian Data Center database, and produces an annual IMBCR report.

The IMBCR partnership's monitoring objectives using the IMBCR design (White et al. 2015) are to:

1. Provide robust density, population, and occupancy estimates that account for incomplete detection and are comparable at different geographic extents.
2. Provide long-term status and trend data for all regularly occurring breeding species throughout the study area.
3. Provide a design framework to spatially integrate existing bird monitoring efforts in the region to provide better information on distribution and abundance of breeding landbirds, especially for high priority species.

4. Provide basic habitat association data for most bird species to address habitat management issues.
5. Maintain a high-quality database that is accessible to all of our collaborators, as well as to the public, over the internet in the form of raw and summarized data.
6. Generate decision support tools that help guide conservation efforts and provide a better measure of conservation success.

METHODS

Bird Conservation Regions (BCRs) provide a spatially consistent framework 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). RMBO biometricians overlaid BCRs with 1-km^2 sample grids, randomly selected sample grids, and used a 4 × 4 point count array with 16 survey points spaced 250 m apart within each sample grid (Fig. 3; Hanni et al. 2014).

Prior to surveys, field technicians completed an intensive training program covering protocols, bird and plant identification, and distance estimation. Technicians used distance sampling (Buckland et al. 2001) and IMBCR sampling methods established by RMBO (Hanni et al. 2014) to conduct point counts during the field season. They surveyed grids in the morning from 0.5 hr before sunrise to 1100 hrs, and surveyed each count point for 6 min to facilitate estimation of site occupancy. For each bird detected, technicians recorded species, sex, horizontal distance from the observer, minute of detection, and type of detection (e.g., song, call, visual). Other data, such as the presence of migrants, flyovers, clusters, species difficult to detect, and the presence of Abert's squirrels (*Sciurus aberti*) and red squirrels (*Tamiasciurus hudsonicus*), were also noted. Technicians recorded time, ambient temperature, cloud cover, precipitation, and wind speed at the start and end of each grid survey. They also recorded vegetation data within a 50-m radius of each survey point and included dominant habitat type and relative abundance; species, percent cover, and mean height of trees and shrubs; grass height; and ground cover types. Distance from a road, if within 100 m, was also noted.

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 2014, the IMBCR program encompassed three entire states (Colorado, Montana, and Wyoming); portions of nine additional states (Arizona, Idaho, North Dakota, Nebraska, New Mexico, Oklahoma, South Dakota, and Texas); two entire USFS Regions (Regions 1 and 2);

portions of two additional USFS Regions (Regions 3 and 4); all of BCR 17 (Badlands and Prairies); and portions of BCRs 9 (Great Basin), 10 (Northern Rockies), 11 (Prairie Potholes), 16 (Southern Rockies/Colorado Plateau), 18 (Shortgrass Prairie), 19 (Central Mixed-grass Prairie), and 34 (Sierra Madre Occidental; White et al. 2015; Fig. 2).

Between 16 May and 14 August 2014, field technicians and biologists with RMBO and WYNDD completed 2,455 point counts on 190 of the 191 planned survey grids (99.8%) within the 37 strata in the 5 BCRs in Wyoming, covering a total of 253,467 km^2 (White et al. 2015; Table 1; Figs. 1 and 4). Statewide results were obtained by compiling and jointly analyzing data from survey locations within the 37 different strata (White et al. 2015).

Field personnel detected a total of 176 species in 2014, including 18 SGCN (White et al. 2015). RMBO biometricians were able to estimate occupancy (Psi; ψ) for 143 of the 176 species (81.3%), 15 of which are SGCN (Table 2). Data provided robust estimates (i.e., CV <50%) for 92 species (52.3%), including 8 SGCN (Table 2). RMBO biometricians were able to estimate density (D) and population size (N) for 150 of the 176 species (85.2%), 18 of which are SGCN (Table 3). Data provided robust density estimates for 67 of the 150 species (44.7%), including 6 SGCN (Table 3).

Annual and multi-year reports, species accounts, and density estimate tables and graphs from the IMBCR program are available on the Rocky Mountain Avian Data Center web site (RMBO 2015). 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 view just the 2014 field season results, follow the link, select "Year" from the Filter drop down box on the top left of the screen, click the "Add" button, select 2014, click "Add Filter", and then click "Run Query" (White et al. 2015).

DISCUSSION

The methods employed by RMBO and project partners to monitor avian populations using the IMBCR design 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. 2015). The IMBCR program 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 program 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 2014 IMBCR design 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 design and hierarchical framework of nested strata provide accurate information about bird populations on multiple scales, from local management units to BCRs. Population estimates at the management unit scale can be used to support local management efforts, while regional- and BCR-level monitoring provides managers with dependable information about the status and changes of bird populations at ecologically relevant scales (NABCI 2009). Managers can also compare population estimates at the management unit scale to those at the BCR scale to provide a regional context for the estimates, allowing for informed conservation planning and an accurate assessment of conservation responsibility (White et al. 2015).

There are five major categories for management applications from IMBCR data (White et al. 2015):

1. The ability to compare estimates of bird populations in space and time. For example, estimates at the state and regional levels can be compared with stratum-level estimates to determine whether local populations are above or below estimates for the region.
2. Population estimates can help inform management decisions about where to focus conservation efforts. For example, managers can focus protection strategies on strata with large populations of avian species, and conservation actions can be targeted to those strata with lower populations. Managers could set thresholds that trigger specific management actions when populations reach preset levels.

3. The effectiveness of management actions within treatment areas can be evaluated by comparing stratum-level population estimates of those treatment areas to regional estimates. For example, population estimates within manipulated areas can be compared to regional estimates to determine if the treatment is beneficial or detrimental to the avian species present.
4. Annual density and occupancy estimates can be compared over time to determine if population changes are a result of population growth or decline and/or range expansion or contraction. For example, if occupancy rates of a particular species remains constant but population density declined over time, then declines in local abundance was the cause of the population change. Moreover, if both density and occupancy rates of a species declined, then range contraction was the cause of the change in population.
5. The area of land occupied by a particular species can be estimated by multiplying the size of the land area by the species' occupancy rate. For example, if the land area comprises 120,000 km^2 and the occupancy rate for a particular species is 0.57, managers can estimate that 68,400 km^2 of habitat within that land area are occupied by that species.

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. 2015). 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. The IMBCR design can also be used in research applications as overlay or auxiliary projects, which incorporate detection data from the IMBCR program into the research project's analyses. 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.

ACKNOWLEDGEMENTS

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Table 1. Planned and completed surveys, by stratum, conducted in Wyoming between 16 May and 14 August 2014 using the Integrated Monitoring in Bird Conservation Regions design.

BCR name	BCR number	Number of strata	Strata area (km^2)	Number of surveys planned	Number of surveys completed	Percent surveys completed (%)
Great Basin	9	1	119	2	2	100
Northern Rockies	10	23	165,332	112	111	99.1
Southern Rockies/Colorado Plateau	16	4	11,594	36	36	100
Badlands and Prairies	17	6	64,164	29	29	100
Shortgrass Prairie	18	3	12,258	12	12	100
Statewide total		37	253,467	191	190	99.8

Table 2. Estimated proportion of sample units occupied (ψ), standard error (SE), percent coefficient of variation (% CV), and number of grids with ≥1 detections (n) of 21 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2010-2014. Occupancy estimates are considered robust if % CV <50%, and are noted in bold. Scientific names are presented below the table.

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	0.013	52	8
American Three-toed Woodpecker	2013	0.047	0.03	63	8
American Three-toed Woodpecker	**2014**	**0.051**	**0.018**	**35**	**16**
Ash-throated Flycatcher	2010	0	0	71	1
Black Rosy-Finch	**2010**	**0**	**0**	**0**	**5**
Black Rosy-Finch	2012	0.028	0.015	55	3
Black Rosy-Finch	2013	0.036	0.02	57	5
Brewer's Sparrow	**2010**	**0.541**	**0.051**	**9**	**80**
Brewer's Sparrow	**2011**	**0.505**	**0.052**	**10**	**77**
Brewer's Sparrow	**2012**	**0.533**	**0.049**	**9**	**87**
Brewer's Sparrow	**2013**	**0.602**	**0.048**	**8**	**97**
Brewer's Sparrow	**2014**	**0.554**	**0.056**	**10**	**83**
Chestnut-collared Longspur	2010	0.033	0.021	64	3
Chestnut-collared Longspur	2012	0.023	0.02	88	2
Chestnut-collared Longspur	2013	0.025	0.02	82	3
Chestnut-collared Longspur	2014	0	0	71	1
Dickcissel	2014	0.006	0.006	94	1
Grasshopper Sparrow	**2010**	**0.128**	**0.036**	**28**	**27**
Grasshopper Sparrow	**2011**	**0.103**	**0.028**	**27**	**26**
Grasshopper Sparrow	**2012**	**0.107**	**0.03**	**28**	**16**
Grasshopper Sparrow	**2013**	**0.062**	**0.029**	**47**	**13**
Grasshopper Sparrow	**2014**	**0.085**	**0.028**	**33**	**15**
Greater Sage-Grouse	**2014**	**0.033**	**0**	**0**	**1**
Lark Bunting	**2010**	**0.199**	**0.037**	**18**	**37**
Lark Bunting	**2011**	**0.144**	**0.029**	**20**	**37**
Lark Bunting	**2012**	**0.17**	**0.038**	**22**	**24**
Lark Bunting	**2013**	**0.196**	**0.042**	**22**	**34**
Lark Bunting	**2014**	**0.246**	**0.042**	**17**	**34**
Lewis's Woodpecker	2011	0.003	0.003	90	1
Lewis's Woodpecker	2014	0.002	0.002	105	1

Table 2. Continued

Species	Year	ψ	SE	% CV	*n*
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	0.023	50	6
McCown's Longspur	**2013**	**0.024**	**0.01**	**43**	**4**
McCown's Longspur	2014	0.019	0.01	54	3
Mountain Plover	2010	0	0	71	1
Mountain Plover	2013	0.003	0.002	62	2
Northern Goshawk	2012	0.031	0.027	87	3
Northern Pygmy-Owl	2013	0.001	0.001	110	1
Pygmy Nuthatch	2010	0.001	0.001	59	2
Pygmy Nuthatch	2011	0.008	0.004	58	2
Pygmy Nuthatch	**2012**	**0.004**	**0.002**	**44**	**4**
Pygmy Nuthatch	2013	0.002	0.001	68	2
Pygmy Nuthatch	**2014**	**0.005**	**0.002**	**46**	**4**
Sagebrush Sparrow	**2010**	**0.191**	**0.038**	**20**	**24**
Sagebrush Sparrow	**2011**	**0.161**	**0.029**	**18**	**23**
Sagebrush Sparrow	**2012**	**0.152**	**0.033**	**22**	**22**
Sagebrush Sparrow	**2013**	**0.144**	**0.032**	**22**	**20**
Sagebrush Sparrow	**2014**	**0.123**	**0.031**	**25**	**14**
Sage Thrasher	**2010**	**0.252**	**0.047**	**18**	**34**
Sage Thrasher	**2011**	**0.238**	**0.039**	**16**	**33**
Sage Thrasher	**2012**	**0.353**	**0.08**	**23**	**38**
Sage Thrasher	**2013**	**0.182**	**0.039**	**21**	**26**
Sage Thrasher	**2014**	**0.223**	**0.048**	**21**	**22**
Sandhill Crane	2013	0.04	0.038	96	2
Swainson's Hawk	2010	0.017	0.017	101	2
Swainson's Hawk	2012	0.003	0.003	98	2
Swainson's Hawk	2013	0.141	0.126	89	2
Swainson's Hawk	2014	0.071	0.071	101	1
Upland Sandpiper	2010	0.038	0.029	77	5
Upland Sandpiper	2011	0.024	0.02	83	6
Upland Sandpiper	2012	0.014	0.008	62	2
Upland Sandpiper	2014	0.076	0.044	58	4
Willow Flycatcher	2010	0.06	0.04	67	4
Willow Flycatcher	2012	0.059	0.058	98	2
Willow Flycatcher	2013	0.001	0.001	97	1
Willow Flycatcher	2014	0.063	0.058	93	2

Table 2. Continued.

Index of Scientific Names:

American Three-toed Woodpecker	*Picoides dorsalis*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Black Rosy-Finch	*Leucosticte atrata*
Brewer's Sparrow	*Spizella breweri*
Chestnut-collared Longspur	*Calcarius ornatus*
Dickcissel	*Spiza americana*
Grasshopper Sparrow	*Ammodramus savannarum*
Greater Sage-Grouse	*Centrocercus urophasianus*
Lark Bunting	*Calamospiza melanocorys*
Lewis's Woodpecker	*Melanerpes lewis*
McCown's Longspur	*Rhynchophanes mccownii*
Mountain Plover	*Charadrius montanus*
Northern Goshawk	*Accipiter gentilis*
Northern Pygmy-Owl	*Glaucidium gnoma*
Pygmy Nuthatch	*Sitta pygmaea*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sage Thrasher	*Oreoscoptes montanus*
Sandhill Crane	*Grus canadensis*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Willow Flycatcher	*Empidonax traillii*

Table 3. Estimated density (*D*; individuals per km^2), population size (*N*), percent coefficient of variation (% CV), and number of independent detections (*n*) of 20 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2009-2014. Density estimates are considered robust if % CV <50%, and are denoted in bold. Scientific names are presented below the table.

Species	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
American Three-toed Woodpecker	**2014**	**0.41**	**103,291**	**45**	**24**
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**	**1,235**
Brewer's Sparrow	**2014**	**31.76**	**8,048,826**	**19**	**907**
Burrowing Owl	2014	0	240	99	1
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
Chestnut-collared Longspur	2014	0	380	137	8
Dickcissel	2014	0.01	3,420	107	1
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
Grasshopper Sparrow	**2014**	**1.65**	**418,926**	**42**	**66**
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**
Lark Bunting	**2014**	**13.69**	**3,469,547**	**30**	**1,025**
Lewis's Woodpecker	2014	0	473	101	1
Long-billed Curlew	2011	0.16	41,209	86	3
Long-billed Curlew	2012	0.14	34,494	108	3

Table 3. Continued.

Species	Year	*D*	*N*	% CV	*n*
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
McCown's Longspur	2014	0.4	100,987	101	16
Mountain Plover	2013	0	863	80	3
Mountain Plover	2014	0.14	34,447	89	17
Northern Pintail	2014	0.05	12,410	111	1
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
Pygmy Nuthatch	2014	0.04	9,243	61	5
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**
Sagebrush Sparrow	**2014**	**3.02**	**764,327**	**25**	**234**
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**
Sage Thrasher	**2014**	**1.76**	**444,993**	**14**	**278**
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
Sandhill Crane	2014	0.06	15,775	57	21
Sharp-tailed Grouse	2013	0	485	101	2

Table 3. Continued.

