THREATENED, ENDANGERED, AND NONGAME BIRD AND MAMMAL INVESTIGATIONS

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

Annual Completion Report

Period Covered:
15 April 2018 to 14 April 2019

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TABLE OF CONTENTS

DISCLAIMER

FUNDING

Funding for the Wyoming Game and Fish Department Nongame Program comes from a variety of agencies, entities, and programs. We wish to credit the following funding sources for their generous contributions, which enable us to complete necessary inventory and monitoring efforts for numerous Species of Greatest Conservation Need in Wyoming.

Bureau of Land Management Cooperative Agreement (BLM CA)
Bureau of Reclamation Cooperative Agreement (BOR CA)
Lenox Baker Foundation (LBF)
National Park Service Cooperative Agreement (NPS CA)
United States Army Corp of Engineers (USACE)
United States Fish and Wildlife Service Cooperative Agreement (USFWS CA)
United States Fish and Wildlife Service Section 6 Funding (USFWS S6)
United States Fish and Wildlife Service State Wildlife Grants (USFWS SWG)
United States Fish and Wildlife Service WNS Grants to States (USFWS WNS GS)
United States Forest Service Cooperative Agreement (USFS CA)
Western Association of Fish and Wildlife Agencies (WAFWA)
Wyoming Game and Fish Department Commission Funds (WGFD/WGFC)
Wyoming Governor's Big Game License Coalition (WG BGLC)
Wyoming Governor's Endangered Species Account Fund (WG ESAF)

OVERVIEW OF NONGAME PROGRAM PROJECTS AND FUNDING SOURCES

Species or project	BLM CA	BOR CA	LBF	NPS CA	USACE	USFWS CA	USFWS S6	USFWS SWG	USFWS WNS GS	USFS CA	WAFWA	WGFD/WGFC	WG BGLC	WG ESAF
Preble’s meadow jumping mouse												X		
Black-footed ferrets - Meeteetse							X	X						
Black-footed ferrets - Shirley Basin							X	X						
Prairie dogs in ferret areas							X	X						
Environmental DNA for ferrets												X	X	
Scent dogs for ferrets			X				X	X				X		
Trumpeter Swans						X						X		
Secretive marsh bird surveys												X		
Grassland avian SGCN monitoring												X		
Bald Eagle monitoring					X							X		
Raptor nest surveys										X		X		
Peregrine Falcon monitoring												X		

Species or project	BLM CA	BOR CA	LBF	NPS CA	USACE	USFWS CA	USFWS S6	USFWS SWG	USFWS WNS GS	USFS CA	WAFWA	WGFD/WGFC	WG BGLC	WG ESAF
WYPIF and IMBCR	X			X				X		X		X		
NABat implementation								X	X			X		
Bat hibernation									X					X
Wyoming pocket mice														X
Small mammals and habitats								X						X
Spotted skunks											X	X		X
Chain Lakes nongame species												X		
Falconry	X											X		
Breeding Bird Survey	X	X		X		X				X		X		
Central Flyway Nongame Migratory Bird Technical Committee												X		
WY Bird Records Committee	X											X		
WY Bat Working Group								X						
WY Black-footed Ferret Working Group							X	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 oil, gas, coal, livestock forage, timber, and a variety of minerals. 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. In 2017, the Nongame Program was moved from Legislative General Funds back to Wyoming Game and Fish Commission Funding (Commission). The Nongame Program was funded by Legislative General Funds from FY09-FY17, and the Department is grateful for funds provided during this timeframe. The Commission has graciously provided funding identical to that provided by the Legislature. 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.

Over the past two decades, at both the national and state level, a number of efforts have focused on finding 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, including the current effort to pass the bi-partisan Recovering America's Wildlife Act.

In response, Congress established the federally funded State Wildlife Grants (SWG) program in 2000. In 2019, the Department was allocated $585,638 in SWG funds to help 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 (SWAP) 2010, and the SWAP 2017. Since 2010, the SWAP has been used to direct nongame work within Wyoming. SWG funding has primarily been utilized to implement the SWAP, conducting monitoring and research to meet identified management and data needs for Species of Greatest Conservation Need within the state.

Funding provided by the Commission, Wyoming Governor's Endangered Species Account, and Western Association of Fish and Wildlife Agencies, as well as cooperative agreement funds from the Bureau of Land Management, US Fish and Wildlife Service, and US Forest Service, have greatly enhanced our ability to collect information on numerous species in Wyoming, including Species of Greatest Conservation Need. These funds have given us the opportunity to greatly increase our knowledge of distribution and abundance of these species, as well as allowing us to increase our understanding of what is needed for effective and proactive management of those species. These funds have also allowed us to work cooperatively with other partners to implement projects that will provide population status and trend information on additional Species of Greatest Conservation Need. Partners include the USGS Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Wyoming Natural Diversity Database, Bird Conservancy of the Rockies, Audubon Rockies, Intermountain Bird Observatory, private contractors, and citizen scientists.

The future remains uncertain as we navigate through economic and political challenges. Anthropogenic and environmental stressors, such as climate change, 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 the most recent nongame bird and mammal work conducted in Wyoming from 15 April 2018 through 14 April 2019, although the complete coverage of some work may be slightly outside of this reporting period. Nongame surveys and projects in this report have been 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 Department Regional 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, with a second revision completed in 2017. This Nongame Annual Completion Report presents information in 8 major sections that compliment these planning efforts. These include Threatened and Endangered species, Species of Greatest Conservation Need; raptors taken for falconry; other nongame surveys; technical committees and working groups; an appendix that contains reports from other entities on projects that were conducted with Department assistance; and appendix of presentations and publications by Nongame Program personnel; and an appendix of the official state list of birds, mammals, amphibians, and reptiles in Wyoming.

The FY19 appropriation for the Nongame Program was $808,940. This includes funds for personnel, Maintenance and Operations (M&O), and $155,000 for sensitive species program projects. In addition to Commission funds, the Governor's Endangered Species Account provided $1,358,807 for FY17/18 to the Department to supplement sensitive species project work. We also used several sources of federal funding for specific projects. Commission 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.

Utilizing funds for the study and monitoring of nongame species is vital to accomplishing the Department's legislative mandate to management all native wildlife in Wyoming. The nongame program utilizes funds to assess and monitor Species of Conservation Need in an effort to ensure population health, and when necessary take additional management actions to ensure species survival. 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 raptor 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 Ornithological Society's guidelines and supplements. Mammal names follow the most recent Revised Checklist of North American Mammals North of Mexico.

THREATENED AND ENDANGERED SPECIES

PREBLE'S MEADOW JUMPING MOUSE RECOVERY GOALS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – White-tailed prairie dog

FUNDING SOURCE: Wyoming Game and Fish Department Commission Funds

PROJECT DURATION: 1 January 2018 – 30 September 2019

PERIOD COVERED: 1 June 2018 – 30 September 2018

PREPARED BY: Ian Abernethy, Lead Vertebrate Zoologist, WYNDD

SUMMARY

Preble's meadow jumping mouse (*Zapus hudsonius preblei*; hereafter Preble's) is found exclusively in riparian and adjacent upland habitats. Within its range, the availability of suitable riparian habitat is declining due to agricultural, residential, and commercial development. In 1998, Preble's was listed as Threatened under the Endangered Species Act. Management of Preble's is a high priority for management agencies, but effective management has been complicated by taxonomic and distributional uncertainty. While genetic investigations have clarified taxonomic confusion to a degree, there remains considerable uncertainty about the distribution of the taxon, particularly in the northern part of its range. The primary goal of this study is to identify 3 Preble's populations within each of 3 different Recovery Units in Wyoming that can be targeted for recovery actions by the Wyoming Game and Fish Department and the US Fish and Wildlife Service. We conducted live-trapping surveys in the Glendo Reservoir, Lower Laramie, and Horse hydrologic units (HUCs) in southeast Wyoming. We live-trapped small mammals in riparian habitats suitable for jumping mice between 13 June and 14 September 2018. We sampled 7 sites across 3 hydrologic units and captured a total of 49 *Zapus spp.*, including 35 unique individuals. Genetic results from tissue samples collected from these individuals are pending analysis at the University of Nevada, Reno's Nevada Genomics Center. We located *Zapus* populations in 5 of the 7 sites surveyed in 2018. This includes at least one population in each HUC. We plan to continue surveys in 2019 and plan to focus primarily in the Horse HUC. Populations of Preble's will be targeted for future management actions to promote recovery. See Appendix 1 for the complete project report.