Species	Year	*D*	*N*	% CV	*n*
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
Swainson's Hawk	2014	0.05	12,241	91	4
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
Upland Sandpiper	2014	0.15	37,022	68	19
Willow Flycatcher	2013	0.01	2,429	107	1
Willow Flycatcher	2014	0.21	52,528	95	3

Index of Scientific Names:

American Three-toed Woodpecker	*Picoides dorsalis*
Brewer's Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Chestnut-collared Longspur	*Calcarius ornatus*
Dickcissel	*Spiza americana*
Grasshopper Sparrow	*Ammodramus savannarum*
Lark Bunting	*Calamospiza melanocorys*
Lewis's Woodpecker	*Melanerpes lewis*
Long-billed Curlew	*Numenius americanus*
McCown's Longspur	*Rhynchophanes mccownii*
Mountain Plover	*Charadrius montanus*
Northern Pintail	*Anas acuta*
Pygmy Nuthatch	*Sitta pygmaea*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sage Thrasher	*Oreoscoptes montanus*
Sandhill Crane	*Grus canadensis*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Willow Flycatcher	*Empidonax traillii*

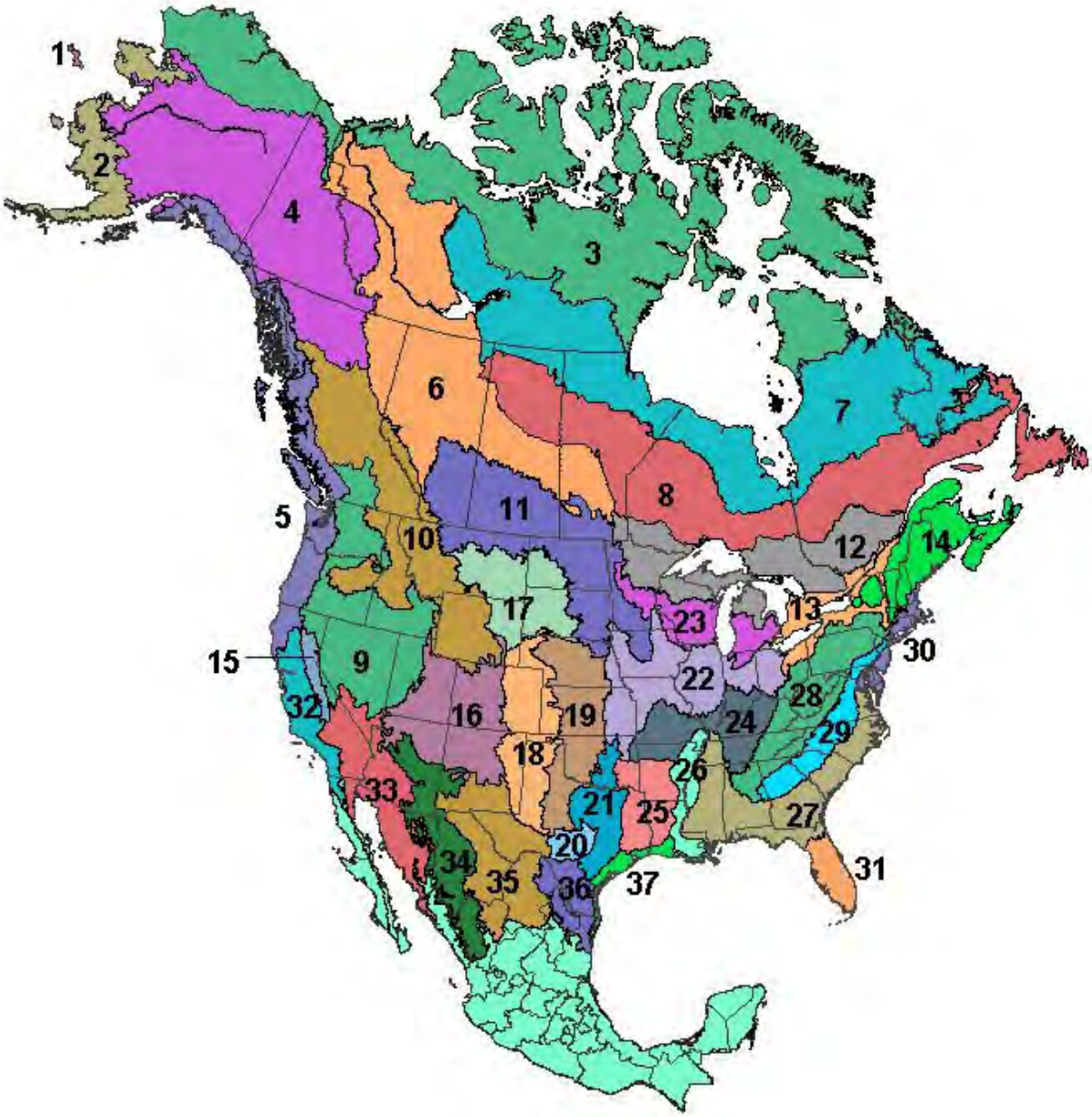

Figure 1. The North American Bird Conservation Region (BCR) map, excluding Hawaii and Mexico (NABCI 2015). Portions of BCRs that occur in Wyoming are: 9 – Great Basin, 10 – Northern Rockies, 16 – Southern Rockies/Colorado Plateau, 17 – Badlands and Prairies, and 18 – Shortgrass Prairie. Surveys were conducted all BCRs except BCR 9 in 2014.

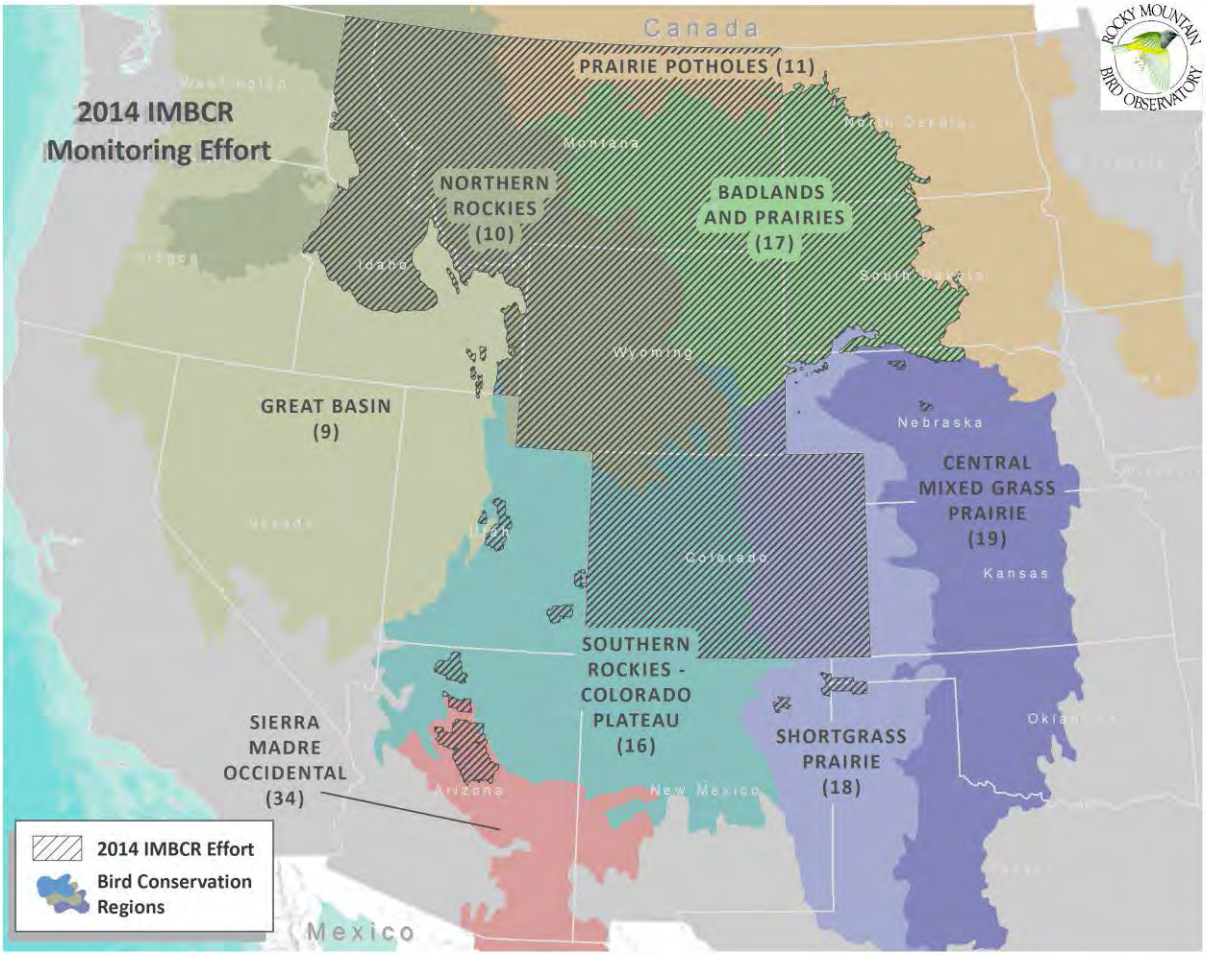

Figure 2. Spatial extent (hashed areas) of the IMBCR program in 2014 (White et al. 2015).

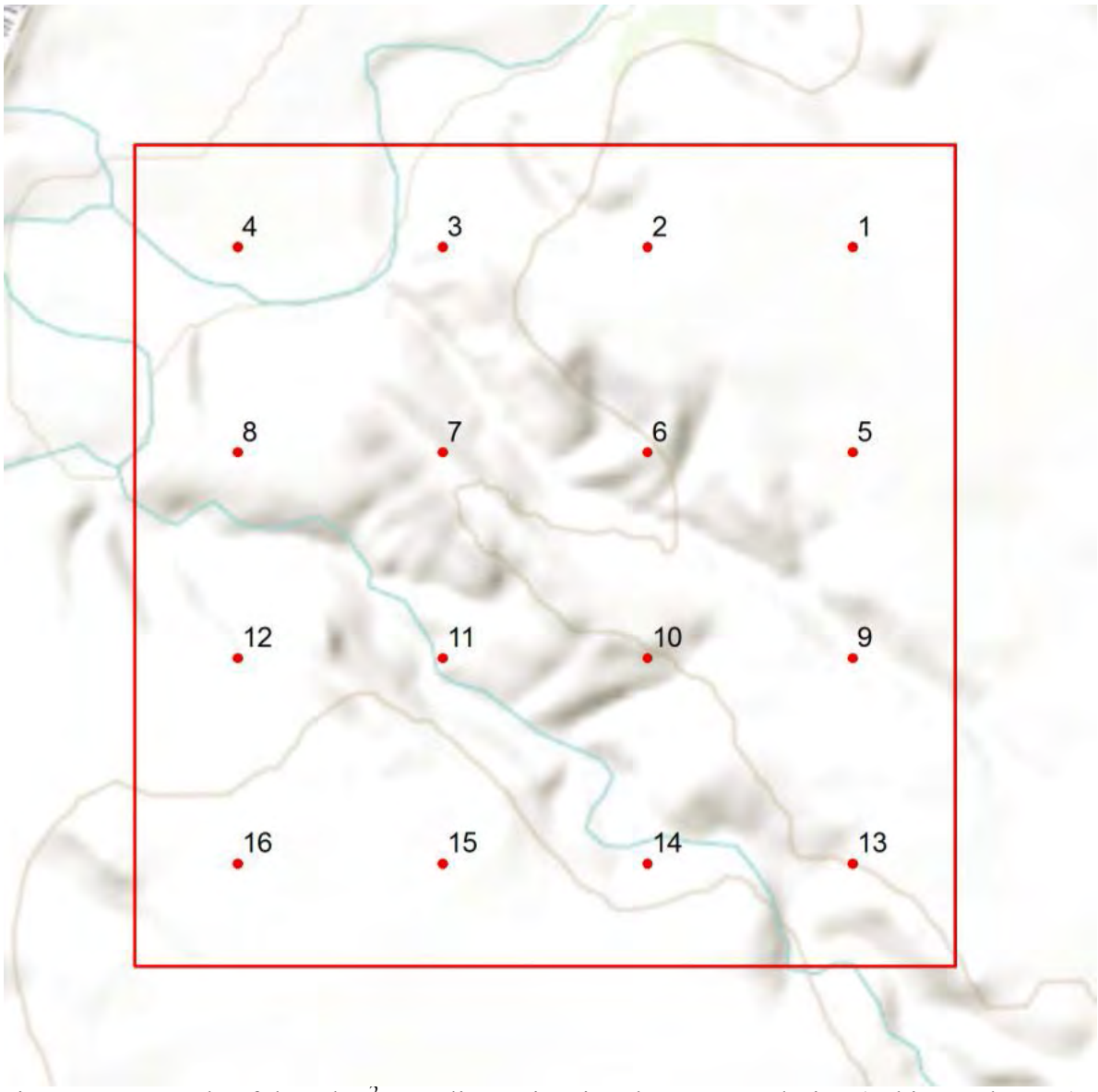

Figure 3. Example of the 1 km^2 sampling unit using the IMBCR design (White et al. 2015).