MONITORING EFFORTS AND SUPPLEMENTAL RELEASES FOR BLACK-FOOTED FERRETS (*MUSTELA NIGRIPES*) 2 YEARS POST-REINTRODUCTION IN THE MEETEETSE REINTRODUCTION AREA

STATE OF WYOMING

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

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funds
United States Fish and Wildlife Service State Wildlife Grant

PROJECTION DURATION: Annual

PERIOD COVERED: 15 April 2017 – 14 April 2018

PREPARED BY: Dana Nelson, Nongame Biologist

ABSTRACT

In 2016, a 2nd reintroduction area for the endangered black-footed ferret (*Mustela nigripes*) was established in Wyoming at the Meeteetse Reintroduction Area, returning ferrets to the same location at which this species was rediscovered 35 years prior. Although surveys conducted 30 days and 1 year following the reintroduction suggested the newly released ferrets were succeeding in the short-term, long-term monitoring is necessary to comprehensively assess the viability of the population and prescribe appropriate management actions. This report summarizes the efforts conducted in 2018 to evaluate the population 2 years after the establishment of the reintroduction area. During the month of September, we conducted supplemental releases of 21 captive-reared ferrets to augment the existing population. In addition, we conducted 263 hours of spotlight surveys during which we located ≥26 ferrets. Captures included 4 of the 35 ferrets released in 2016, 1 ferret released in 2017, and 16 wild-born ferrets. Despite a reduction in prairie dog abundance in portions of the reintroduction area, indices of population size and growth suggest ferrets are successfully becoming established in the Meeteetse Reintroduction Area. We observed signs of reproduction in all captured female ferrets and documented litters produced by wild-born ferrets for the first time since reintroduction. Provided no drastic decreases in prairie dog abundance, we expect continued growth of the ferret population, particularly due to high survival and recruitment rates observed in wild-born ferrets. Although many challenges to long-term success remain, efforts thus far indicate that ferrets within the Meeteetse Reintroduction Area are quickly becoming a viable population for the first time in decades.

INTRODUCTION

In 2016, a 2nd reintroduction area for the endangered black-footed ferret (*Mustela nigripes*) was established in Wyoming at the Meeteetse Reintroduction Area (MRA), returning ferrets to the same location at which the species was rediscovered 35 years prior (Boulerice et al. 2017). The release of captive-reared ferrets marked the first time ferrets occurred in Meeteetse since the last of the rediscovered population was captured from the site in 1987 and used to formulate the first successful captive-breeding program for the species. The success of captive breeding ultimately saved the species from extinction, and each ferret population that has been re-established as part of reintroduction efforts are genetically derived from the founder population captured in Meeteetse. Therefore, the return of ferrets to Meeteetse and the establishment of the MRA was a celebrated event highlighting what has been called one of the greatest conservation success stories of North America. Together with the population at the Shirley Basin Reintroduction Area, ferrets in Meeteetse now add to the total number of ferrets existing in Wyoming, thus contributing to state and federal recovery goals for this species (USFWS 2013, WGFC 2018).

Similar to the Shirley Basin Reintroduction Area, first established in 1991, the Wyoming Game and Fish Department (Department) is responsible for all monitoring and management actions associated with the MRA. Preceding the reintroduction of ferrets, the Department defined the boundary of the MRA to include 5,916 acres of active white-tailed prairie dog (*Cynomys leucurus*) colonies mapped during the summer of 2015-2016 (Boulerice 2017). In addition, >5,000 acres of these colonies were treated with deltramethrin in 2016 in an effort to mitigate a localized epizootic outbreak of sylvatic plague (Boulerice 2017). Efforts were also conducted to establish community and local landowner support for the establishment of the MRA, aided by the recent approval of a statewide 10(j) designation for ferrets in Wyoming (USFWS 2015, Boulerice 2017, Boulerice et al. 2017). On 26 July 2016, 35 ferrets were reintroduced to selected locations throughout the reintroduction area (Boulerice 2017). Both 30-day and 2-month post-release spotlight surveys were conducted in 2016 and revealed short-term survival rates among the highest reported to-date (J. Hughes, USFWS National Black-footed Ferret Conservation Center, personal communication). Spotlight surveys in 2017 located the first generation of wild-born ferrets and suggested 1-year survival rates similar to those of reintroduction sites with established ferret populations. These results suggest that many of the released ferrets were able to successfully find food and shelter, avoid predation, and successfully reproduce, at least in the short-term, all of which are traits necessary for establishing a viable population at the MRA. As is typical for newly established reintroduction areas, supplemental releases of 24 captive-reared ferrets took place in 2017 to augment the population and provide additional reproductive opportunities for the original cohort (BFFRIT 2016, Boulerice 2018a).

Although our results from the first 2 years suggest the ferret population in Meeteetse was initially able to persist on the landscape, long-term monitoring will be necessary to assess the viability of the population, inform management decisions, and measure progress toward recovery goals. Decades of monitoring in Shirley Basin and at other sites outside of Wyoming have demonstrated the sensitivity of both ferrets and prairie dogs to stochastic events, as populations tend to fluctuate rapidly with weather and disease. Challenges associated with both of these factors were known to occur within the MRA at the time of, or shortly after, reintroduction.

Thus, monitoring efforts conducted in 2018 to measure 2-year survival rates of newly released and wild-born ferrets are important to determine the nascent success of the population within the MRA.

In the summer and fall of 2018, the Department conducted multiple efforts to manage and monitor ferrets in Meeteetse. First, actions directed at promoting habitat for ferrets, including updating prairie dog colony maps, establishing baseline density estimates for prairie dogs, and disease management are described in detail in a separate report (see Boulerice and Nelson 2019). Additionally, as is standard procedure for newly established reintroduction areas, we released additional captive-reared ferrets to supplement the existing population (BFFRIT 2016). Finally, we completed spotlight surveys to evaluate the population at the site 2-years post reintroduction. Each of these monitoring and management actions fulfilled objectives for the MRA outlined in the 2016 management plan for this reintroduction area (WGFD 2016). This report describes both the supplemental release and survey efforts conducted in 2018 for the MRA.

METHODS

We conducted surveys to evaluate survival and reproduction of ferrets 2 years after the establishment of the reintroduction area. Similar to the established survey protocols used in Shirley Basin, we divided the MRA into a series of survey routes by designating sections in which established roads, fence lines, or other obstructions created logical divisions (i.e., circular routes and/or physical boundaries). Survey routes varied in size from 200-425 ha. We used the standard spotlighting method employed at many ferret reintroduction sites to survey for ferrets, including Shirley Basin (BFFRIT 2016, Boulerice 2016). Specifically, we conducted surveys by foot, truck, ATV, or a combination thereof, and used high-powered spotlights to locate the distinctive eyeshine of ferrets. Where existing roads allowed within each survey route, we drove vehicles equipped with window-mounted spotlights (Model RM 240 Blitz, Lightforce Professional Lighting Systems, Orofino, ID). To survey portions of each route not accessible by truck, we navigated by foot or ATV and used a backpack spotlight unit (Walkabout Kit, Lightforce Professional Lighting Systems, Orofino, ID) to detect ferrets. We surveyed from 2000-2300 hours and 0100-0600 hours in blocks of 3 consecutive nights (Grenier 2008, Grenier et al. 2009). Unlike Shirley Basin, we conducted surveys in Meeteetse in pairs (2 people per survey route) in order to reduce the likelihood of grizzly bear (*Ursus arctos*) encounters throughout the MRA.

After we detected ferrets, we used an unbaited live-trap to attempt to capture observed individuals (Sheets 1972). We checked traps hourly throughout the night and removed all traps at sunrise. We transferred captured ferrets into tubes made of corrugated plastic. Once the animal was in the plastic tube, we scanned for the passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) with which all captive-reared ferrets were marked prior to release with a PIT tag reader. (Note: PIT tags could not be scanned while ferrets were in the metal live-traps.) Based on the PIT identification number, captured animals were designated into 1 of 3 groups: captive-reared ferrets released in 2016, captive-reared ferrets released in 2017, and wild ferrets (juvenile or adult with no PIT tag).

With the exception of ferrets released in 2018 prior to spotlight surveys, all captured ferrets were transferred to a mobile processing trailer where we used isoflurane gas to anesthetize individuals to aid in processing (Kreeger et al. 1998). We removed any ectoparasites visible on ferrets (e.g., ticks, mites, fleas). We collected and stored any fleas for future disease testing. We collected hair samples from all captured ferrets and stored for future analysis. We vaccinated captured ferrets for sylvatic plague and canine distemper with vaccines provided by the US Fish and Wildlife Service (USFWS) National Black-footed Ferret Conservation Center (Wellington, CO). For animals without PIT tags, we confirmed age to ensure the individual was a juvenile and thus wild-born versus an adult released previously for which the PIT tag was lost or malfunctioning. We verified age class by palpation of the sagittal crest, examination of dentition and tooth wear, and determination of reproductive status (Thorne et al. 1985). We marked all untagged ferrets with PIT tags. We collected morphometric measurements from all ferrets. We also marked animals along the throat and chest with temporary hair dye. Following a brief recovery period, we returned the ferret to the burrow from which the animal was captured. We estimated number of discrete ferrets observed during survey efforts by following guidelines outlined by Grenier (2008) in the same manner as has been conducted in at the Shirley Basin Reintroduction Area since 2013. We provide re-encounter rates for all cohorts of ferrets previously marked in captivity or 2017 survey efforts to provide a measure of minimum survival rate (Biggins et al. 1998).

We designated 21 specific locations where ferrets would be released during supplemental releases of captive-reared animals. Each location included ≥1 burrow in which a prairie dog was observed ≤3 days prior to release and was within an area of high burrow density. In an effort to increase the distribution of ferrets throughout the MRA, we selected areas for releases that included colonies or portions of colonies where ferrets were not released previously or where ferrets had not been detected in recent surveys. In addition, we selected locations for releases in accordance to spacing guidelines established by the USFWS, specifically such that ferrets were released 284 m apart and at a density ≤20 acres per ferret in high quality habitat and ≥75 acres per ferret on low quality habitat (BFFRIT 2016). We conducted releases by dividing ferrets and releasers into 2 groups such that releases occurred simultaneously and within a short time period in order to minimize stress on ferrets. All ferrets were released by opening the doors on the pet carriers in which the ferrets were delivered by the USFWS at the designated locations. Once released, we provided ferrets with a portion of prairie dog meat for nourishment. We removed all equipment from the site at the conclusion of releases. We released ferrets on 2 separate dates.

RESULTS

We spent 263.4 hours during 6 nights spotlighting for ferrets from 19 – 21 September and 24 – 27 September (Table 1). A total of 8,152 acres were surveyed by spotlighting (Figure 1). We recorded 54 ferret observations comprised of ≥26 discrete ferrets, resulting in a discrete ferret every 10.1 hours. Remote cameras deployed as part of an effort to validate scent dog areas of interest captured photos of 2 additional ferrets who would be considered discrete (Nelson and Hurt 2019), but we did not included these individuals in the estimate of discrete ferrets from spotlighting. We captured 21 ferrets, comprised of 4 individuals released in 2016, 1 individual released in 2017, 5 wild-born adults, and 10 wild-born kits (Table 2, Figure 2). We detected ≥5 litters. Between survey dates, we spotlighted 2 survey routes with reduced prairie dog density and located 1 of the individuals released in 2016 included above. Distribution of discrete ferret observations is shown in Figure 2. Observations of all species recorded during spotlight surveys were submitted to the Wildlife Observation System. Detections of Species of Greatest Conservation Need other than ferrets included 25 swift fox (*Vulpes velox*) and 4 Burrowing Owl (*Athene cunicularia*) sightings.

All of the 2016 releases we captured were also located in 2017 surveys. Their captures represent an 11.4% minimum survival rate over 2 years for the 2016 release cohort but a 40% reencounter rate between years 1 and 2. The only ferret located from the 2017 release cohort was a reproductive female who was not detected as a kit in the surveys following her release. This capture represents a 4.2% minimum annual survival rate for the 2017 release cohort of 24 individuals. None of the 8 adult ferrets released 13 days prior to spotlight surveys were detected. We re-encountered 2 of the 6 wild-born kits marked last year as adults this year, but we also captured 4 adult ferrets not marked with a PIT tag. This represents a minimum survival rate of 60% for kits known to have been born in Meeteetse in 2017, 4 of which were not vaccinated for plague or canine distemper during their first year. Physiological signs of litter production (i.e., swollen mammae) were present in all captured females, indicating reproduction by 2016 releases, 2017 releases, and wild-born adults.

Our 3rd year of supplemental releases took place on 6 September with 8 adults released and 28 September with 13 ferrets released. Together, these releases constituted a total of 21 ferrets comprised of 9 adults (6m:3f) and 12 juveniles (7m:5f). Age, sex, date of birth, breeding facility, and PIT tag numbers for all released ferrets are described in Table 3, and release locations are mapped in Figure 3.

DISCUSSION

In the 2nd year of post-reintroduction monitoring, we recorded a greater number of observations, discrete ferrets, wild-born kits, and litters relative to the surveys in the 1st year of establishment. The reported numbers of animals here represents a minimum, as additional ferrets have likely gone undetected during survey efforts. In 2 years of post-release monitoring, we have recorded 9 distinct instances where released ferrets were not located in the spotlight survey session immediately following their release or birth date but were found the subsequent year (Boulerice 2018a). In 2018, this included the unmarked adult ferrets, indicating that ≥4 wild-born kits were not captured in the previous year's survey, as well as the only ferret detected from the 2017 release group. Further, remote cameras set to validate scent detection dog surveys detected ferrets on a route where spotlight surveyors failed to locate any ferrets, including 2 ferrets that would be considered discrete (Nelson and Hurt 2019). Reasons for imperfect detection of ferrets are numerous and discussed in detail by Boulerice (2018b). In addition, the MRA is bounded to the north by private land that is not included in surveys due to access restrictions. This area is known to contain prairie dog colonies well within average dispersal distances of ferrets (Boulerice 2018a) and supported ferrets in the 1980s before the population was first removed (WGFD 1987). We strongly speculate that ferrets within the Meeteetse population today move to and from this un-surveyed area, thus contributing to the population but eluding detection during survey efforts. Moreover, additional litters of wild-born kits may be present within these inaccessible colonies. Therefore, the ferret population at the MRA is expected to be greater than the 26 ferrets we observed while spotlighting.

We speculate that our plague management actions, specifically application of deltamethrin dust, were an important contribution to ferret population growth. Boulerice and Nelson (2019) reported a decline in relative density on 740 acres and a 100% decline in prairie dog abundance within a visual count plot that received no plague management. Notably, 22 of the 26 discrete ferrets observed during spotlight surveys were located on portions of the colony that received deltamethrin dust between 2016 and 2018. The remaining 4 ferret observations were located on portions of the colony that received dust in 2016. These results suggest that the application of deltamethrin dust is effectively conserving prairie dog density at a level that supports the current population of ferrets, but that the ferrets may be shifting their distribution to better match patterns in prairie dog density.

While sample sizes are small and occasions too few to model vital rates with mark-recapture methods, the reencounter rates of released and wild-born adult ferrets provide further evidence that conditions at the MRA are capable of supporting this species. Minimum survival rates vary between cohorts, although ≥1 representative of each age class or release group was detected. Wild-born ferrets known to be alive in 2017 were the group with the highest 1-year reencounter rate, as 60% of kits born in 2017 were recaptured in 2018, higher than the annual apparent survival rates for kits in Shirley Basin, estimated at 39% using mark-recapture methods (Grenier 2008). These surviving wild-born ferrets exhibited successful reproduction for the first time since establishment of the reintroduction area, as 2 wild-born adult female ferrets were observed with litters. While specific factors leading to litter size and recruitment in ferret populations are unclear (Ayers et al. 2014), signs of reproduction in all captured adult females suggest that conditions are sufficient for growth of the population within MRA. Population matrix models based on the Shirley Basin Reintroduction Area demonstrated that ferret population growth is highly sensitive to 1st year survival and 1st year fecundity (Grenier et al. 2007). As long as prey density remains adequate, the combined high reproduction rates by 1-year old adults (both released and wild-born) and high survival rates of juveniles at the MRA suggest that the ferret population is capable of increasing dramatically over coming years.

The release of additional captive-reared ferrets is expected to support the growth of the population at MRA, but perhaps with diminishing returns. We observed reproduction by a ferret from a supplemental release in 2017, demonstrating that additional individuals are increasing reproductive opportunities for ferrets and expanding the distribution of the population. This ferret was released in a previously unoccupied southwestern portion of the colony that appeared to contain suitable habitat for ferrets but where releases did not previously take place (Boulerice 2018a). However, she was the only individual reencountered from that release group of 24 ferrets. The other individuals released in 2017 may have dispersed further. Anecdotal evidence from other augmented reintroduction sites suggest lower reencounter rates of ferrets released to occupied colonies (T. Tretten, personal communication). Increased dispersal distances by ferrets released onto occupied colonies relative to unoccupied colonies have been documented at UL Bend (D. Biggins, personal communication). We expect that the individuals released in 2018 will settle into areas unoccupied by ferrets, but this may translate to dispersal outside the bounds of the MRA. With observed successful reproduction and relatively high survival rates of juvenile ferrets from released and wild-born ferrets, we recommend that supplemental releases discontinue until decreases in ferret population size or distribution are observed during annual surveys. We instead recommend efforts over the next year to include surveying areas outside of the MRA where possible to understand the status of prairie dog colonies and distribution of ferrets, potentially after altered behavior post-release.