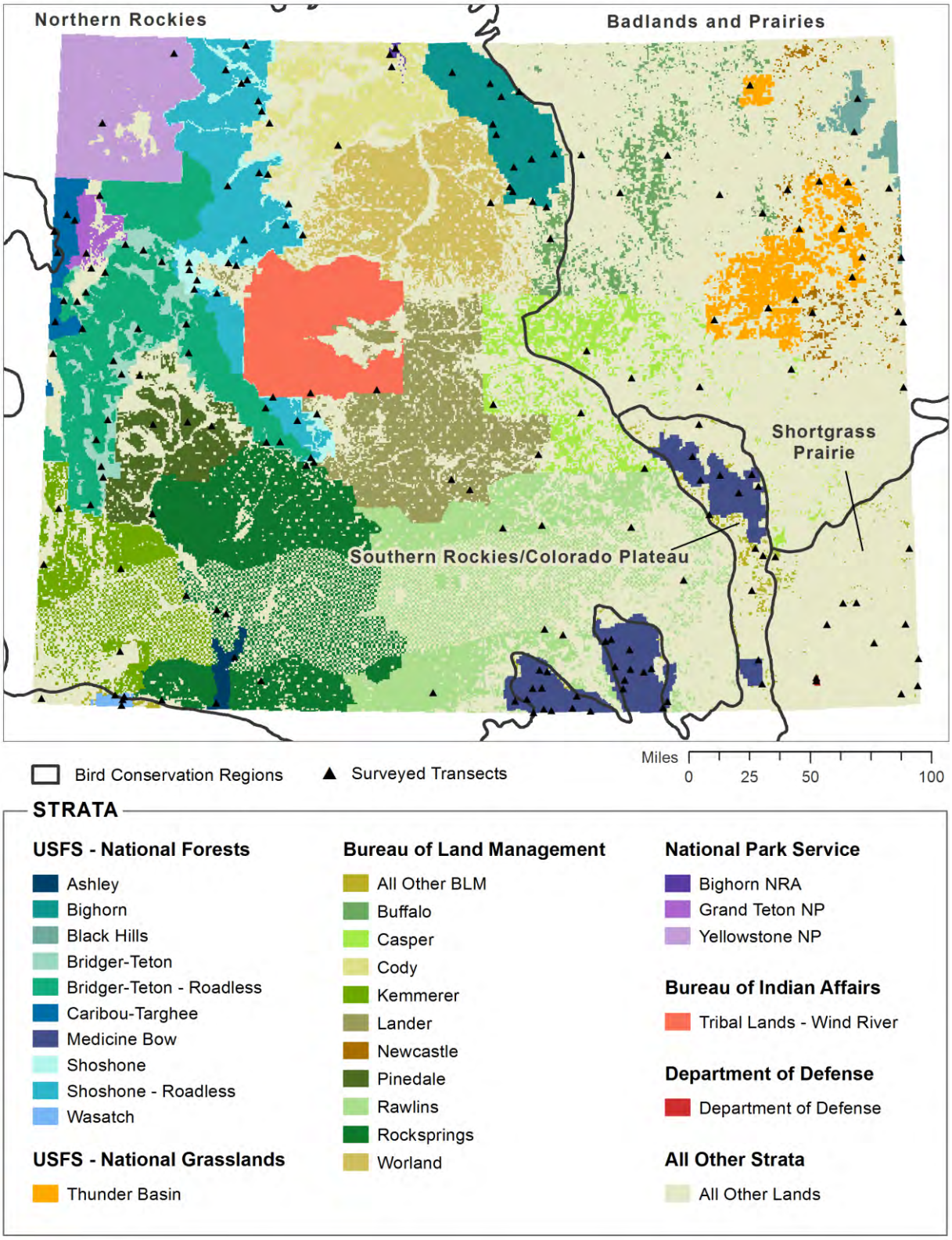

Figure 4. Integrated Monitoring in Bird Conservation Regions strata and survey grid locations in Wyoming, 2014 (White et al. 2015).

OTHER NONGAME – MAMMALS

EVALUATION OF ORAL SYLVATIC PLAGUE VACCINE IN WHITE-TAILED PRAIRIE DOGS (*CYNOMYS LEUCURUS*): YEAR TWO

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, 2014 – April 15, 2015

PREPARED BY: Jesse Boulerice, Nongame Project Biologist

ABSTRACT

Since its unintentional introduction to North America in the early 1900s, sylvatic plague has been a major contributor to the decline of populations of prairie dogs (*Cynomys* spp.). Several wildlife species 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 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. Our efforts from year one of this 3-year study are discussed in Boulerice and Grenier (2014). During year two, we distributed vaccine-laden baits at two colonies of white-tailed prairie dog at Pitchfork Ranch near Meeteetse, Wyoming in the same manner as in year one. We then conducted mark-recapture surveys to generate estimates of abundance and survival to assess trends in population from year one relative to vaccination efforts. During 5,120 trap days, we captured 446 unique white-tailed prairie dogs over four 16.2 ha plots and estimated abundance to be 144.5 individuals (95% CI: 127.1-188.9) for plot A, 136.6 (95% CI: 126.1-165.5) for plot B, 103.2 (95% CI: 96.5-137.4) for plot C, and 149.9 (95% CI: 127.9-209.0) for plot D. Density at over all four plots averaged at approximately eight prairie dogs per ha. We estimated the probability of annual survival of prairie dogs from 2013 to 2014 to be 66.3 (95% CI: 51.2-85.9) for plot A, 60.1 (95% CI: 47.8-76.2) for plot B, 37.4 (95% CI: 25.3-55.3) for plot C, and 31.4 (95% CI: 19.2-51.5) for plot D. These estimates suggest that abundance of prairie dogs increased significantly from 2013 to 2014. However, since no significant difference in

abundance or survival was found between vaccinated compared to unvaccinated individuals, we posit that these increases may be only partially due to vaccination efforts and other environmental factors promoting reproduction and recruitment of young had significant influence on observed trends in the population. In an effort to assess populations of small mammals at the colonies, we captured North American deermice (*Peromyscus maniculatus*, *n* = 113), olive-backed pocket mice (*Perognathus fasciatus*, *n* = 16), northern grasshopper mice (*Onychomys leucogaster*, *n* = 4), and prairie voles (*Microtus ochrogaster, n* = 5). We 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 and 2014.

INTRODUCTION

Sylvatic plague is an exotic disease caused by bacteria *Yersinia pestis* that has affected a multitude of 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* is especially prevalent within mammalian species of social nature, such as prairie dogs (*Cynomys* spp.; Antolin et al. 2002). With mortality rates of >90% in infected individuals, epizootic outbreaks of sylvatic plague often result in localized or even regional extirpation of colonies of prairie dogs (Cully and Williams 2001). The combined impacts of decades of poisoning, shooting, habitat loss, and sylvatic plague have diminished populations of prairie dogs nationwide, leading to range reduction of >98% for black-tailed prairie dogs (*Cynomys ludovicianus*), and reductions are likely to be similar for other species (Van Putten and Miller 1999, Miller and Cully 2001). Several other species of wildlife exhibiting an obligate or facultative dependency on prairie dogs also suffer from declines of this keystone species as a result of plague (Kotliar et al. 1999). Most notably, this includes the Endangered black-footed ferret (*Mustela nigripes*), a species that depends on prairie dogs as a primary source of food and shelter. Additionally, transmission of infected fleas from prairie dogs to ferrets is thought to be common, and ferrets are highly vulnerable to the direct effects of plague (Williams et al. 1994, Grenier et al. 2009, Jachowski and Lockhart 2009). Prompted by the severity of the threats posed by this disease to prairie dogs, ferrets, and affiliated communities, conservation efforts have been focused on developing strategies and tools for combating sylvatic plague (Rocke et al. 2010, Abbott et al. 2012).

The US Geological Survey (USGS), University of Wisconsin, and Western Association of Fish and Wildlife Agencies (WAFWA) has recently begun evaluating a new vaccine for sylvatic plague (sylvatic plague vaccine, SPV; Rocke et al. 2010). SPV 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). As an alternative 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, Rocke et al. 2010, 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, SPV 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.

A crucial component of these efforts to evaluate SPV includes assessing how species-specific differences between species of prairie dogs influence the effectiveness of the vaccine. Each species of prairie dog afflicted by plague exhibits variation in social behaviors, density of individuals within a colony, proximity of burrows, and configuration of colonies across the landscape that must be accounted for in designing an effective tool for mitigation of plague across species (Cully and Williams 2001, Antolin et al. 2002). Specifically, these differences are likely to produce critical distinctions in the rate of transmission of infected fleas between individuals, persistence of plague during enzootic periods, and frequency and lethality of epizootic outbreaks (Cully and Williams 2001, Antolin et al. 2002, Hanson et al. 2007). Likewise, rate of consumption of SPV baits and degree of antibiotic response are expected to vary by species, and may require distinct density, pattern, and frequency of distribution of SPV to account for these differences. Accordingly, the collaborative project by the USGS seeks to elucidate these relationships between the vaccine, plague, fleas, and each species of prairie dog through field trials of SPV nationwide in order to maximize the success of SPV at combating the virulence and spread of sylvatic plague.

In conjunction with species-specific differences among prairie dogs, the dynamics of plague and SPV are further complicated by small rodent communities that also may play a veiled but significant role. For example, rodent species occurring within colonies such as the northern grasshopper mouse (*Onychomys leucogaster*) and North American deermouse (*Peromyscus maniculatus*) are capable of harboring infected fleas or even sustaining direct infection with *Y. pestis* without suffering the lethal effects of plague. Due to this reduced virulence in small rodents, these species are thought to be largely responsible for the persistence of the plague bacterium within an ecological system, especially during enzootic periods (Biggins and Kosoy 2001, Salkeld et al. 2010). In addition, movement of these alternative host species throughout and between colonies of prairie dogs may increase the spread of infection more so than by prairie dogs alone, whose movements tend to be localized to a particular set of burrows and small home range (Stapp et al. 2004, Salkeld et al. 2010). As a result of this increased connectivity, high abundances of small rodents have been linked to greater likelihood of plague outbreak within prairie dog colonies (Salkeld et al. 2010). These attributes of alternative hosts dictate that efforts to combat sylvatic plague in prairie dogs must include consideration of the influence of small rodents on plague and the success of SPV.

The Wyoming Game and Fish Department agreed to participate with the USGS and other agencies in the collaborative project to test the effectiveness of SPV in populations of wild prairie dogs. We selected colonies of white-tailed prairie dogs (*C. leucurus*; WTPD) near Meeteetse as the site of SPV trials in Wyoming, due to a well-documented history with prairie dogs, plague, and ferrets in the region (WGFD 1990, Menkens and Anderson 1991). WTPD are the least-social of all of the species of prairie dog in North America and ,therefore, are likely to exhibit species-specific differences that could be crucial to successfully combating plague with

SPV (Cully and Williams 2001, Antolin et al. 2002). As one of only two sites participating in this endeavor to focus on WTPD, our efforts are fundamental in assessing the use of SPV as a tool for mitigating the impacts of sylvatic plague specific to this species, which ranges throughout much of Wyoming. The overall goal of this project in Wyoming was to determine if the vaccine will result in significant increases in survival rates as compared to unvaccinated individuals of WTPD (T. Rocke, pers. comm.). Following a protocol standardized for use among all agencies participating in the project, a mark-recapture approach was employed to compare survival rates between prairie dogs presented with vaccine-laden or placebo baits over a 3-year period. Our results from Meeteetse will be used by the USGS to inform a multi-species assessment.

During the summer of 2013, we completed the first year of surveys on four 16 ha plots at two distinct colonies (two plots per colony, colonies AB and CD) of WTPD at our study site. Expanded details of these efforts, summarized below, can be found in Boulerice and Grenier (2014). Within the four plots, we marked and processed 282 unique WTPD comprised of 137 males and 145 females (m:f: 0.9:1). We collected biological samples for each prairie dog, and sent samples to the USGS to assess consumption of bait and antibiotic response to SPV. Based on closed population models, we established a baseline estimate of abundance in 2013 to be 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. We determined that a single 8-day trapping cycle may be optimal to future efforts to estimating abundance of WTPD, rather than the two 5-day trapping cycle employed in 2013. We also conducted preliminary surveys to assess populations of small rodents within the colonies. Additionally, we found correlation between a commonly used index of abundance and the derived estimates of abundance from mark-recapture analysis, and suggested that this relationship be explored further in subsequent years of this project.

In 2014, we established several objectives building specifically off the results of 2013. First, we estimated abundance and density for WTPD in 2014 by using a single 8-day trapping cycle and compared results to that of 2013 to assess the influence of SPV on trends within our study site. We then generated estimates of annual survival based on those animals originally tagged in 2013, and compared differences in survival between animals receiving SPV and those receiving a placebo. We also established a robust protocol for estimating abundance of small mammals and assessed the influence of alternative hosts to plague specific to our study area. Finally, we re-evaluated the validity of an index for abundance through comparison with our derived estimates of abundance in 2014.

METHODS

During mid-June through mid-August 2014, we conducted the second year of surveys on colonies of white-tailed prairie dogs at Pitchfork Ranch, approximately 24 km west of Meeteetse. We surveyed the same colonies that were surveyed in 2013 (Boulerice and Grenier 2014). We surveyed a pair of 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 abundance of small mammals by establishing trapping grids within each of the four plots for 2014. We modified the number, size, and location of trapping grids in 2014 from that of trapping efforts in 2013 in order to increase total number of captures and obtain a more robust estimate of abundance. Specifically, each trapping grid for small mammals (SMG) was centered within each respective plot and labeled accordingly (i.e., SMG-A was centered on plot A, SMG-B was centered on plot B, etc.; Fig. 1). Each SMG consisted of 132 small mammal traps (339A non-folding trap, Sherman Trap, Inc., Tallahassee, FL) spaced 16 m apart in a 12 × 11 array. We trapped small mammals at each grid for four consecutive nights. We baited all traps with steel cut oats at approximately 1700 hrs and returned to process captures the following morning at 0800 hrs. Each captured individual was marked with a single ear tag (1005-1, National Band and Tag Co., Newport, KY). Due to the small size of ears, we alternatively marked olive-backed pocket mice (*Onychomys leucogaster*) with a passive integrated transponder (PIT tags; AVID Microchip I.D. Systems, Folsom, LA). We collected hair and whisker samples, and recorded sex, age, and weight from all captured animals. We collected blood samples from all adult animals >15 g. Biological samples were sent to the USGS for analysis.

We then distributed baits supplied by the USGS between 4-5 June on plots A and B, and between 1-2 July on plots C and D. Dates of distribution of baits differed from that of 2013 as dictated by our switch from two five-occasions trapping cycle to a single eight-occasion in order to ensure that decomposition of the baits was consistent across plots. Baits were provided in two forms; treatment (i.e., with vaccine) and placebo (i.e., without vaccine). Plots that received either the treatment or placebo form in 2013 received the same form in 2014. As in 2013, USGS pre-assigned baits to each plot a blind manner, such that field personnel were unaware whether they were distributing treatment or placebo baits to prevent any bias in distribution. 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 2 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, consumption 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 a Tomahawk live-trap (Model #102 or #103, Tomahawk Live Trap, LLC, Hazelhurst, WI). We locked open traps for 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-baiting, we trapped each set of paired plots for 8 consecutive mornings for a total of 1,280 trapping occasions per plot (160 traps × 8 occasions). Each morning, between 0630 and 0800 hrs, 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 (1005-1, National Band and Tag Co., Newport, KY). 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 biological samples to the USGS for analysis.

We estimated the abundance of prairie dogs at each plot in 2014 by using Huggins conditional likelihood formulation in program MARK (Huggins 1989, White and Burnham 1999). Our candidate model set included model combinations that considered the effect of individual heterogeneity (π), time, age (adult, subadult), sex, number of nearby burrows (bur), age × time, sex × time, and bur × time on probability of capture (*p)* and recapture (*c*; Otis et al. 1978, White et al. 1982). We calculated number of nearby burrows by averaging the number of active burrows within 20 m of each trap in which an individual was captured. We calculated the weight of each model based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (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). In order to compare estimates of abundance from 2014 to those of 2013, for which we did not consider the effect of covariates, we generated new estimates for captures in 2013 that also included the influence of age, sex, and bur on *p* and *c*.