Overall, the 2nd year of post-establishment monitoring at the MRA has indicated that the reintroduced population of ferrets is continuing to become established. This new population has faced several documented challenges, including a severe first winter, ≥1 localized epizootic outbreak of sylvatic plague, and a reduction in prairie dog abundance on >300 acres of the reintroduction area. In addition to observing more ferrets than in the previous year, we were able to document reproduction and successful rearing of healthy kits by both captive-reared and wild-born ferrets. Management efforts conducted by the Department to aid in the establishment of ferrets in Meeteetse, including disease management actions and supplemental releases of captive-reared ferrets, appear to be contributing to the success of recovery. Given the well-documented struggles that the population at the Shirley Basin Reintroduction Area experienced during the first decade following reintroduction and the sensitivity of both prairie dogs and ferret populations to stochastic events (Grenier 2008, Boulerice and Grenier 2014), we recognize that the early accomplishments we have thus far experienced in MRA do not preclude the population from future challenges. Active management and extensive monitoring of prairie dogs and ferrets at the site will be required if ferrets are to persist at the MRA, and the Department is committed to ensuring the success of this site. While challenges to the continued success of this population certainly remain, the status of the reintroduced ferrets in 2018 suggests that conditions in Meeteetse are presently suitable for maintaining a viable population at the site.

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Table 1. Survey effort expended while spotlighting for black-footed ferrets (*Mustela nigripes*) at the Meeteetse Reintroduction Area, Wyoming in September 2018. We conducted a total of 263.4 hours of spotlighting by vehicle and on foot throughout white-tailed prairie dog (*Cynomys leucurus*) colonies. Surveys conducted by ATV are included in the driving total.

Dates	Walking	Driving	Total
19-21 Sep.	51.4	55.5	106.9
24-27 Sep.	30	126.5	156.5
Total	81.4	182	263.4

Table 2. Capture details for 21 black-footed ferrets (*Mustela nigripes*) captured within the Meeteetse Reintroduction Area, Wyoming during survey efforts conducted in September 2018. Ferrets were assigned to 1 of 3 cohorts: captive-reared ferrets released in 2016 (Rel 2016), captive-reared ferrets released in 2017 (Rel 2017), and ferrets born in Meeteetse in either 2016 or 2017 (Wild-born).

#	Pit tag	Date	Route	Observer	Cohort	Age	Sex	Plague vaccine	Distemper vaccine
1	836530543	20-Sep	8	K. Likos/S. Rhine	Rel 2016	Adult	M	N	N
2	019055518	20-Sep	6	P. Anderson/J. Druze	Wild-born	Kit	M	Y	Y
3	048262818	21-Sep	15	A. Mahoney/F. Stetler	Rel 2017	Adult	F	Y	Y
4	836538593	21-Sep	8	P. Anderson/J. Druze	Rel 2016	Adult	F	N	N
5	040842040	21-Sep	6	P. Anderson/J. Druze	Wild-born	Kit	F	Y	Y
6	837850611	21-Sep	6	P. Anderson/J. Druze	Wild-born	Kit	F	Y	Y
7*	836542038	22-Sep	14	D. Nelson/F. Stetler	Rel 2016	Adult	M	N	N
8	019023847	24-Sep	12	P. Anderson/D. Nelson	Wild-born	Kit	M	Y	Y
9	019039639	24-Sep	5	A. Guevara/S. Kerrisun	Wild-born	Adult	M	Y	Y
10	019061855	24-Sep	5	A. Guevara/S. Kerrisun	Wild-born	Kit	F	Y	Y
11	019028792	24-Sep	4	R. Kindermann/S. Ryder	Wild-born	Kit	F	Y	Y
12	040847067	24-Sep	1	S. Rhine/T. Stitzlein	Wild-born	Adult	M	Y	Y
13	019049022	25-Sep	12	P. Anderson/D. Nelson	Wild-born	Adult	M	Y	Y
14	836538629	25-Sep	5	A. Guevara/S. Kerrisun	Rel 2016	Adult	F	N	N
15	019056319	25-Sep	4	R. Kindermann/S. Ryder	Wild-born	Kit	M	Y	Y
16†	040837089	25-Sep	4	R. Kindermann/S. Ryder	Wild-born	Adult	F	Y	Y
17	837856613	25-Sep	4	R. Kindermann/S. Ryder	Wild-born	Kit	M	Y	Y
18†	040825603	26-Sep	12	P. Anderson/D. Nelson	Wild-born	Adult	M	Y	Y
19	019038090	26-Sep	5	A. Guevara/S. Kerrisun	Wild-born	Adult	F	Y	Y
20	019005623	26-Sep	4	R. Kindermann/S. Ryder	Wild-born	Kit	M	Y	Y
21	837846835	26-Sep	4	R. Kindermann/S. Ryder	Wild-born	Kit	F	Y	Y

* Indicates ferret captured during surveys associated with additional spotlighting efforts for ferrets
† Indicates ferret a wild-born kit previously captured in 2017

Table 3. Details for the 21 captive-reared black-footed ferrets (*Mustela nigripes*) released within the Meeteetse Reintroduction Area in September 2018. All ferrets released in Meeteetse were raised at the USFWS National Black-footed Ferret Conservation Center (Wellington, CO).

PIT tag	DOB	Release date	Sex	Age
025-885-541	2014	9/6/2018	M	Adult
836-518-833	2015	9/6/2018	F	Adult
836-517-383	2015	9/6/2018	F	Adult
026-093-044	2014	9/6/2018	M	Adult
026-113-610	2014	9/6/2018	M	Adult
026-093-086	2015	9/6/2018	F	Adult
026-112-892	2014	9/6/2018	M	Adult
025-889-862	2014	9/6/2018	M	Adult
843-514-104	6/1/2018	9/28/2018	M	Kit
600-023-050	6/9/2018	9/28/2018	F	Kit
600-017-888	6/10/2018	9/28/2018	M	Kit
601-105-352	6/3/2018	9/28/2018	F	Kit
018-635-066	2014	9/28/2018	M	Adult
601-100-855	5/25/2018	9/28/2018	F	Kit
600-579-859	6/1/2018	9/28/2018	M	Kit
601-088-800	5/26/2018	9/28/2018	M	Kit
601-104-843	5/26/2018	9/28/2018	F	Kit
601-088-020	6/3/2018	9/28/2018	M	Kit
601-083-554	5/27/2018	9/28/2018	M	Kit
601-105-833	5/25/2018	9/28/2018	M	Kit
601-090-533	5/28/2018	9/28/2018	F	Kit

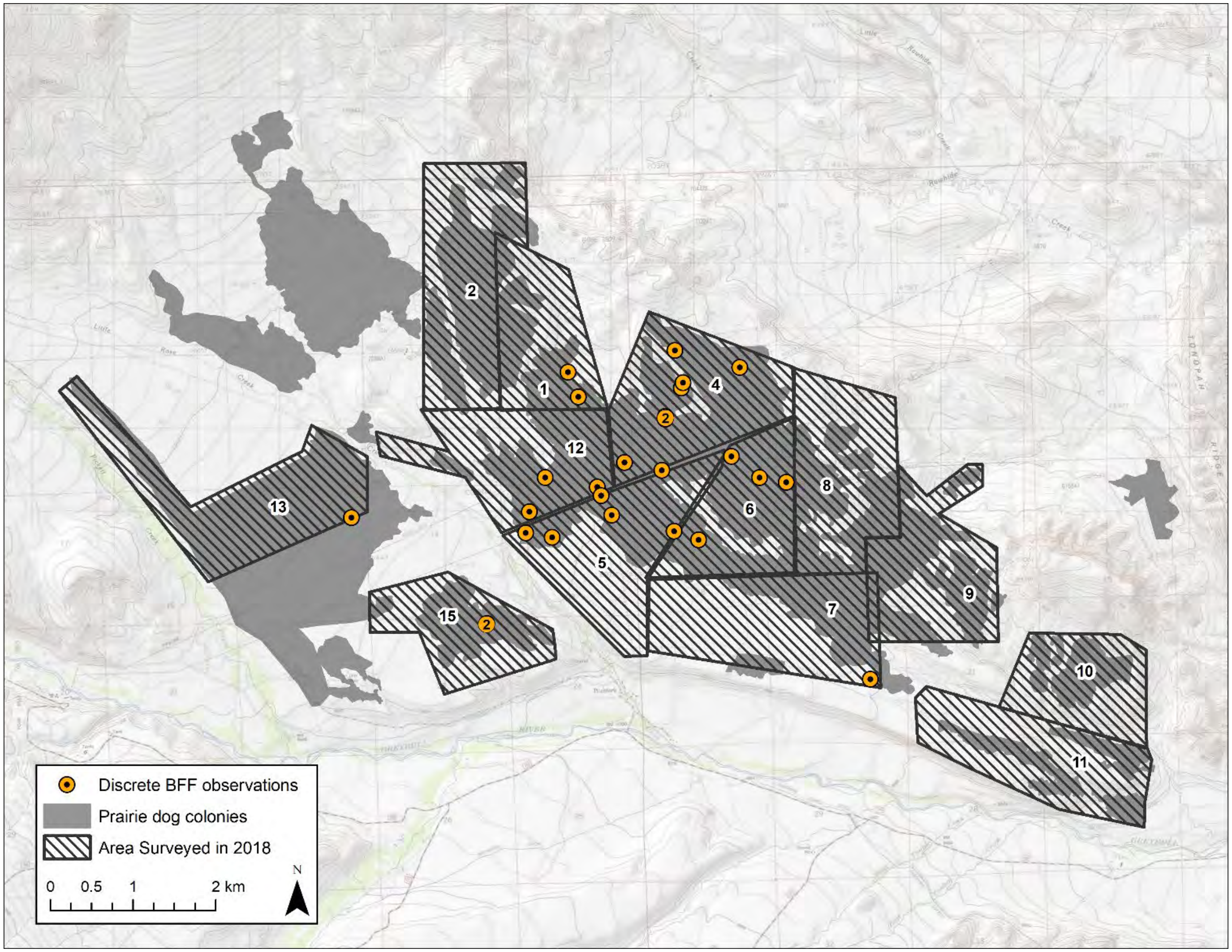

Figure 1. Spatial arrangement of routes surveyed and locations of 26 unique spotlighted black-footed ferrets (*Mustela nigripes*) within the Meeteetse Reintroduction Area in September 2018. Total area surveyed includes all regions contained within a survey route. Total area included in survey efforts was 8,152 acres.

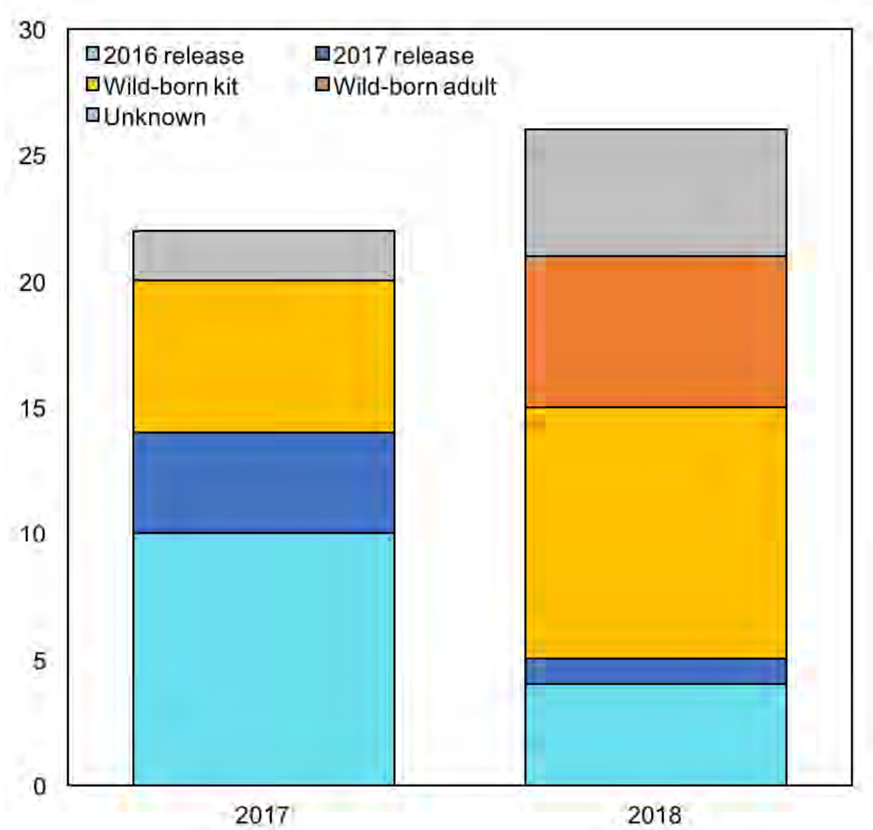

Figure 2. Comparison of black-footed ferrets (*Mustela nigripes*) in each age cohort detected during spotlight surveys at the Meeteetse Reintroduction Area in 2017 and 2018. The category "unknown" represents discrete observations of ferrets who were detected during spotlight surveys but not captured.

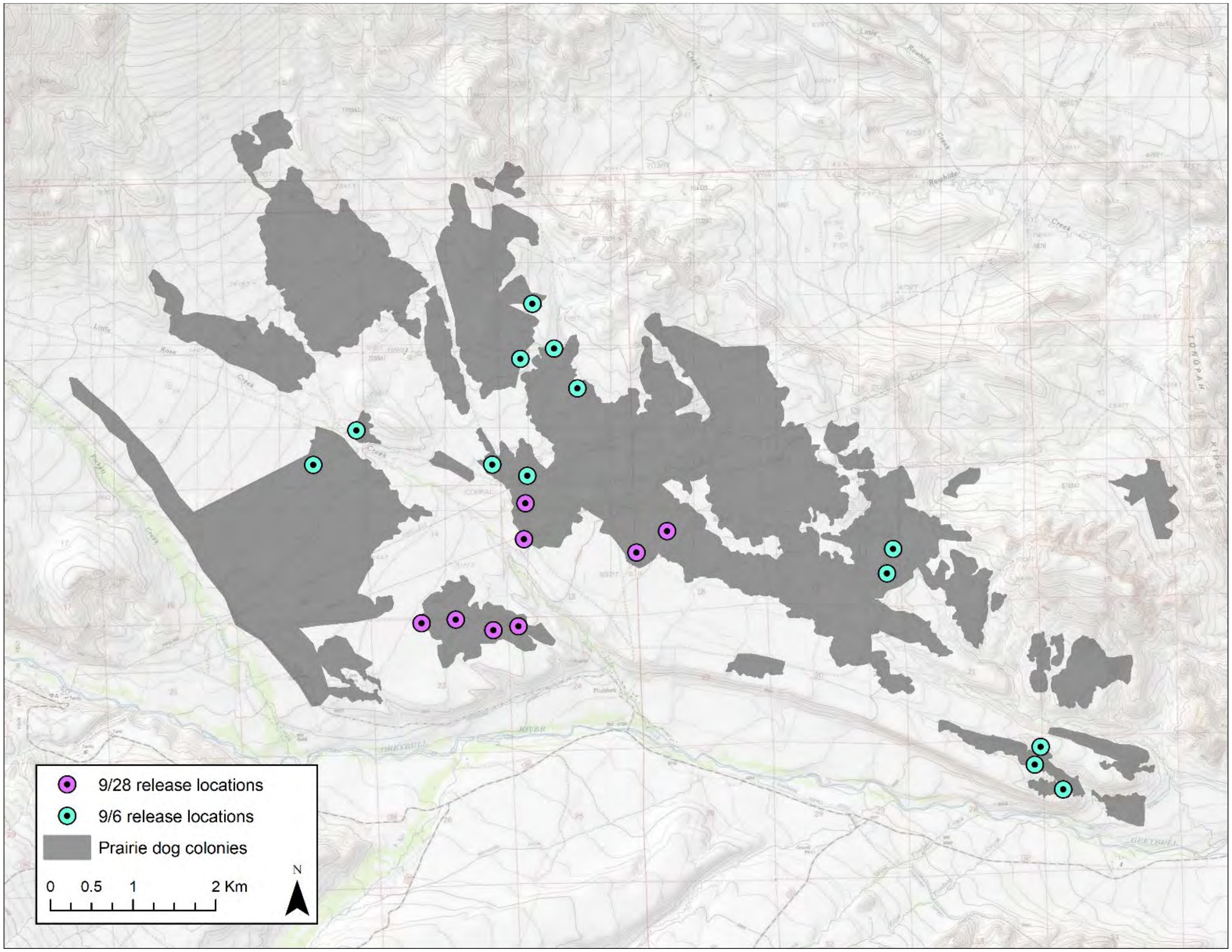

Figure 3. Locations of the 21 black-footed ferrets (*Mustela nigripes*) released in the Meeteetse Reintroduction Area in September 2018. We selected areas for release that included portions of colonies where ferrets were not released previously or where ferrets had not been detected during previous spotlight surveys.