We estimated the probability of survival of prairie dogs at each plot by using the Cormack-Jolly-Seber formulation (Cormack, 1964, Jolly, 1965, Seber 1965) in MARK. Our candidate model set for this analysis included model combinations that considered the effect of time, age (adult, subadult), sex, age × time, and sex × time on probability of capture (*p*), and probability of survival (Φ) from 2013 to 2014. As above, we calculated the weight of each model based on AIC*c* (Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002).

We conducted 100% burrow counts for 2014 during early August to generate an additional index of abundance for 2014. As in 2013, 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 away. We mapped all active burrows using ArcGIS 10.1. We then compared total number of burrows to derived estimates of abundance for each plot, respectively, to determine the relationship defined by estimated number of WTPD per burrow per plot.

RESULTS

During small mammal trapping, we captured 138 unique individuals consisting of 113 North American deermice (*Peromyscus maniculatus*), 16 olive-backed pocket mice (*Perognathus fasciatus*), 4 northern grasshopper mice (*Onychomys leucogaster*), and 5 prairie voles (*Microtus ochrogaster*). 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 to3 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 5,120 trap occasions, we captured prairie dogs 1,051 times for a capture rate of 0.2 prairie dogs per trap occasion. Of those, 446 were unique individuals comprised of 218 males and 228 females (m:f = 0.95:1). Number of individuals captured at each plot was 116 for A, 120 for B, 95 for C, and 115 for D. A comparison of captures by plot for 2013 and 2014, including the ratio of new captures to re-captures for 2014, is displayed in Table 2. We captured individuals 2.2 times on average (SE ±0.06, range = 1-8) over 8 sampling occasions, and 60% of individuals were recaptured at least once. We collected blood, hair, and whisker samples from 244 individuals.

We estimated the abundance of prairie dogs in 2014 to be 144.5 individuals (95% CI: 127.1-188.9) for plot A, 136.6 individuals (95% CI: 126.1-165.5) for plot B, 103.2 individuals (95% CI: 96.5-137.4) for plot C, and 149.9 individuals (95% CI: 127.9-209.0) for plot D. In regenerating closed population models from 2013 to include the same covariates of age, sex, and number of nearby burrows as 2014, we arrived at slightly different estimates of abundance from that reported in Boulerice and Grenier 2014. Specifically, we found the abundance in 2013 to be 78.3 (95% CI: 76.0-85.7) for plot A, 100.4 (95% CI: 92.0-118.9) for plot B, 66.6 (95% CI: 60.9-80.8) for plot C, and 100.9 (95% CI: 80.1-150.0) for plot D. Comparisons of estimates of abundance for each plot by year are shown in Figure 2. Top models for estimates of abundance from 2013 and 2014 are shown in Table 3. During analysis, we removed those models from 2014 that included a sex × time effect on p and c and those models from 2013 that included the effect of π and c together, as these models generated estimates with standard errors that were too large to allow for meaningful comparison between years. This inflated variation in estimates of abundance often occurs within the Huggins formulation when p is close to zero for some animals (Pollock 2002), which is likely the case here. However, the confidence intervals of removed models overlapped that of retained models, suggesting that removal did not influence the accuracy of our estimates of abundance.

Based on the estimates of abundance for 2014, we estimated density of prairie dogs (i.e., individuals per ha) to be 8.92 (95% CI: 7.85-11.66) for plot A, 8.44 (95% CI: 7.78-10.22) for plot B, 6.37 (95% CI: 5.96-8.48) for plot C, and 9.26 (95% CI: 7.90-12.91) for plot D. We also derived new estimates for density of prairie dogs in 2013 using the updated estimates of abundance. Density of prairie dogs in 2014 was compared to density in 2013 by plot in Figure 3.

We estimated the probability of annual survival of prairie dogs from 2013 to 2014 to be 66.3 (95% CI: 51.2-85.9) for plot A, 60.1 (95% CI: 47.8-76.2) for plot B, 37.4 (95% CI: 25.3-55.3) for plot C, and 31.4 (95% CI: 19.2-51.5) for plot D. Estimates of survival are graphed in Figure 4. Top models for estimates of survival are shown in Table 4.

Results for 100% burrow counts revealed a total of 3,204 active burrows over all four plots. Total number of active burrows per plot, and density of burrows per plot for 2013 and 2014 are shown in Table 5. Based on the estimates of abundance for 2014, we calculated a ratio

of 0.154 prairie dogs per burrow for colony AB, and 0.184 for colony CD. From the reassessed estimates in 2013, we calculated 0.132 prairie dogs for colony AB, and 0.138 for colony CD.

DISCUSSION

Compared to baseline estimates of abundance we established in 2013, we found the abundances of prairie dogs over both colonies increased approximately 50% from 2013 to 2014 (Fig. 2). This increase in abundance is supported by anecdotal evidence from the field, specifically an apparent increase in visual observations of prairie dogs during the 2014 surveys. From 2013 to 2014, estimates of density per hectare of prairie dogs at each colony increased from slightly below the range typical of healthy colonies of white-tailed prairie dogs to a density within the range of estimates from other studies throughout Wyoming (Table 6). In addition, we recorded a 25% increase in the number of active burrows over both colonies from 2013 to 2014.

While all of our metrics used to assess abundance support a significant increase in prairie dogs from 2013 to 2014, the cause of this increase remains unresolved. Increases may be due in part to distribution of SPV across the treatment plots of each colony. Responses to SPV, including increases in antibiotic resistance to the plague bacterium, are expected to increase the survival, and ultimately the abundance, of prairie dogs on vaccinated colonies (Rocke et al. 2010). However, while abundances increased ubiquitously across all of our study area, we did not find support for a significant difference in abundance between paired-plots, or specifically plots receiving the SPV and plots receiving placebo baits, as would be expected if SPV was the primary driver of increased abundance. Likewise, although we detected differences in estimates of survival for each colony, survival between paired-plots was essentially identical (Fig. 2). Therefore, while SPV may play a role in the increase in abundance we observed, other factors are likely to have contributed significantly to the change. Weather conditions and/or availability of food resources throughout the summer of 2013 or early spring of 2014 may have promoted reproductive activity and recruitment of young during the spring mating season, resulting in an increase of juveniles in 2014. In conjunction, supplemental feeding from our trapping efforts (i.e., horse feed used to bait animals into traps) may have endowed some nutritional value to prairie dogs. However, the amount and duration of this food source seems unlikely to provide a sizeable benefit. Immigration from neighboring colonies is also not expected to add significantly to the population at our study site, as these colonies are fairly isolated except from each other (see Fig. 1).

Our assessment of small rodent populations suggests that alternative hosts of sylvatic plague, most notably North American deermice and northern grasshopper mice, could play a significant role in the dynamics of the disease and vaccination efforts within our colonies. Extrapolation of our estimates of abundance suggests an average of 125.2 deer mice occurred within the confines of each plot (16.2 ha). Although our estimates for northern grasshopper mice include only a few individuals per plot, the large home range and high mobility of individuals may compensate for low densities in terms of capacity to interact with prairie dogs. The high density of deermice and high mobility of grasshopper mice likely accelerate the spread of fleas throughout our colonies, while simultaneously provides a suitable alternative host for the persistence of plague during enzootic periods. Additionally, the high density of deermice

undoubtedly reduced the number of SPV baits available to prairie dogs, as deermice also readily consume baits at our colonies. SPV consumption by non-target species such as deermice may provide immunization from plague, and efforts to quantify the benefits to non-target species are currently ongoing within the collaborative project with USGS. However, consideration of the amount of non-target consumption, likely correlated to abundance, is vital to determining the appropriate density and pattern of distribution of SPV for vaccinating prairie dogs. The influence of the other small rodent species we detected on our plots, including olive-backed pocket mice and prairie voles, is unknown, although these species are also capable of carrying fleas and consuming baits.

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). In 2013, we found the estimated abundance of prairie dogs per active burrow to be nearly identical when calculated independently for each colony, and we recommended exploring this relationship further in years 2014-2015 (Boulerice and Grenier 2014). In 2014, we found this ratio to show slight deviation between colonies and from estimates in 2013. Given the dynamics in annual abundance of prairie dogs and distribution of burrows, this deviance is not unexpected but does challenge the validity of correlating number of burrows to abundance. However, we believe for the purpose of a crude estimate of abundance, 100% burrow counts may still be a useful tool, as long as some level of imprecision in estimates is allowable. We caution that this technique may only be applicable to our study site, and the relationship between abundance and number of burrows may vary greatly in other locations. We recommend that counts be conducted in a similar manner in 2015 to further explore this relationship.

Inherently, one of the initial 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 and 2014, 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 the USGS revealed that 97% of WTPD captured at our colonies in 2013 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 (approximately 100 baits per ha) by foot at a rate of roughly 1.32 ha per hr in both 2013 and 2014. 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 regional scale and, therefore, may preclude SPV from being used at a level that is ecologically meaningful unless density of baits or cost of production are reduced. Nevertheless, as currently structured, SPV may become a valuable tool for localized management in the near future.

Although results from the second year of this project did not show a clear relationship between increased survival or abundance of WTPD and SPV, this lack of correlation does not indicate SPV is ineffective at combating plague. Two assumptions must be met within the system in order for vaccination with SPV to result in significant changes in survival or abundance of prairie dogs. First, plague must be present in the population. Given the well-documented history of drastic declines in populations of WTPD in the Meeteetse region as a result of plague, as well as persistence of the disease long after epizootics, we are confident that this assumption is met and *Y. pestis* remains present within our study site (WGFD 1990, Menkens and Anderson 1991). Second, the effects of plague must sufficiently suppress the population, in terms of a reduction in survival, reproduction, recruitment, etc., such that the liberation from suppression after immunization is measurable. During enzootic periods, *Y. pestis* can persist either within primary hosts like prairie dogs at low levels without noticeable effects on the species, or within alternative hosts (Antolin et al 2002). With no evidence of a recent epizootic outbreak, and an abundance of alternative hosts, we believe that our study site is in the midst of an enzootic period where the effects of plague are likely subdued and, therefore, this second assumption may not be met. Accordingly, assessment of effectiveness of SPV is based instead on capacity to deliver the vaccine to prairie dogs (rate of consumption, ease of distribution) and antibiotic response to plague antigens (results pending). While the former of these factors thus far suggests that SPV has the potential to be an effective tool to combating plague in WTPD, at least on a small scale, we anticipate that the results of this project after year three will allow for a more thorough assessment.

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Table 1. Captures of small mammals on grids at Pitchfork Ranch, Meeteetse, Wyoming conducted June-July 2014. We captured small mammals at four grids located in the center of each of the four plots: small mammal grid (SMG) A, B, C, and D.

Species	SMG-A	SMG-B	SMG-C	SMG-D	Total
Peromyscus maniculatus	40	22	30	21	113
Perognathus fasciatus	7	6	3	0	16
Onychomys leucogaster	1	1	2	0	4
Microtus ochrogaster	1	2	2	0	5
Total	49	31	37	21	138

Table 2. Captures of white-tailed prairie dogs (*Cynomys leucurus*) on each of four plots at Pitchfork Ranch, Meeteetse, Wyoming from surveys conducted June-July 2013 and 2014.

Plot	Total captured in 2013	Recaptured in 2014	Percent recaptured in 2014	New in 2014	Total captured in 2014
A	75	37	0.49	79	116
B	85	41	0.48	79	120
C	57	16	0.28	79	95
D	65	14	0.21	101	115
Total	282	108	0.38	338	446

Table 3. Results from Huggins closed population models to estimate abundance of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, Wyoming, June-August 2013 and 2014. Our candidate model set included model combinations that considered the effect of individual heterogeneity (π), time, age (adult, subadult), sex, number of nearby burrows (Bur) , age × time, sex × time, and bur × time on probability of capture (*p)* and recapture (*c*; Otis et al. 1978, White et al. 1982). Only the top six models are shown for each year. We calculated the weight of each model based on Akaike's Information Criterion for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and unconditional standard error of abundance were calculated for each plot by weighted model-averaging across all models (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). Model average estimates shown in bold were derived from the entire dataset.

CLOSED POPULATION MODELS

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	$\widehat{N}(\widehat{SE})$ Plot A	$\widehat{N}(\widehat{SE})$ Plot B	$\widehat{N}(\widehat{SE})$ Plot C	$\widehat{N}(\widehat{SE})$ Plot D
2013							
π+Time+Sex+Age+Bur+Bur*Time	3133.65	0.00	0.342	78.27 (2.16)	99.92 (6.18)	67.04 (4.86)	102.45 (16.72)
π+Time+Sex+Age+Bur*Time	3134.60	0.95	0.212	78.24 (2.14)	99.72 (6.12)	66.17 (4.41)	102.95 (18.33)
π+Time+Sex+Age+Bur	3135.30	1.65	0.149	78.27 (2.15)	99.59 (6.16)	67.11 (4.91)	100.83 (15.86)
π+Time+Age+Bur+Bur*Time	3136.20	2.55	0.095	78.43 (2.22)	102.54 (6.79)	66.49 (4.68)	96.89 (12.99)
π+Time+Sex+Age	3137.29	3.64	0.055	78.52 (2.27)	99.76 (6.10)	65.87 (4.27)	105.37 (20.38)
π+Time+Age+Bur*Time	3137.41	3.77	0.052	78.32 (2.17)	102.28 (6.80)	65.45 (4.11)	94.77 (12.12)
Model Average				**78.31 (2.17)**	**100.39 (6.30)**	**66.60 (4.65)**	**100.86 (16.14)**
2014							
π+Time+c+Sex+Age+Bur	4045.32	0.00	0.664	144.80 (14.37)	136.46 (8.98)	101.58 (4.42)	152.37 (17.78)
π+Time+c+Sex+Age	4048.81	3.49	0.116	142.74 (13.69)	137.41 (9.51)	101.88 (4.60)	150.56 (17.23)
π+Time+c+Sex+Bur+Bur*Time	4049.47	4.15	0.083	146.72 (15.640	136.61 (9.24)	117.57 (13.14)	124.61 (5.57)
π+Time+c+Age+Bur	4049.69	4.37	0.075	143.91 (15.05)	136.23 (9.31)	100.72 (3.89)	152.35 (17.69)
π+Time+c+Age	4051.71	6.39	0.027	142.02 (15.05)	137.93 (10.55)	100.94 (3.98)	151.74 (18.42)
π+Time+c+Sex+Age+Bur*Time	4052.53	7.20	0.018	143.78 (14.11)	137.43 (9.47)	102.14 (4.74)	149.09 (16.83)
Model Average				**144.51 (14.43)**	**136.61 (9.12)**	**103.21 (5.27)**	**149.89 (16.75)**

Table 4. Results from Comack-Jolly-Seber open population models to survival abundance of white-tailed prairie dogs (*Cynomys leucurus*) at Pitchfork Ranch, Meeteetse, Wyoming between July-August 2013 and 2014. .Our candidate model set for this analysis includes model combinations that considered the effect of time, age (adult, subadult), sex, age by time, and sex by time on probability of capture (*p*), and probability of survival (Φ). Only the top six models are shown. We calculated the weight of each model based on Akaike's Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). Estimates and unconditional standard error of survival were calculated for each plot by weighted model-averaging across all models (Burnham and Anderson 2002). 95% Confidence Intervals (95% CI) for each estimate of survival are reported in parentheses. Model average estimates shown in bold were derived from the entire dataset.