MONITORING EFFORTS AND SUPPLEMENTAL RELEASES FOR BLACK-FOOTED FERRETS (*MUSTELA NIGRIPES*) IN THE SHIRLEY BASIN REINTRODUCTION AREA

STATE OF WYOMING

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

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funding
United States Fish and Wildlife Service State Wildlife Grant

PROJECTION DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Dana Nelson, Nongame Biologist

ABSTRACT

The black-footed ferret (*Mustela nigripes*) faces numerous challenges to recovery, including diseases, which remain the biggest threat to the persistence of the black-footed ferret in Shirley Basin, Wyoming. Releases of black-footed ferrets in Shirley Basin were initiated in 1991 but were terminated in 1994 as a result of sylvatic plague and disease epizootics, which reduced abundance of its prey, the white-tailed prairie dog (*Cynomys leucurus*) throughout the reintroduction area. During this period, the reintroduced population was characterized by slow population growth. However, the black-footed ferret persisted despite these challenges, and the population increased exponentially from 2000-2006 before transitioning to logistical growth from 2006-2010. In 2013-2015, a dramatic decline was observed and attributed to low recruitment of prairie dogs following poor weather conditions in 2011-2012. In 2016, surveys indicated that localized recovery may be occurring on a portion of the reintroduction area, but surveys in the same area in 2017 indicated a 50% decline from the previous year. In 2018, we surveyed for ferrets in August following existing protocol. We obtained a total of 72 observations of black-footed ferrets and observed ≥7 litters. We determined the minimum number alive to be 30 individuals based on a summation of discrete observations. These results suggest that the population within the main study area has increased, potentially due to greater prairie dog abundance and reproduction by released ferrets in 2017. While ferret density appears to have increased relative to the previous year, the population in the main study area remains low. Given the unknown impacts associated with proposed wind-energy development throughout the region, we recommend that increased monitoring of both ferrets and prairie dogs be initiated in order to ensure that ferret populations continue to remain viable within the Shirley Basin Reintroduction Area.

INTRODUCTION

In 1991, the first reintroduction site for black-footed ferrets (*Mustela nigripes*; ferret) in the world was established in Shirley Basin, Wyoming. Following the initial releases of 228 ferrets between 1991-1994, regular monitoring of the population has confirmed that ferrets have persisted for >25 years under a minimal management strategy. Early monitoring efforts demonstrated that epizootics of sylvatic plague and canine distemper occurred shortly after releases were completed in 1994. These diseases challenged the newly established population and significantly decreased the abundance of white-tailed prairie dogs (*Cynomys leucurus*) and ferrets throughout the reintroduction site. During this period, the reintroduced ferret population was characterized by slow population growth where few (i.e., ≤20) ferrets were located annually prior to 2000. However, as prairie dog abundance rebounded in the years following these disease outbreaks, regular monitoring conducted between 2003 and 2006 estimated an annual growth rate of 35%, suggesting that the population of ferrets within the Shirley Basin Reintroduction Area was increasing despite the nascent challenges (Grenier et al. 2006a, 2007). Since prairie dog distribution had also increased in other portions of Shirley Basin where ferrets were believed to be absent, an additional 250 ferrets were released into areas north and south of Shirley Basin during the fall and winter of 2005, 2006, 2007, and 2012 (Grenier et al. 2006b, Schell and Grenier 2007).

Primary monitoring interests have remained focused on a portion of the prairie dog complex totaling about 8,000 ha, hereafter termed the "main study area". By 2006, the population had grown rapidly within the main study area to 229 ferrets (95% CI: 169-289; Grenier et al. 2009). Estimates from 2008 (240; 95% CI: 176-303) and 2010 (203; 95% CI: 137-270) suggested that population growth had begun to taper off as rate of growth appeared to transition from an exponential to a logistical pattern (Van Fleet and Grenier 2009, 2011). However, surveys in 2013 suggested that the population had declined dramatically to ≥39 individuals, thought to be in response to poor weather conditions that reduced recruitment of prairie dogs throughout the reintroduction area (Boulerice and Grenier 2014). Although the Wyoming Game and Fish Department (Department) expected that ferrets would recover following this decline (Boulerice and Grenier 2014), surveys were not conducted in 2014 due to financial restrictions and personnel turnover. In 2015, ≥45 discrete ferrets were observed during an exhaustive effort (>1,200 hours, >10,000 ha) to evaluate the status of the population within the larger Shirley Basin complex. Of these individuals, ≥43 were observed within the main study area, which suggested that the population had not experienced significant change since the decline observed in 2013 (Boulerice 2016). In 2016, surveys encompassing approximately half of the main study area found ≥34 individuals, representing a 36% increase in abundance for the area surveyed compared to 2015 (Boulerice 2017). However, this increase did not indicate recovery from low numbers, as only >16 individuals located during surveys in 2017 (Boulerice 2018b).

Given the decline in abundance of ferrets that the reintroduction area has experienced since 2013, annual monitoring continues to be crucial to understanding the contribution of Shirley Basin Reintroduction Area to ferret recovery efforts, both towards state and national recovery goals (USFWS 2013, WGFC 2018). Additional research and monitoring for both ferrets and prairie dogs are even more pertinent and time-sensitive given that Shirley Basin is facing significant landscape-level anthropogenic habitat alterations for the first time since the inception of the reintroduction area. Aside from periodic outbreaks of diseases, human-caused disturbances associated with the land management practices occurring throughout the region have been minimal. However, several proposed large-scale wind-energy development projects are slated to occur as early as 2019 throughout the entirety of the reintroduction area. The impact of wind energy development on ferrets and prairie dogs is unstudied throughout the West; thus viable populations of both species may be able to coexist with large-scale wind-energy production, or the disturbances caused by development and construction may have a negative impact.

In 2018, we conducted monitoring efforts within the main study area of the Shirley Basin Reintroduction Area to assess the status of the ferret population. In addition, we completed supplemental releases of captive-reared ferrets within the reintroduction area. This report summarizes both the annual spotlighting survey effort and the supplemental releases.

METHODS

We conducted spotlight surveys in 2018 within a portion of the main study area of the Shirley Basin complex that has historically contained the greatest abundance of ferrets. Specifically, we surveyed a portion of the reintroduction site east of Highway 478 that had been surveyed in 2006, 2008, 2010, 2013, 2015, 2016, and 2017 (Figure 1). We specifically targeted 3 large colonies on the easternmost boundary of the main study area, including the southeastern colony where supplemental releases took place in 2017. We incorporated the updated survey boundaries first implemented in the 2016 survey to account for differences between the outdated maps of prairie dog colonies that were available and the distribution of colonies we observed during the summer of 2016 (Boulerice 2017, Figure 1). We contacted all landowners for permission to access private lands prior to the initiation of surveys.

We surveyed for ferrets either on foot, by vehicle (truck or ATV), or a combination thereof. Sampling plots accessible only by foot were approximately 300 acres in size, while those accessible by vehicle were approximately twice as large (i.e., approximately 600 acres). Actual size of the survey plots varied due to size and shape of the prairie dog colony and other geographical boundaries. We surveyed each plot from 2000 – 0000 hours and 0100 – 0600 hours in blocks of 3 consecutive nights (Grenier 2008, Grenier et al. 2009). To locate ferrets, we drove vehicles equipped with window-mounted spotlights (Model RM 240 Blitz, Lightforce Professional Lighting Systems, Hindmarsh, Australia) along existing roads. Field personnel used a backpack spotlight unit (Walkabout Kit, Lightforce Professional Lighting Systems, Hindmarsh, Australia) to traverse portions of or entire plots that could not be surveyed from a vehicle.

After we located ferrets, we used an unbaited live trap to attempt to capture observed individuals (Sheets 1972). We checked traps hourly throughout the night and removed all traps at sunrise. We transported captured ferrets to a mobile processing trailer where we used isoflurane gas to anesthetize individuals (Kreeger et al. 1998). Ferrets were assigned to juvenile or adult age classes by palpation of the sagittal crest, examination of dentition and tooth wear, and determination of reproductive status (Thorne et al. 1985). We marked ferrets with passive integrated transponders (PIT tags; AVID Microchip I.D. Systems, Folsom, LA) and hair dye (Grenier 2008). We removed any ectoparasites visible on ferrets (e.g., ticks, mites, fleas, etc.). Fleas were collected and stored for future disease testing. We collected hair samples from all captured ferrets and stored for future analyses. We vaccinated captured ferrets for sylvatic plague and canine distemper with vaccines provided by the National Black-footed Ferret Conservation Center (NBFFCC; Wellington, CO). Following a brief recovery period, we returned the ferret to the burrow from which the animal was captured. We estimated minimum number alive (MNA) by summing all discrete observations of ferrets following guidelines outlined by Grenier (2008) and consistent with surveys completed since 2013.

Following surveys, we conducted supplemental releases of captive-raised ferrets within the main study area. We designated 22 specific locations where ferrets would be released (Figure 2). Each location included ≥1 burrow in which a prairie dog was observed 3 days prior to release and was within an area of high burrow density. In addition, we selected locations in accordance to spacing guidelines established by the US Fish and Wildlife Service, specifically such that ferrets were released 284 m apart and at a density ≤20 acres per ferret in high quality habitat and ≥75 acres per ferret in low quality habitat (BFFRIT 2016). Ferrets were divided between portions of large prairie dog colonies that have historically supported large densities of ferrets but recent surveys have suggested a decline in abundance. We conducted releases by dividing ferrets and releasers into 3 groups such that releases occurred within a short time period and minimized stress on ferrets. Ferrets were transported from the NBFFCC in pet carriers and were released by simply opening the doors on the carriers at the release site. Once released, we provided ferrets with a portion of prairie dog meat for nourishment. We removed all equipment from the site at the conclusion of releases. All ferrets were released on private lands, and permission from landowners was obtained prior to release.

RESULTS

We spent 188.9 hours during 5 nights spotlighting for ferrets from 23-24 August and 27-29 August (Table 1). The first survey window included only 2 nights due to heavy rain creating impassable road conditions. We surveyed a total 14,811 acres over 13 sampling plots. We recorded 72 observations of ferrets and determined the MNA to be 30 individuals (Table 2, Figure 3). This amounted to a discrete ferret approximately every 6.3 hours of surveying. We detected ≥7 litters. We compared MNA within the main study area to previous years (Figure 4). MNA was standardized by effort as both time and area surveyed (Figure 5). We recorded 33 observations of 8 other Species of Greatest Conservation Need while spotlighting (Table 3).

Concurrent with spotlight surveys, we captured 15 ferrets, including 8 juveniles (4m:4f) and 7 adults (3m:4f). Only 1 of the 15 ferrets was recaptured from previous annual surveys: a female first encountered in 2015. We detected no abnormalities and very few (i.e., ≤10) ectoparasites (i.e., fleas and ticks) on most ferrets handled in 2018. Details for all captured ferrets are summarized in Table 4.

On 18 October 2018 from 1500-1800, we released 22 captive-reared ferrets within the Shirley Basin Reintroduction Area. Released individuals included 15 juveniles (8m:7f) and 7 adults (2m:5f). Age, sex, PIT tag numbers, and captive-breeding facility for all released ferrets are detailed in Table 5 and locations are shown in Figure 2.

DISCUSSION

Indices of population size from MNA according to Grenier (2008) and an increase in observed litters in 2018 suggest that the ferret population in the main study area of Shirley Basin may be starting to recover from the decline observed over the last 5 years. Survey effort was considerably lower than previous years due to suboptimal weather conditions and limited personnel, thus the moderate increase in ferret population numbers in the main study area may be underestimating true population changes. Density of ferrets per acre is marginally higher than in 2017, but the numbers standardized by time spent surveying suggests a more substantial population increase. The number of hours per discrete ferret in 2018 was the lowest observed ratio since 2010 (Van Fleet and Grenier 2011). Further, the number of litters located during this truncated survey effort is higher than the previous 3 years, although surveys in some years occurred outside of the peak kit emergence period (mid-August through early September; Eads et al. 2012) and therefore may have had lower likelihood of detecting litters (Boulerice 2018b).

Increases in population size and recruitment are likely due to a combined effect of increased prey density and additional reproductive opportunities provided by the additional ferrets released in fall 2017. Efforts to evaluate prairie dog density and distribution initiated in 2016 offer useful indices and means for comparison of ferret habitat among years (Boulerice 2017). Average prairie dog density at visual count plots across the main study area in 2018 was 26% higher relative to the previous summer (Boulerice 2018a, Boulerice and Nelson 2019). More habitat resources available to ferrets likely contributed to reproductive success and greater survival to the fall monitoring season.

The increased number of litters produced can also be partially attributed to additional ferrets available due to supplemental releases. In the southern portion of the main study area, 3 litters were spotlighted on survey routes with no recorded ferret observations since 2015. In one instance, kits were captured <200 m from a 2017 supplemental release location. While we did not capture any of the released ferrets, it is plausible that these individuals have contributed to increased reproductive output. Our efforts in 2018 to release 22 new ferrets to the main study area may further benefit reproduction and continued persistence at the reintroduction area by increasing reproductive opportunities for wild ferrets already present in the area and contributing to population numbers by reproducing with wild or other newly released ferrets.

Future populations of both ferrets and prairie dogs in Shirley Basin will likely be required to coexist with large-scale wind-energy development throughout the region. Published research is sparse related to the impacts of wind energy development on terrestrial mammals. One study in Great Britain has suggested negative post-construction impacts on fossorial mammals stemming from infrasound, as European badgers (*Meles meles*) showed chronically high levels of stress hormones within 1 km of wind turbines (Agnew et al. 2016). We speculate that landscape disturbances associated with installation of the required road networks, turbines, transmission lines, etc. through Shirley Basin could impact both prairie dog and ferret abundance and distribution. Further, if fossorial animals at Shirley Basin show similar effects to Agnew et al. (2016), we could observe effects at the organismal level as animals display signs of physiological stress. Given the scale at which wind-energy is planned to occur in Shirley Basin, these disturbances may be extensive and far-reaching. Research projects aimed at determining the impacts of wild-energy development, specifically directed toward evaluating changes in densities, movement patterns, and demography of prairie dogs and ferrets in disturbed compared to undisturbed areas, will be vital across the Shirley Basin Reintroduction Area in order to guide future management action.

Continued and more intensive monitoring in the main study area will allow the Department to efficiently assess the viability of the Shirley Basin ferret population and will provide important data for comparison with prairie dog and ferret numbers following wind energy development. However, as time and funding allow, we suggest expanding effort in additional locations to update our understanding of the distribution of ferrets throughout the reintroduction area. Nocturnal presence surveys for swift fox (*Vulpes velox*) and ferrets conducted by consultants in 2018 in advance of wind turbine construction recorded 15 observations of ≥7 ferrets within dispersal distance of historic release locations near Rock River. These areas with ferret observations have never been spotlighted and have no current prairie dog distribution data recorded. Review of high-resolution, recent aerial imagery to determine prairie dog burrow density will serve as an important first step in determining ferret habitat and locations for spotlight surveys outside of the main study area (Boulerice 2018b, Boulerice and Nelson 2019). By identifying changes to outdated maps of colony boundaries and locating areas of high prairie dog densities, the Department will be able to refocus management actions on areas important to ferret population size and connectivity and will be able to more accurately measure the Shirley Basin population's contribution to recovery goals.

In conclusion, monitoring efforts in 2018 within the main study area of Shirley Basin Reintroduction Area suggested that, although population size remains low in the main study area, the increased prey availability and additional ferrets available for reproduction are contributing to population growth. Indices of population size and reproduction suggest that the population of ferrets within the main study area have the potential to recover from the sharp decline observed in 2013 (Boulerice and Grenier 2014; Boulerice 2016, 2017, 2018a). Given that ferret populations in historically dense colonies are persisting at relatively low levels and the possible impending challenges associated with wind-energy development throughout the region, increased monitoring and management of prairie dog and ferret populations throughout the Shirley Basin Reintroduction Area are warranted.

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Seymour and A. Soble. In addition, thank you to C. Keefe with BLM for his assistance with recruiting survey help. Department personnel T. Christensen, T. Cufaude, E. Hall, R. Kepple, L. Knox, and S. Rhine assisted with the release, and, as always, we thank the staff of the National Black-footed Ferret Conservation Center for their assistance and coordination of release efforts. Funding for this project was provided by the US Fish and Wildlife Service through Section 6 of the Endangered Species Act and State Wildlife Grants, for which we are extremely grateful.

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Table 1. Survey effort in hours expended while spotlighting for black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming in August 2018. A total of 188.9 hours of spotlighting was conducted by vehicle and on foot throughout white-tailed prairie dog (*Cynomys leucurus*) colonies.