OPEN POPULATION MODELS

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	$\widehat{\Phi}$(95% CI) Plot A	$\widehat{\Phi}$(95% CI) Plot B	$\widehat{\Phi}$(95% CI) Plot C	$\widehat{\Phi}$(95% CI) Plot D
2013							
Φ(Sex*t),p(Plot,t,Sex,Sex*t)	617.42	0.00	0.384	0.69 (0.56,0.85)	0.63 (0.51,0.77)	0.38 (0.26,0.56)	0.33 (0.21,0.52)
Φ(Sex*t,Age*t),p(Plot,t,Sex,Sex*t)	619.35	1.94	0.146	0.69 (0.56,0.85)	0.63 (0.51,0.77)	0.38 (0.26,0.56)	0.33 (0.21,0.52)
Φ(Sex,Age,Age*t),p(Plot,Sex,Sex*t,Age,Age*t)	622.94	5.52	0.024	0.72 (0.60,0.88)	0.63 (0.51,0.77)	0.41 (0.28,0.6)	0.33 (0.21,0.52)
Φ(Sex*t),p(Plot,Sex,Sex*t,Age*t)	622.97	5.55	0.024	0.63 (0.50,0.80)	0.58 (0.47,0.71)	0.36 (0.24,0.52)	0.3 (0.19,0.48)
Φ(Sex,Sex*t),p(Plot,Sex,Sex*t)	623.01	5.60	0.023	0.58 (0.46,0.73)	0.55 (0.45,0.68)	0.34 (0.23,0.5)	0.28 (0.17,0.45)
Φ(Age,Age*t),p(Plot,Sex,Sex*t)	623.80	6.39	0.016	0.66 (0.53,0.83)	0.58 (0.47,0.73)	0.37 (0.25,0.55)	0.31 (0.2,0.49)
Model Average				**0.66 (0.51-0.86)**	**0.60 (0.48,0.76)**	**0.37 (0.25,0.55)**	**0.31 (0.19,0.52)**

Table 5. Results of 100% burrow counts conducted at Pitchfork Ranch, Meeteetse, Wyoming, August 2013 and 2014. Density represents number of burrows per hectare.

Plot	2013		2014	
	Count	Density	Count	Density
A	681	42.0	919	56.7
B	673	41.5	907	60.0
C	646	39.9	698	43.1
D	561	34.6	680	42.0
Total	2561	39.5	3204	49.4

Table 6. 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 2013**
6.3 – 9.2	**Meeteetse, WY**	**This project 2014**
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

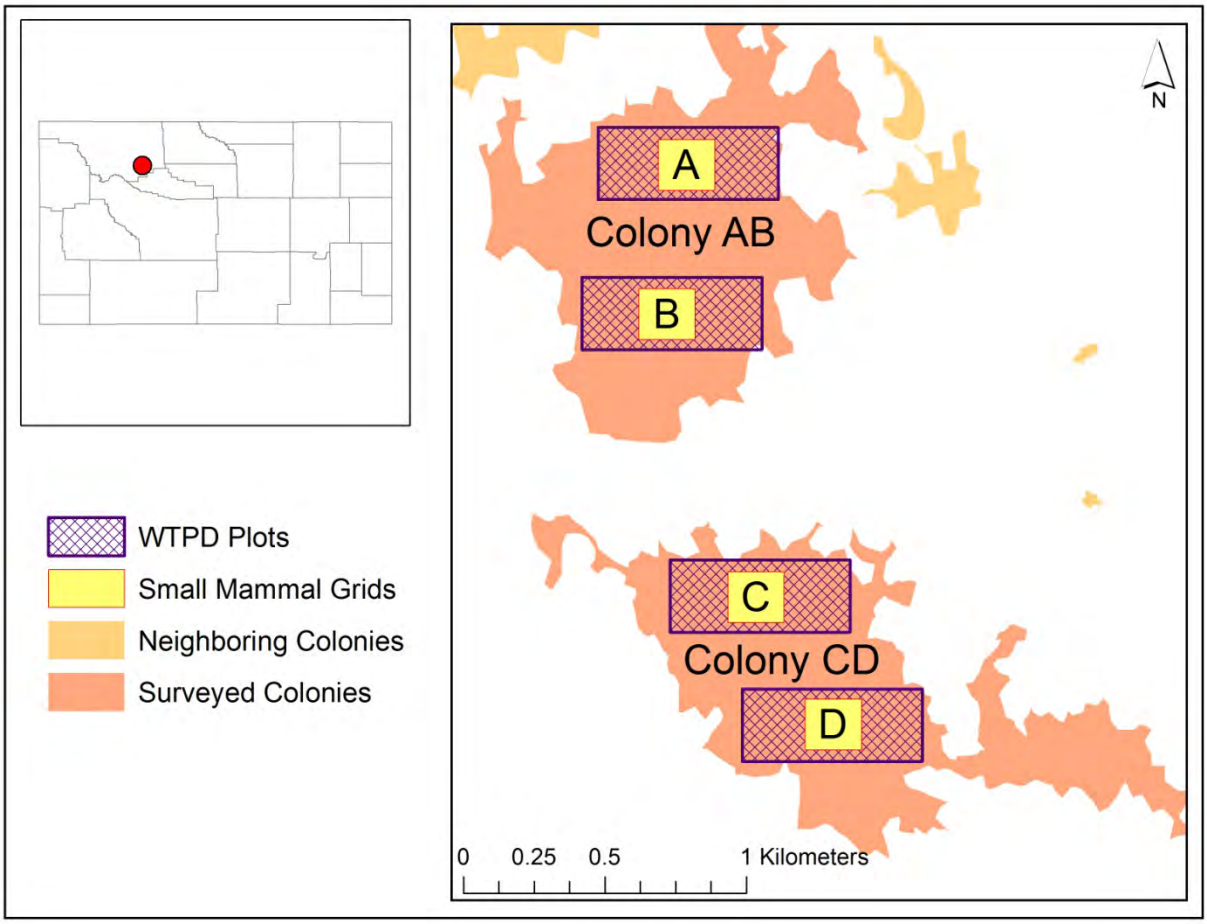

Figure 1. Location of colonies, plots, and small mammal grids at Pitchfork Ranch, Meeteetse, Wyoming, 2014. Plots were paired such that one plot in each colony received the vaccine-laden baits, while the other received a placebo (paired-plots). Baits were distributed in a blind manner. Small-mammal grids were located at the center of each plot and trapped prior to distribution of baits.

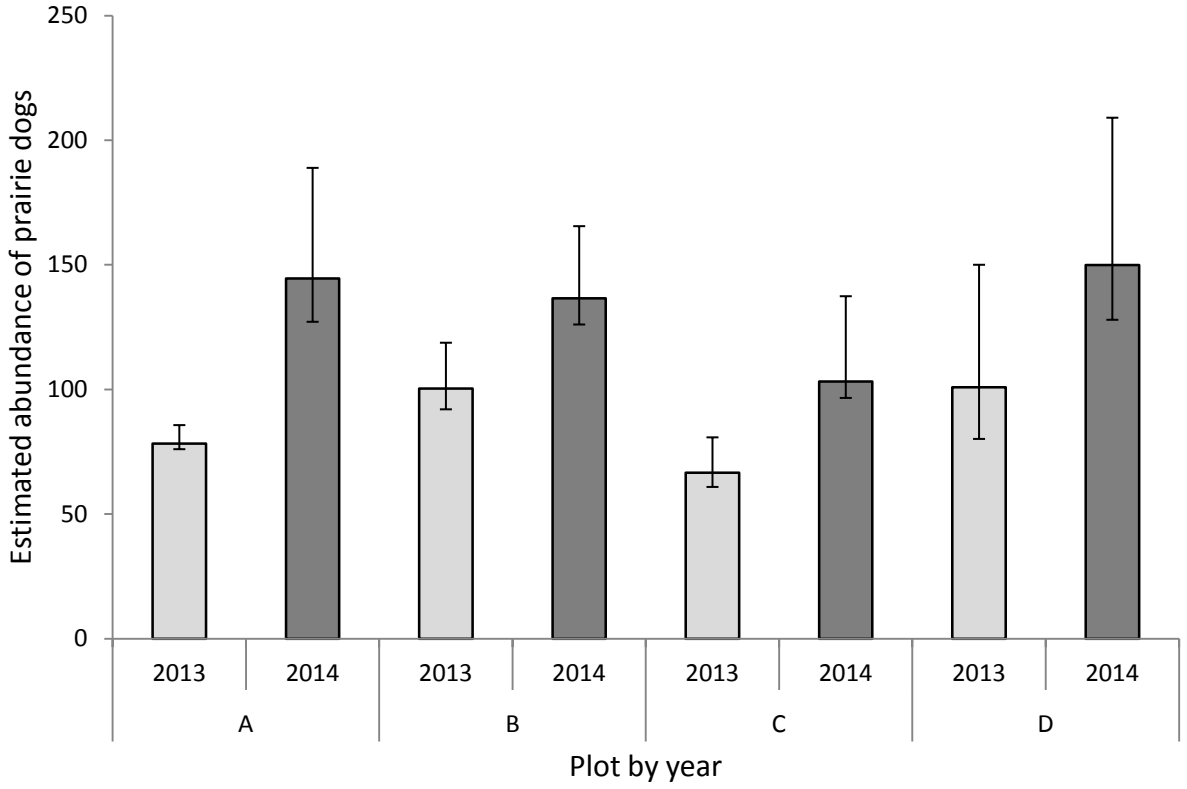

Figure 2. Estimates of abundance of white-tailed prairie dogs (*Cynomys leucurus*) within each plot at Pitchfork Ranch, Meeteetse, Wyoming, June-August 2013 and 2014. Estimates were derived under closed population models using Huggins conditional likelihood formulation (Huggins 1989, White and Burnham 1999). Light bars represent estimates from 2013 and dark bars represent estimates from 2014. Estimates from 2013 were regenerated based on models incorporating that addition of covariates and therefore differ slightly from estimates reported in Boulerice and Grenier 2014. 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.

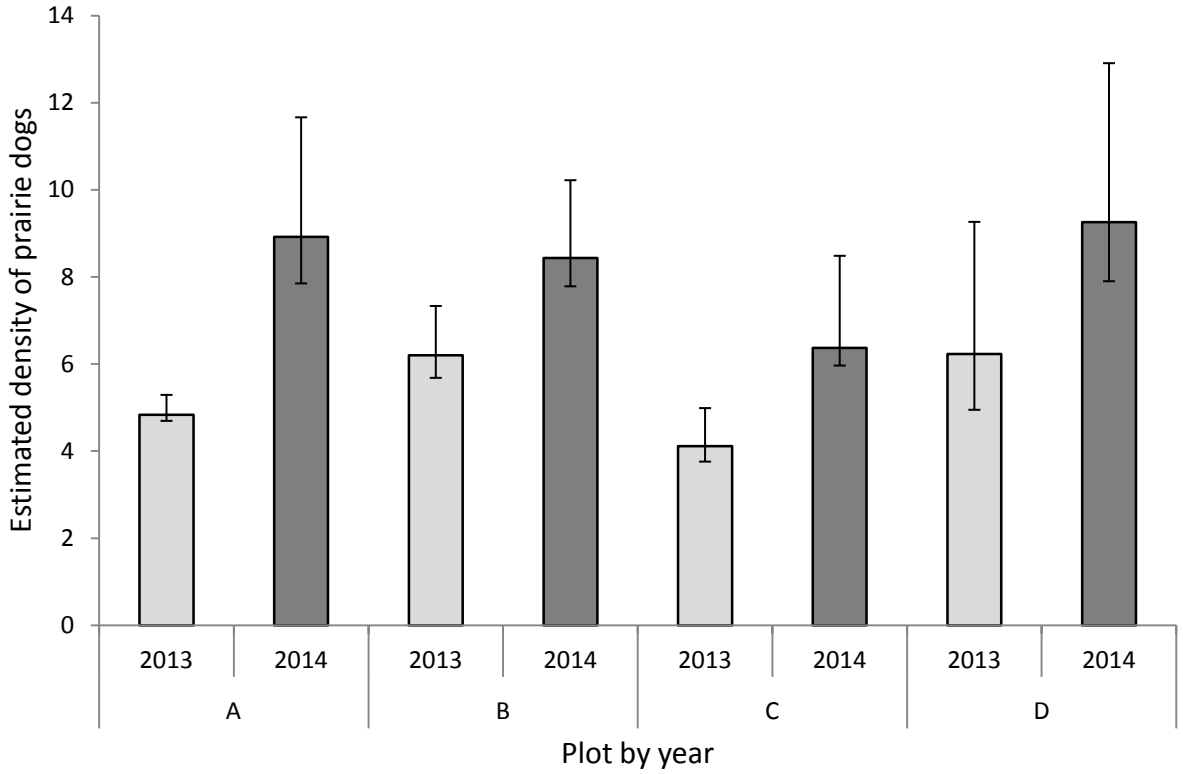

Figure 3. Estimates of density of white-tailed prairie dogs (*Cynomys leucurus*) per hectare within each plot at Pitchfork Ranch, Meeteetse, Wyoming, June-August 2013 and 2014. Density was derived from estimates of abundance generated under closed population models using Huggins conditional likelihood formulation (Fig. 3; Huggins 1989, White and Burnham 1999). Light bars represent density from 2013 and dark bars represent density from 2014. Error bars indicate log-transformed 95% confidence intervals for each estimate (Chao 1987).

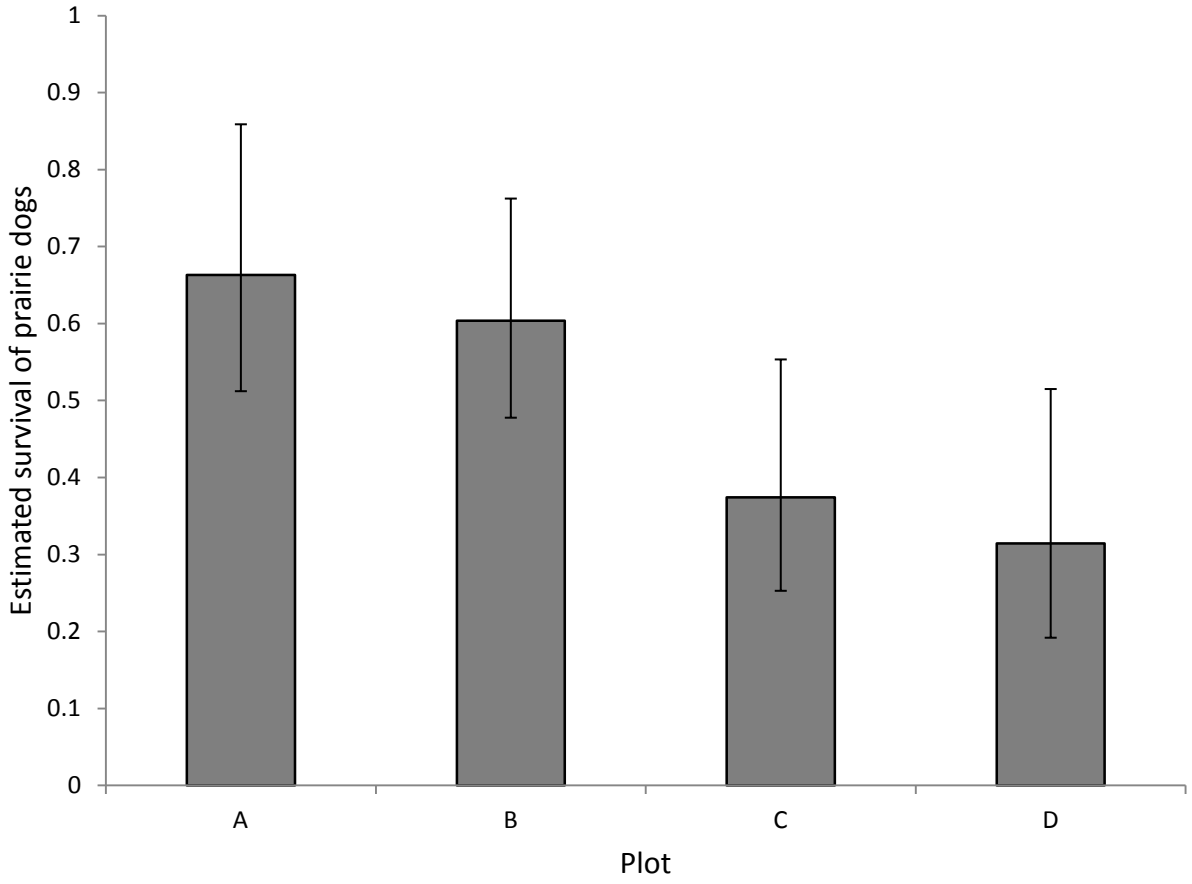

Figure 4. Estimated probability of annual survival of white-tailed prairie dogs (*Cynomys leucurus*) within each plot at Pitchfork Ranch, Meeteetse, Wyoming, from June-August 2013 to 2014. Estimates were derived using the Cormack-Jolly-Seber formulation (Cormack, 1964, Jolly, 1965, Seber 1965). Error bars indicate 95% confidence interval of each estimate.

EVALUATING THE STATUS OF SPOTTED SKUNKS (*SPILOGALE* SPP.) IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Eastern and Western Spotted Skunk

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

PROJECT DURATION: October 2014 – March 2015

PERIOD COVERED: October 2014 – March 2015

PREPARED BY: Jesse Boulerice, Nongame Project Biologist

ABSTRACT

Two species of spotted skunk (*Spilogale* spp.) occur in Wyoming: the western spotted skunk (*Spilogale gracilis*) and the plains spotted skunk (*Spilogale putorius interrupta*), a subspecies of the eastern spotted skunk (*Spilogale putorius*). Members of this genus are typically uncommon, small-sized, elusive, and nocturnal. Therefore, much of the natural history of spotted skunks, including species-specific distributions and habitat associations, are poorly understood throughout their ranges. The US Fish and Wildlife Service received a petition in 2012 to list the plains spotted skunk as a Threatened species under the Endangered Species Act. In order to respond to potential listing and address a significant knowledge gap for spotted skunks, the Wyoming Game and Fish Department initiated efforts to examine the status and distribution of these species in Wyoming. During winter of 2014-2015, a combination of camera stations, track plates, and live-trapping were employed to survey 160 locations throughout the eastern two-thirds of Wyoming. In total, spotted skunks were detected at 16 locations within central Wyoming, including the Laramie, Shirley, and Pedro Mountains, as well as the Sweetwater rocks area. Based on occupancy analysis, we found probability of occupancy of a spotted skunk to be positively associated with rock outcrops and negatively associated with dense canopy cover. Our results suggest that spotted skunks in Wyoming may be more common than previously thought and are relatively easy to detect with targeted surveys in appropriate habitat. Additionally, we found cameras to be more effective and efficient at detecting spotted skunks compared to track plates, and developed a technique for live-trapping and collecting genetic samples.

INTRODUTION

The United States is home to two species of the *Spilogale* genus, or spotted skunk, both of which inhabit Wyoming. The western extent of the range of the plains spotted skunk (*Spilogale putorius interrupta*), a subspecies of the eastern spotted skunk (*Spilogale putorius*), is thought to currently run roughly north-south through central Wyoming (Kinlaw 1995). This boundary represents the transition line between the plains spotted skunk, and the eastern extent of the closely-related western spotted skunk (*Spilogale gracilis*; Verts et al. 2001). However, as members of this genus are relatively uncommon, small-sized, elusive, and nocturnal, much of the natural history of spotted skunks, including species-specific distributions and habitat associations, are poorly understood throughout their ranges (Gompper and Hackett 2005). Based on the limited amount of available data, abundances of eastern spotted skunk, including the plains spotted skunk subspecies, are thought to be experiencing range-wide decline (Kaplan and Mead 1991, Gompper and Hackett 2005). Although the cause of declines remains unclear, the US Fish and Wildlife Service (USFWS) received a petition in December 2012 to list the plains spotted skunk as Threatened under the Endangered Species Act (ESA; USFWS 2012). This listing would include the western portion of the range of the species in Wyoming, likely encompassing a significant portion of the eastern half of the state.

In Wyoming, information on both plains and western spotted skunks is lacking. All skunk species occurring in the state are currently classified as a predatory animal by Wyoming Statute §23-1-101 and, as such, are offered no protection from take. Under this classification, neither plains nor western spotted skunk are designated as nongame mammals, and neither is recognized as a Species of Greatest Conservation Need (SGCN, WGFD 2010). Consequently, observations are seldom reported for these species even though trappers acknowledge occasional non-target captures of spotted skunks in traps set for bobcat (*Lynx rufus*) or other furbearers (Boulerice, pers. obs.). Observations reported to the Wildlife Observation System are dated and likely represent misidentifications at the species level, since *Spilogale* species of Wyoming are difficult to tell apart without genetic verification (Armstrong et al. 2011, Foresman 2012, M. Grenier, pers. comm.). To date, virtually no effort has been made by the Wyoming Game and Fish Department (Department) to investigate any aspect of spotted skunk ecology in Wyoming. This knowledge gap prevents the Department from clearly distinguishing the transition line between western and plains spotted skunks, a crucial designation if listing under the ESA is deemed warranted. Likewise, habitat associations have been estimated based primarily on anecdotal evidence, and abundances and population trends are unknown. Although techniques to survey for spotted skunks have been employed infrequently in other regions, none are known to have been evaluated for effectiveness specific to Wyoming where habitat regimes are likely to vary significantly.

Spotted skunks have been described as small (0.5-1.5 kg), omnivorous members of the Mephitid family, with fine, dense fur, distinguished by an infinitely varying pattern of jet-black marked with four to six white or white-brown broken body stripes (Kinlaw 1995, Verts et al. 2001). Most notably, both the plains and western spotted skunks express a unique warning behavior during which animals will stand entirely on their front legs ("hand-stand") and flash their tail, to emphasize their dramatic color pattern to predators prior to spraying an odor of similar pungency as other skunk genera (Johnson 1921, Kinlaw 1995). Spotted skunks typically occur in brushy, rocky, and wooded habitats, as cover is likely important to avoiding predation (Kinlaw 1995, Lesmeister et al. 2009, Verts et al. 2001). In Wyoming, preferred

habitat for plains spotted skunk has been described as ponderosa pine, pine-juniper, meadows, rock outcrops, and near streams (Orabona et al. 2012). Preferred habitat for western spotted skunk is described as shrublands, greasewood, and grasslands (Orabona et al. 2012). However, these associations are based on a limited number of observations in Wyoming, for which species identification was likely assumed and not verified with genetics. In addition, several of the observations for spotted skunks are derived from roadway mortalities, which may represent dispersing individuals traveling through less-preferred habitat.

Given the implications of listing and the paucity of information currently available, the Department conducted efforts during the winter of 2014-2015 aimed at enhancing our understanding of spotted skunks in Wyoming. Specifically, this project achieved several important objectives related to spotted skunks. First, we evaluated the effectiveness of two techniques at detecting the presence of spotted skunks in Wyoming. Second, we explored habitat associations of spotted skunks, enabling us to update our information and designate specific locations to focus additional efforts. While subsequent efforts by the Department will be required to appropriately determine the distribution and abundance information necessary to respond to listing petitions, this project provided a critical first step in obtaining data for a *Spilogale* species of Wyoming for which no previous efforts have been completed.

METHODS

We conducted surveys for spotted skunks throughout the eastern two-thirds of Wyoming during the months of October 2014 through March 2015. Three priority areas were identified based on the predicted transition line between eastern and western spotted skunks in Wyoming and data reported to the Wildlife Observation System. The three priority areas were designated as 1) Shirley and Pedro Mountains, 2) Laramie Mountains, and 3) western slope of the Bighorn Mountains. In each priority area, we overlaid a grid of 1 km^2 square cells. We then randomly selected cells for survey that contained some element of protective cover (either tree canopy cover or rocky crevices) based either remotely using tree canopy or soil type layers in ArcGIS 10.1 or in the field. As time permitted, we also surveyed additional sites beyond the priority areas following the same procedures.

During the months of October and November, we evaluated the effectiveness of using track plates to detect the presence of spotted skunks. Specifically, within a random subset of selected cells, we installed an array of five track plates in an X pattern (one plate at each of four corners, one at center) with 500 m between each corner plate. Each track plate consisted of a base, a tracking medium, and a weather-protective housing (Fig. 1; modified from Conners et al. 2005). A single 60.96 × 30.48 cm rectangular piece of 31.75 mm steel sheeting was employed as a base. Our tracking medium was comprised of an ink source and track recorder. Ink source included an 8:1.5:0.5 mixture of anhydrous ethyl alcohol, graphite powder, and mineral oil spread directly over the base. A 22.86 × 30.48 cm sheet of adhesive paper (Con-Tact Multipurpose Adhesive Liner - White) was used as a track recorder installed between the ink and attractant. Attractant was placed at the rear of the plate and consisted of a bait of sardines or cat food and 7 ml of lure of either canine call or skunk essence (Caven's Gusto Lure or Tinctured Skunk Essence, F&T Fur Harvesters Alpena, MI). The housing consisted of

a plastic tote (Sterilite's 18 Gallon Tote, 60.69 × 46.67x40.00 cm) placed upside down with an 20.32 × 30.48 cm hole cut in one side to allow a skunk to enter. The base and tracking medium were set flush with the bottom of the tote housing along the ground (Fig. 1). We also placed 7 ml of lure outside the track plate on a nearby tree to attract animals to the track plate. We checked track plates once every 7 days during a 14-day period. Adhesive paper and ink mixture were replaced if tracks were recorded or otherwise disturbed.

During the months of October through March, we employed baited camera stations to record the presence of spotted skunks. Within each cell, we installed a single Reconyx camera near the center. We baited each camera station with a can of cat food and 2 tablespoons of scent lure (Caven's Gusto Lure or Tinctured Skunk Essence, F&T Fur Harvesters Alpena, MI). We attached bait combinations at approximately 0.5 m up the trunk of a tree approximately 4 m in front of the camera. Cameras were positioned to capture the image contained within 2 m of the base of the bait tree to 1 m above the bait. We programmed cameras to record a series of three photographs each time the internal motion sensors were activated for a period of at least 480 consecutive hours (20 days) with no delay between activations. After retrieving cameras, we reviewed photos to generate detection histories for all species detected during surveys.

During November, we live-trapped spotted skunks to collect genetic samples and develop a technique for trapping skunks. Specifically, we selected sites for trapping at which we had recently detected a spotted skunk with either the track plates or cameras. At each trapping site, we installed a 500 × 500 m grid of tomahawk traps (25 traps per site; #103 or 605 Tomahawk Live Trap, Hazelhurst, WI). Traps were placed 100 m apart along a grid centered on the location of the detection. Each trap was positioned under tree branches, covered in black plastic sheeting, and buried with debris to mimic a natural cavity. Traps were baited with sardines or cat food, and 7 ml of lure of either canine call or skunk essence was placed at the rear of the trap. We also placed 14.7 ml of lure outside of the trap on a nearby tree. Traps were opened prior to dusk, checked for captures the following morning at sunrise, and closed during daytime hours to reduce non-target captures.

In order to collect biological samples from captured skunks, we devised the following setup. Upon capture, traps containing skunks were approached slowing and quietly from the side while holding a tarp to block spray. The entire trap containing the skunk was rotated vertically, and carefully placed within an anesthetization chamber. The chamber consisted of two five-gallon plastic buckets stacked lid to lid and sealed together with duct tape. The top of the bucket chamber (bottom of the top bucket) was cut out to allow the trap to fit through the end. Two cotton balls soaked in isoflurane were dropped into the bucket. A clear plexi-glass tile large enough to overhang in all directions was placed over the opening, thus sealing the chamber and allowing a view of the skunk as the chamber filled with isoflurane vapor. Once the skunk appeared adequately anesthetized, the animal was removed from the trap and processed in hand. We collected genetic samples by using an ear punch and stored the punch in alcohol.

We conducted single-species single-season occupancy analysis to estimate the influence of a variety of environmental factors on occupancy and detection of spotted skunks (MacKenzie et al. 2005). We based this analysis on the detection histories derived by camera

surveys from regions where spotted skunks were detected at least once, excluding data from regions without spotted skunk detection or obtained from track plates. Specifically, we considered the influence of several habitat attributes on occupancy of a cell by spotted skunks either at the site-level (camera location), or landscape-level (500 m buffer around each camera) using ArcGIS 10.1. Descriptions of habitat attributes we considered as part of this analysis are summarized in Table 1. In addition, we collected weather variables, including average daily temperature, average daily wind speed, and total daily precipitation, from the nearest weather station to each respective camera location to measure the influence of these factors on detection of a skunk. We tested all covariates for correlation using Pearson's r correlation test. When covariate pairs were found to be correlated ($r > \pm 0.7$), we retained only those variables thought to be a better predictor of skunk occupancy or detection before generating model sets. We first ran model sets of all combinations of detection covariates while occupancy was held constant to determine which covariates best predicted detection of spotted skunks based on Akaike Information Criterion adjusted for small sample size (AIC*c*; Burnham and Anderson 2002). We then generated a final model set, which included all combinations of occupancy covariates, while detection was modeled using the top detection covariates found in the previous step. We included squared terms in model combinations for covariates predicted to potentially have a non-linear relationship with probability of occupancy (i.e., canopy cover, elevation). All covariates were standardized prior to modeling to facilitate comparison, interpretation, and likelihood convergence (Grueber et al. 2011). We determined the estimated influence of each covariate based on weighted model averaging of AIC*c* weights for all models with a delta AIC*c* ≤ 5.0 (Burnham and Anderson 2002, Doherty et al. 2012). We then used the weighted model averaged estimates to predict the probability of occupancy of spotted skunks at all cells. All analyses were conducted in program R using packages unmarked (Fiske and Chandler 2011) and MuMIn (Barton 2009).

RESULTS

In total, we surveyed for spotted skunks at 160 unique cells over the 5-month survey period consisting of 11 cells surveyed with track plates and 156 cells surveyed with cameras (7 cells were surveyed with both track plates and cameras). Track plate surveys were conducted exclusively within the Shirley and Pedro Mountain priority area for a total of 18,480 survey hours (55 plates × 14 days). Camera surveys were conducted throughout all three regions, as well as non-priority areas, for a total of approximately 82,500 camera hours (156 cameras × 22 days). We detected the presence of spotted skunk at 16 cells, 6 in the Shirley and Pedro Mountains, 10 in the Laramie Mountains, and 0 in the western slope of the Bighorn Mountains. Distribution of survey locations and skunk detections are displayed in Figure 2. We detected one spotted skunk by using track plates (Fig. 1). Other species detected by track plates included red squirrel (*Tamiasciurus hudsonicus*) and mice (*Peromyscus* spp.). We detected spotted skunks at 15 cells by using camera surveys. Several other species were detected by camera, summarized in Table 2.

We live-captured 1 spotted skunk within the Shirley and Pedro Mountain priority area in a total of 50 trap nights (2 sites × 25 traps × 1 night). The technique we employed for anesthetization with isoflurane was effective, as the animal was easily subdued for 30 seconds

after brief exposure to isoflurane (<10 seconds) and showed no ill effects upon recovery and release. Skunk remained relatively calm leading up to and proceeding anesthetization and handling, and did not spray handlers.

In completing our occupancy modeling, we excluded capture histories from regions where spotted skunks were not detected, including the Bighorn Mountain region and all non-priority areas. During preliminary analysis of the 88 remaining sites, we found several covariates for assessing land-cover type, including Fir, Lodge, Jun, to be correlated with average percent canopy cover (see Table 1 for covariate descriptions). In addition, post hoc univariate analysis verified that Fir, Lodge, and Jun did not have a significant influence on occupancy ($p<0.05$). We, therefore, removed these land-cover type covariates from all models and retained canopy cover. In modeling detection covariates, we found models containing detection covariates of temperature and amount of precipitation to show the greatest support (AIC*c* weight = 0.3, Table 3). Based on our final model set, including temperature and precipitation for detection covariates in all models, we found models containing occupancy covariates of percent rocky outcrop and canopy cover to have the greatest AIC*c* weight (AIC*c* weight = 0.17). Weighted model averaged effect sizes and unconditional standard errors of all models with a delta AIC*c* ≤ 5, as well as AIC*c* weights, effect sizes, and standard errors, of top ten models, are displayed in Table 4.

DISCUSSION

Surveys conducted as part of this project, representing the first efforts in the history of the Department aimed specifically at spotted skunks, were met with a high level of success. In 5 months, we doubled the number of observations of spotted skunks reported to the Wildlife Observation System in the last 15 years, sustainably adding to the Department's records for this genus. We confirmed the existence of extant populations of spotted skunks at 16 locations throughout central Wyoming, including the Laramie, Shirley, and Pedro Mountains, as well as the Sweetwater rocks area. In addition, we determined a relatively straightforward and reliable technique for documenting the presence of this uncommon and elusive species.

Previous to this study, both eastern and western spotted skunks were considered uncommon in Wyoming (Orabona et al. 2012). Observations are likely to have historically been infrequent because the preferred habitats, activity patterns, and elusiveness of this genus reduce the probability of detecting spotted skunks without a targeted survey effort. However, our surveys detected spotted skunks at nearly 18% of all locations within two of our priority areas at which spotted skunks were detected at least once. By removing locations within those priority areas for which the model-based predicted probability of occupancy was low ($\psi<0.10$), we detected spotted skunks at nearly 25% of remaining locations. Although we were unable to differentiate between species, these results suggest that members of the *Spilogale* genus may be more common in Wyoming than previously thought, especially within preferred habitat. In addition, our results suggest that efforts to assess the status of spotted skunks in Wyoming must include targeted surveys in appropriate habitat, and cannot be based simply on road mortality data or anecdotal observations.

We failed to detect spotted skunk along the western slope of the Bighorn Mountains, a region we targeted as a priority area due to a relatively large number of spotted skunk observations reported to the Wildlife Observation System. This absence could indicate that populations of spotted skunks have declined to the point of extirpation throughout the region, or that these species are less common in the Bighorns than in the Shirley, Pedro, and Laramie Mountains where we detected spotted skunks. However, we note that snow depth was substantially greater at the time of survey throughout all survey locations within the Bighorn Mountains compared to other regions. Given the small size of spotted skunks, deep powdery snow likely presents a significant challenge to locomotion, resulting in limited mobility, and thereby reducing detection probability. Similarly, the availability of subnivean space within rocky areas covered under snowpack may reduce the time spotted skunks spend above the snow. We attribute our failure to detect spotted skunks in the Bighorn Mountains priority area to the weather conditions at time of survey rather than the status of spotted skunk, and recommend that additional surveys be conducted during warmer seasons to verify population status.

The results of our occupancy analyses agreed with our field observations regarding habitat associations of spotted skunks in Wyoming. At a landscape-level, soil types characterized by rock outcrops and tree canopy closure were found to influence the probability of occupancy of spotted skunks. Specifically, we observed a positive relationship between the amount of rock outcrops within 500 m and occupancy such that spotted skunks were nearly four times as likely to occupy a cell consisting entirely of rocky outcrops compared to a cell with no rock outcrops. Rock outcrops provide many benefits to spotted skunks, including denning habitat and protection from common predators such as bobcats, coyotes, and birds of prey (Kinlaw 1995, Lesmeister et al. 2008, 2009). In addition, crevices within rocks may assist with thermal regulation of spotted skunks by providing subnivean spaces during winter and shade during summer. Conversely, we found the relationship between average canopy cover within 500 m to be negative, suggesting that areas with greater than 30% canopy cover had virtually no probability of being occupied ($\psi<0.05$). This finding contradicts research conducted outside of Wyoming, which suggests that areas of high canopy cover are strongly preferred by spotted skunks (Carroll 2000, Lesmeister et al. 2009). While the reason for this regional difference in influence of canopy cover is unclear, we suggest two hypotheses. First, dense forest of high canopy closure is typically restricted to higher elevation montane environments throughout much of Wyoming. Seasonal snowpack and difficult terrain, combined with a possible decline in abundance, diversity, or vulnerability of preferred prey species or food source, may reduce the benefits of these montane forest communities to spotted skunks, compared to the low elevation forest of other regions. Second, the acreage and distribution of rock outcrops in Wyoming, which tend to be characterized by sparse tree cover, is likely greater than other studies conducted either in the southeastern (i.e., Lesmeister et al. 2009) or west coast (i.e., Carroll 2000) of the United States. Rock outcrops that characterized central Wyoming may provide the necessary habitat requirements for spotted skunks in terms of protection from predators, denning opportunities, and access to prey, thus reducing the relative value of habitats consisting of high canopy closure. However, neither of these theories has been tested, and questions related to the ecological basis of habitat preferences for spotted skunks in Wyoming merit further exploration beyond the scope of this study.

In our evaluation of two survey techniques for detecting the presence of spotted skunks, we found camera surveys to be more effective and efficient than track plate surveys. Both camera and track plates have been extensively used to non-invasively survey for small to mid-sized carnivores, and a variety of literature is available comparing these two techniques (Zielinski 1995**,** Neiswenter and Dowler 2005, Ray and Zielinski 2008). However, few studies have looked at the effectiveness of cameras versus track plates specifically for spotted skunks. Hackett el al. (2007) found track plates to produce significantly higher detection rates than cameras for eastern spotted skunks in Arkansas. and suggested that smaller species like spotted skunks may go undetected by motions sensors of the cameras resulting in a high rate of false absences. However, the Reconyx cameras employed here appeared to be effective at detecting spotted skunks, as well as several other significantly smaller-bodied species such as bushy-tailed woodrat (*Neotoma cinerea*) and *Peromyscus* spp. In addition, we found cameras to be much more efficient to deploy by reducing installation time, requiring no periodic checks, providing an undisputable identification of species (pictures versus tracks), and significantly decreasing the amount of equipment field personnel needed to carry over difficult terrain. While we found track plates to be effective at detecting one skunk in November, the usefulness of track plates diminished with the onset of winter. Snow frequently buried track plates, or moisture and cold temperatures severely reduced the adhesiveness of the tracking medium. We acknowledge that the effectiveness of track plates is likely to increase if employed during warmer seasons or with improved design. However, given the superiority of cameras in both detection rates and deployment, we recommend cameras be employed over track plates during subsequent efforts to document the presence of spotted skunks in Wyoming.

Our efforts to live-trap and collect biological samples from spotted skunks also appeared to be effective, albeit from the smallest of sample sizes. In one night of trapping with 25 traps, we were able to capture a spotted skunk approximately 400 m from where the individual was first detected. This skunk was quickly and safety processed, and field personnel were not sprayed during handling. However, we ceased all additional live-trapping efforts when nightly temperatures dropped below -6°C or once snow accumulated. Given the small size of a spotted skunk, we felt that restraining skunks for multiple hours at such low temperatures could have detrimental impacts on animals without significant trap design modifications (M. Ben-David, pers. comm.). Likewise, given that skunk primarily occurred on steep rocky hillsides, slippery conditions as a result of snow and ice accumulation made installation of trapping equipment extremely difficult and unsafe to field personnel. Therefore, although we recommend that the trapping and anesthetization techniques for spotted skunks employed here be repeated during subsequent capture efforts, trapping should be conducted during warmer seasons conducive to higher nightly temperatures and safer navigation of field personnel.

Although we significantly expanded our knowledge on the status, habitat requirements, distribution, and techniques associated with spotted skunks in Wyoming, we acknowledge that our inability to differentiate between the eastern and western species represents a major limitation to this study. Specifically, without genetic verification, we are unable to discern the transition line between the two species, an important component to designating the current range of the eastern spotted skunk for listing efforts. Likewise, all conclusions drawn from our data must be made at the genus level. Our ability to collect the necessary genetic samples was

deterred by the difficulties addressed above associated with live-trapping during winter conditions in Wyoming. However, over the relatively short duration of this project, we developed effective techniques to detect, capture, and process spotted skunks. In addition, we provided multiple locations of current populations and habitat requirements of a genus for which virtually no data were previously available specific to Wyoming. Subsequent efforts to address many of the questions related to ecology and listing of spotted skunks in Wyoming beyond the scope of this project will, therefore, be greatly aided by the foundational knowledge uncovered by our efforts.

ACKNOWLEDGEMENTS

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Table 1. Covariates used in occupancy analysis to determine the influence of various environmental factors on occupancy and detection of spotted skunks (*Spilogale* spp.) based on capture histories derived from camera surveys conducted October 2014 to March 2015 from the Shirley and Pedro Mountains and Laramie Mountain priority areas.

Covariate abbreviation	Description	Source
Occupancy		
DistStream	Distance to nearest stream from camera	Tiger/Line 2014 US Census Bureau
DistRoad	Distance to nearest road from camera	Tiger/Line 2014 US Census Bureau
Canopy	Average canopy cover within 500m	2012 LandFire Forest Canopy Cover
Elev	Average elevation within 500m	USGS National Elevation Dataset
Slope	Average slope within 500m	USGS National Elevation Dataset
Rock	Km^2 rock outcrop within 500m	USDA NRCS 2006 Soils
Jun	Km^2 juniper forest within 500m	GAP National Land Cover Data 2011
Fir	Km^2 fir forest within 500m	GAP National Land Cover Data 2011
Lodge	Km^2 lodgepole pine forest within 500m	GAP National Land Cover Data 2011
Detection		
Temp	Average daily temperature	NOAA weather station
Wind	Average daily wind speed	NOAA weather station
Precip	Total daily precipitation	NOAA weather station

Table 2. Summary of species detected during camera surveys for spotted skunk (*Spilogale* spp.) conducted October 2014 to March 2015 throughout Wyoming. Naïve occupancy was calculated based on all survey locations.

Scientific Name	Common Name	Cells Detected (N=156)	Naive Occupancy
***Spilogale* spp.**	**Spotted Skunk spp.**	**15**	**0.096**
Sylvilagus spp.	Rabbit spp.	107	0.685
Lynx rufus	Bobcat	18	0.115
Puma concolor	Mountain Lion	4	0.025
Vulpes vulpes	Red Fox	15	0.096
Canis latrans	Coyote	18	0.115
Martes caurina	Pacific Marten	1	0.006
Mustela frenata	Long-tailed Weasel	3	0.019
Mephitis mephitis	Striped Skunk	10	0.064
Procyon lotor	Raccoon	5	0.032
Erethizon dorsatum	Porcupine	2	0.012
Ursus americana	Black Bear	1	0.006
Neotoma cinerea	Bushy-tailed Woodrat	27	0.173
Odocoileus spp.	Deer spp.	38	0.243
Cervus canadensis	Elk	5	0.032
Tamiasciurus hudsonicus	Red Squirrel	50	0.320
Tamias minimus	Least Chipmunk	3	0.019
Peromyscus spp.	Mouse spp.	19	0.121
	Bird spp.	36	0.230

Table 3. Ranking of detection covariates from occupancy analysis based on capture histories derived from camera surveys for spotted skunk (*Spilogale* spp.) conducted October 2014 to March 2015 in the Shirley and Pedro Mountains and Laramie Mountain priority areas. Top ranked model was used to model detection for all models in final model set including all combinations of occupancy covariates.

Model	AIC*c*	Delta AIC*c*	AIC*c* weight
Temp+Precip	273.48	0	0.30
Temp	274.36	0.88	0.19
Precip	274.56	1.08	0.17
Temp+Precip+Wind	275.66	2.19	0.10
NULL	276.05	2.57	0.08
Temp+Wind	276.40	2.93	0.07
Precip+Wind	276.67	3.19	0.06
Wind	277.98	4.51	0.03

Table 4. Model results from occupancy analysis based on capture histories derived from camera surveys for spotted skunk (*Spilogale* spp.) conducted October 2014 to March 2015 in the Shirley and Pedro Mountains and Laramie Mountain priority areas. All models contained detection covariates of temperature and precipitation (see Table 2). Estimates and standard error (italics) from top ten models are shown. Model averaged results (in bold) are based on the weighted model average of all models with a delta AIC*c* of ≤5.0. Unconditional standard errors were calculated for each model averaged covariate (bold italics).

Model	AIC*c*	Delta AIC*c*	AIC*c* weight	ψ Int	ψ Canopy	ψ Canopy^2	ψ Rock	ψ DistStream	ψ ElevMean	ψ Slope
Canopy+Rock	268.65	0	0.17	-1.699 *0.393*	-0.765 *0.407*	0	0.750 *0.383*	0	0	0
Canopy+Canopy^2+Rock	270.16	1.52	0.08	-1.386 *0.512*	-0.849 0.533	-0.492 *0.638*	0.721 *0.377*	0	0	0
Rock	270.74	2.08	0.06	-1.503 *0.342*	0	0	0.725 *0.355*	0	0	0
Canopy+DistStream+Rock	270.95	2.30	0.05	-1.693 *0.392*	-0.786 0.414	0	0.759 *0.385*	0.087 *0.355*	0	0
Canopy+Elev+Rock	270.95	2.30	0.05	-1.700 *0.393*	-0.840 0.512	0	0.767 *0.389*	0	0.112 *0.456*	0
Canopy	270.96	2.31	0.05	-1.567 *0.347*	-0.771 0.392	0	0	0	0	0
Canopy+DistRoad+Rock	270.96	2.31	0.05	-1.698 *0.395*	-0.782 0.417	0	0.751 0.385	0	0	0
Canopy+Rock+Slope	271.01	2.36	0.05	-1.695 *0.393*	-0.766 0.409	0	0.748 *0.419*	0	0	0.006 *0.350*
Elev+Rock	271.69	3.04	0.04	-1.557 *0.357*	0	0	0.701 *0.370*	0	-0.384 *0.339*	0
Canopy+Canopy^2	272.15	3.50	0.03	-1.232 *0.469*	-0.950 *0.571*	-0.619 *0.701*	0	0	0	0
Weighted Model Average Estimates				**-1.575** ***0.421***	**-0.660** ***0.516***	**-0.107** ***0.245***	**0.602** ***0.447***	**0.009** ***0.066***	**-0.008** ***0.100***	**0.004** ***0.066***

Figure 1. Photographs of the track plates employed to detect spotted skunks (*Spilogale* spp.) October 2014 to November 2015 in the Pedro and Shirley Mountains. Box A depicts the base and tracking medium of each track plate. Tracking medium consists of an 8:1.5:0.5 mixture of denatured anhydrous ethyl alcohol, graphite powder, and mineral oil, and a 22.86 × 30.48 cm sheet of adhesive paper. Box B depicts the track plate complete with weather proof housing.

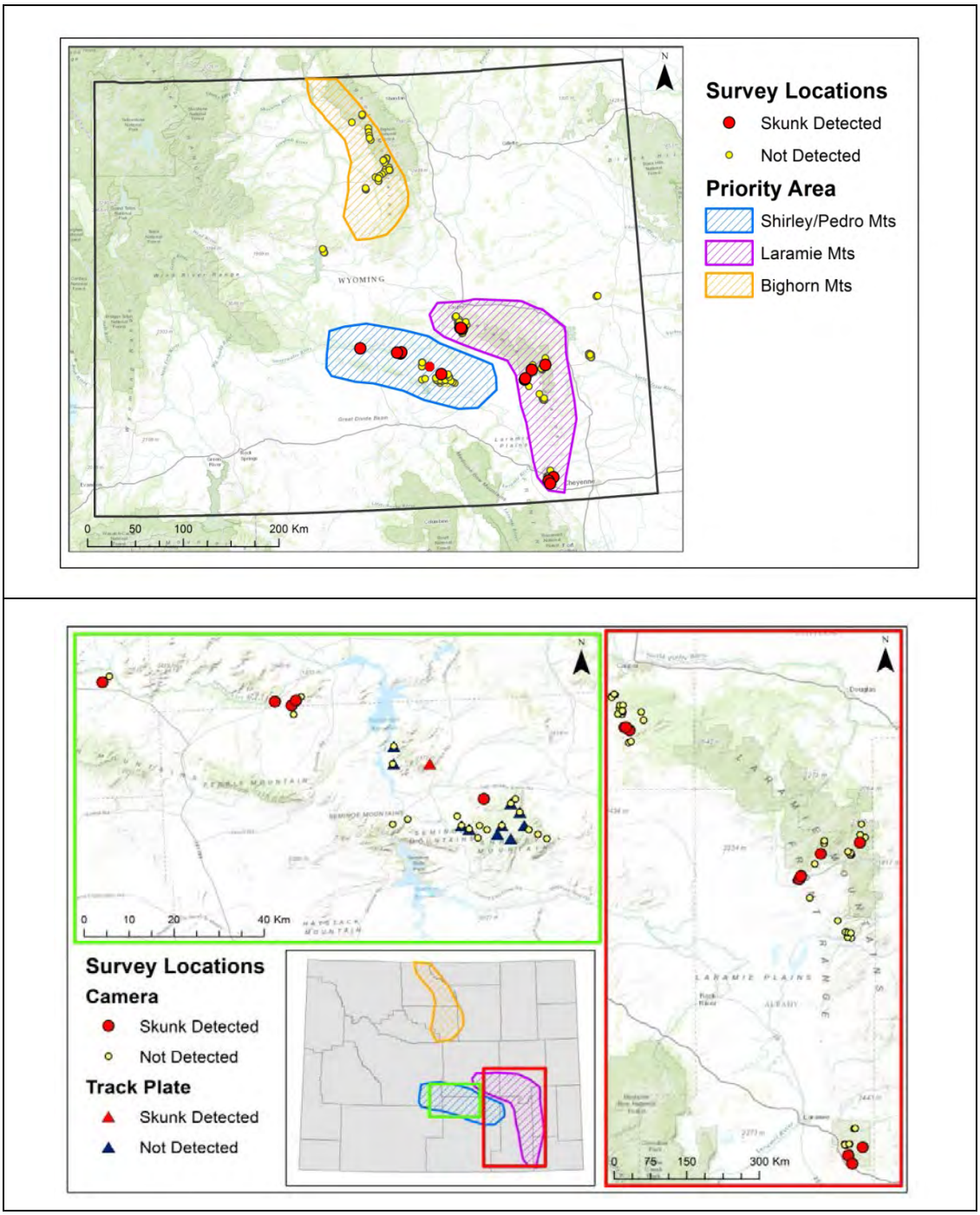

Figure 2. Distribution of survey locations and detections of spotted skunks (*Spilogale* spp.) as part of surveys conducted October 2014 to March 2015 throughout Wyoming. Three priority areas were designated as 1) Shirley and Pedro Mountains, 2) Laramie Mountains, and 3) western slope of the Bighorn Mountains. A total of 160 locations were surveyed. Spotted skunks were detected at 16 locations. Top map depicts all survey locations. Bottom map depicts the Shirley and Pedro Mountain (green) and the Laramie Mountains (red) priority areas in greater detail. Distribution of track plate surveys are also shown. Note: some locations may not be visible on the maps due to overlap of symbols.

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 Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2014 – 14 April 2015

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 12 recommendations to the CFC for signing and submission, and 32 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 since 2007. 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).
July 25, 2013		Peregrine Falcon allocation for falconry purposes.	The CFC recommends a continuation of the alternative outlined above (Recommendation #15).
July 24, 2014	8	Allocation of permits for take of 1st year Peregrine Falcons for falconry purposes.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.

Table 1. Continued.

March 4, 2015	12	Allocation of permits for passage take of Peregrine Falcons for falconry purposes.	The CFC recommends a continuation of the equal distribution of the 36 passage Peregrine Falcon permits between 3 flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.

Table 2. Summary of correspondence submitted by the Central Flyway Nongame Migratory Bird Technical Committee since 2006. Central Flyway (CF); Central Flyway Council (CFC); Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC), 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)	CFNMBTC 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 CFNMBTC 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 CFNMBTC 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.

Table 2. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
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.
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, 2014	George Allen, USFWS	• Blackbird depredation	•
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.
March 31, 2014	USFWS	• Draft Environmental Assessment management of Double-crested Cormorants	• Need a more thorough editorial review. • Double-crested Cormorant population size needs to be revised using best available information.
July 22, 2014 (email sent)	Dave Morrison (TX)	• Double-crested Cormorant management	• Management Plan that the CFNMBTC compiled, as requested by the CFC.
March 4, 2015	Dan Ashe, USFWS	• Results of stable isotope analysis of Peregrine Falcon feathers	• Request for analysis to be completed so that the next steps for passage Peregrine Falcon harvest may be considered.
March 6, 2015	Central Flyway Council	• Southern Wings Program	• Increased awareness of Southern Wings, and support from the CFNMBTC.
March 6, 2015	Central Flyway Council	• CFNMBTC Activities	• A brief update to the CFC on CFNMBTC activities to date, and included correspondence and recommendations logs.

APPENDIX I
THE OFFICIAL STATE LIST OF THE COMMON AND SCIENTIFIC NAMES OF THE BIRDS, MAMMALS, AMPHIBIANS, AND REPTILES IN WYOMING

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]
<u>Gallinaceous Birds</u> **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
<u>Loons</u> **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
<u>Grebes</u> **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
<u>Shearwaters</u> **Order: Procellariiformes** **Family: Procellariidae**				
088.1	Streaked Shearwater	*Calonectris leucomelas*	(AS)	A
<u>Storks</u> **Order: Ciconiiformes** **Family: Ciconiidae**				
188.0	Wood Stork	*Mycteria americana*	(AS)	A, Endangered
<u>Cormorants and Frigatebirds</u> **Order: Suliformes** **Family: Fregatidae**				
128.2	Lesser Frigatebird	*Fregata ariel*	(AS)	A
Family: Phalacrocoracidae				
120.0	Double-crested Cormorant	*Phalacrocorax auritus*		S
<u>Pelicans and Wading Birds</u> **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
<u>Diurnal Birds of Prey</u> **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
<u>Marshbirds</u> **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
<u>Shorebirds</u> **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]
<u>Seabirds, Gulls, and Terns</u> **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
<u>Doves and Pigeons</u> **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
<u>Cuckoos</u> **Order: Cuculiformes** **Family: Cuculidae**				
387.0	Yellow-billed Cuckoo	*Coccyzus americanus*	(FL)	S, NSSU/III
388.0	Black-billed Cuckoo	*Coccyzus erythropthalmus*	(FL)	S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Owls **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
Goatsuckers **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
Swifts **Order: Apodiformes** **Family: Apodidae**				
422.0	Black Swift	*Cypseloides niger*	(AS)	M
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
Hummingbirds **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
Kingfishers **Order: Coraciiformes** **Family: Alcedinidae**				
390.0	Belted Kingfisher	*Megaceryle alcyon*		R
Woodpeckers **Order: Piciformes** **Family: Picidae**				
408.0	Lewis's Woodpecker	*Melanerpes lewis*		S, NSSU/II

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
406.0	Red-headed Woodpecker	*Melanerpes erythrocephalus*	(FL)	S
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
<u>Falcons</u> **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
<u>Passerines</u> **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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
628.0	Yellow-throated Vireo	*Vireo flavifrons*	(AS)	A
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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
644.0	Virginia's Warbler	*Oreothlypis virginiae*	(FL)	S
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	*Spizelloides 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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
545.0	Baird's Sparrow	*Ammodramus bairdii*	(AS)	S
548.0	Le Conte's Sparrow	*Ammodramus leconteii*	(AS)	M
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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
526.0	Brown-capped Rosy-Finch	*Leucosticte australis*	(FL)	R, NSSU/II
515.0	Pine Grosbeak	*Pinicola enucleator*		R
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: Didelphimorphia** **Family: Didelphidae**				
800.0	Virginia Opossum	*Didelphis virginiana*		A
Insectivores **Order: Soricomorpha** **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	Western Water Shrew	*Sorex navigator*		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 Long-eared 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	American Perimyotis	*Perimyotis 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	*Tamias amoenus*		R, NSS4/III
842.0	Cliff Chipmunk	*Tamias dorsalis*		R, NSS3/II
840.0	Least Chipmunk	*Tamias minimus*		R
843.0	Uinta Chipmunk	*Tamias umbrinus*		R, NSS4/III
844.0	Yellow-bellied Marmot	*Marmota flaviventris*		R
846.0	Uinta Ground Squirrel	*Urocitellus armatus*		R
845.0	Wyoming Ground Squirrel	*Urocitellus elegans*		R
849.0	Golden-mantled Ground Squirrel	*Callospermophilus lateralis*		R
847.0	Spotted Ground Squirrel	*Xerospermophilus spilosoma*		R, NSS4/III
848.0	Thirteen-lined Ground Squirrel	*Ictidomys 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	Sand Hills Pocket Gopher	*Geomys lutenscens*		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 mollipilosus*		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 Deermouse	*Peromyscus crinitus*		R, NSS3/II
881.0	White-footed Deermouse	*Peromyscus leucopus*		R
880.0	North American Deermouse	*Peromyscus maniculatus*		R
879.0	Piñon Deermouse	*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	*Myodes gapperi*		R
885.0	Western Heather Vole	*Phenacomys intermedius*		R
888.0	Long-tailed Vole	*Microtus longicaudus*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
887.0	Montane Vole	*Microtus montanus*		R
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: Didopidae				
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	Pacific Marten *	*Martes caurina*		R, NSS4/II
909.0	Fisher	*Pekania 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 *	*Vison 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
<u>Ungulates</u> **Order: Artiodactyla** **Family: Cervidae**				
930.0	Elk (Wapiti) *	*Cervus canadensis*		R

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
932.0	Mule Deer (Black-tailed Deer) *	*Odocoileus hemionus*		R
933.0	White-tailed Deer *	*Odocoileus virginianus*		R
931.0	Moose *	*Alces americanus*		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]		
<u>Salamanders</u> **Order: Caudata** **Family: Ambystomatidae**				
950.0	Tiger Salamander	*Ambystoma mavortium*		R; includes Blotched, Western, and Arizona subspecies.
<u>Toads and Frogs</u> **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, 2015). 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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