Dates	Walking	Driving	Total
Aug. 22-24	40.5	27.7	68.2
Aug. 27-29	44.0	76.7	120.7
Total	84.5	104.4	188.9

Table 2. Complete list of all black-footed ferrets (*Mustela nigripes*) observed in Shirley Basin, Wyoming during surveys conducted in fall of 2018. Discrete observations were determined based on guidelines outlined by Grenier (2008). In total, 72 observations were recorded, of which 30 were determined to be discrete observations.

Date	Time	Colony	Observer	Discrete
8/28/2018	2:08	556-4	D. Nelson\T. Seymour	Yes
8/29/2018	21:40	556-4	D. Nelson\T. Seymour	No
8/27/2018	23:00	554-2	F. Calderón	Yes
8/27/2018	3:30	554-2	F. Calderón	Yes
8/27/2018	3:30	554-2	F. Calderón	No
8/27/2018	4:00	554-2	F. Calderón	Yes
8/27/2018	4:45	554-2	F. Calderón	Yes
8/28/2018	21:10	554-2	F. Calderón	No
8/28/2018	0:10	554-2	F. Calderón	No
8/28/2018	3:30	554-2	F. Calderón	No
8/28/2018	5:20	554-2	F. Calderón	No
8/28/2018	5:20	554-2	F. Calderón	No
8/29/2018	0:30	554-2	F. Calderón	No
8/29/2018	3:15	554-2	F. Calderón	No
8/29/2018	3:15	554-2	F. Calderón	No
8/29/2018	3:20	554-2	F. Calderón	No
8/29/2018	3:30	554-2	F. Calderón	No
8/29/2018	3:45	554-2	F. Calderón	No
8/29/2018	5:20	554-2	F. Calderón	No
8/29/2018	2:05	566-7	J. Martin\A. Soble	Yes
8/27/2018	1:30	556-5	C. Andersen\A. Rojas	No
8/27/2018	1:30	556-5	C. Andersen\A. Rojas	No
8/27/2018	3:30	556-5	C. Andersen\A. Rojas	No
8/27/2018	3:30	556-5	C. Andersen\A. Rojas	No
8/27/2018	4:02	556-5	C. Andersen\A. Rojas	No
8/28/2018	21:00	556-5	C. Andersen\A. Rojas	No
8/28/2018	2:20	556-5	C. Andersen\A. Rojas	No
8/28/2018	2:20	556-5	C. Andersen\A. Rojas	No
8/28/2018	2:50	556-5	C. Andersen\A. Rojas	Yes
8/28/2018	5:00	556-5	C. Andersen\A. Rojas	Yes
8/29/2018	21:15	556-5	C. Andersen\A. Rojas	No
8/29/2018	23:32	556-5	C. Andersen\A. Rojas	Yes
8/29/2018	1:05	556-5	C. Andersen\A. Rojas	No
8/29/2018	1:30	556-5	C. Andersen\A. Rojas	No

Table 2. Continued.

Date	Time	Colony	Observer	Discrete
8/29/2018	1:30	556-5	C. Andersen\A. Rojas	Yes
8/29/2018	1:30	556-5	C. Andersen\A. Rojas	No
8/29/2018	1:30	556-5	C. Andersen\A. Rojas	No
8/29/2018	4:00	556-5	C. Andersen\A. Rojas	No
8/29/2018	4:00	556-5	C. Andersen\A. Rojas	Yes
8/27/2018	23:38	556-2	P. Anderson\C. Battista	Yes
8/27/2018	3:20	556-2	P. Anderson\C. Battista	Yes
8/28/2018	2:52	556-2	P. Anderson\C. Battista	Yes
8/28/2018	3:21	556-2	P. Anderson\C. Battista	Yes
8/28/2018	4:25	556-2	P. Anderson\C. Battista	No
8/29/2018	22:20	556-2	P. Anderson\C. Battista	No
8/29/2018	3:10	556-2	P. Anderson\C. Battista	No
8/28/2018	2:06	556-9	J. Martin\A. Soble	No
8/28/2018	2:06	556-9	J. Martin\A. Soble	Yes
8/27/2018	0:48	556-9	J. Martin\A. Soble	Yes
8/27/2018	22:09	556-8	S. Morrison	Yes
8/27/2018	0:20	556-8	S. Morrison	Yes
8/24/2018	2:30	559-3	D. Nelson	Yes
8/24/2018	2:30	559-3	D. Nelson	Yes
8/23/2018	13:36	559-3	D. Nelson	No
8/23/2018	23:51	559-3	D. Nelson	No
8/23/2018	4:43	559-3	D. Nelson	No
8/23/2018	0:30	559-5	P. Anderson	Yes
8/23/2018	0:55	559-5	P. Anderson	Yes
8/23/2018	1:08	559-4	P. Anderson	No
8/23/2018	5:30	559-5	P. Anderson	Yes
8/23/2018	5:30	559-5	P. Anderson	Yes
8/24/2018	10:54	559-5	P. Anderson	No
8/24/2018	5:31	559-5	P. Anderson	No
8/23/2018	21:00	559-2	F. Calderón\T. Seymour	Yes
8/23/2018	22:40	559-2	F. Calderón\T. Seymour	Yes
8/23/2018	2:30	559-2	F. Calderón\T. Seymour	No
8/23/2018	4:30	559-2	F. Calderón\T. Seymour	Yes
8/24/2018	0:20	559-2	F. Calderón\T. Seymour	No
8/24/2018	2:09	559-4	N. Bjornlie\B. Gee	No
8/23/2018	2:59	559-4	N. Bjornlie\B. Gee	Yes
8/23/2018	4:00	559-E	K. Likos	Yes
8/24/2018	4:46	559-E	K. Likos	No

Table 3. Species of Greatest Conservation Need detected while spotlighting for black-footed ferrets (*Mustela nigripes*) in Shirley Basin, Wyoming in August 2018. All observations of spotlighted wildlife were submitted to the Department's Wildlife Observation System database.

Species	Scientific name	Observations
Swift fox	*Vulpes velox*	22
Greater Sage-Grouse	*Centrocercus urophasianus*	3
Burrowing Owl	*Athene cunicularia*	2
Golden Eagle	*Aquila chrysaetos*	2
Ferruginous Hawk	*Buteo regalis*	1
Olive-backed pocket mouse	*Perognathus fasciatus*	1
Prairie rattlesnake	*Crotalus viridis*	1
Western tiger salamander	*Ambystoma mavortium*	1

Table 4. Details for 15 black-footed ferrets (*Mustela nigripes*) captured in Shirley Basin, Wyoming 2018. Note that "NC" indicates a measurement not collected due to signs of the animal exiting anesthesia.

#	Pit tag	Date	Colony	Observer	Sex	Age	Weight	Plague vaccine	Distemper vaccine
1	040825103	8/23/2018	559-3	D. Nelson	M	Kit	907	Y	Y
2	040821804	8/23/2018	559-2	F. Calderón/T. Seymour	F	Kit	618	Y	Y
3	040796019	8/23/2018	559-2	F. Calderón/ T. Seymour	M	Kit	NC	Y	Y
4	040822118	8/23/2018	559-3	D. Nelson	F	Adult	583	Y	Y
5	040815883	8/24/2018	559-5	P. Anderson	M	Kit	990	Y	Y
6	040854604	8/27/2018	554-2	F. Calderón	F	Adult	716	Y	Y
7	837856067	8/28/2018	556-2	P. Anderson/C. Battista	F	Kit	756	Y	Y
8	040820278	8/28/2018	556-5	C. Andersen/A. Rojas	M	Kit	NC	Y	Y
9	837856259	8/28/2018	554-2	F. Calderón	M	Adult	902	Y	Y
10	837842538	8/29/2018	556-5	C. Andersen/A. Rojas	F	Adult	679	Y	Y
11	837840319	8/29/2018	556-5	C. Andersen/A. Rojas	F	Kit	730	Y	Y
12*	019055586	8/29/2018	556-7	J. Martin/A. Soble	F	Adult	706	N	N
13	837840259	8/29/2018	556-5	C. Andersen/A. Rojas	F	Kit	634	Y	Y
14	040858592	8/29/2018	556-4	D. Nelson/T. Seymour	M	Adult	1004	Y	Y
15	837839086	8/29/2018	556-2	F. Calderón	M	Adult	947	Y	Y

*First captured in 2015

Table 5. Details for the 22 captive-reared black-footed ferrets (*Mustela nigripes*) released within the main study area of the Shirley Basin Reintroduction Area in October 2018. Release locations correspond to the map in Figure 2. Ferrets used in this release came from 3 breeding facilities: the Louisville Zoological Garden (LZG; Louisville, KY), the Smithsonian Conservation Biology Institute (SCBI; Fort Royal, VA), and the USFWS National Black-footed Ferret Conservation Center (NBFFCC; Wellington, CO).

Release location	PIT tag	Date of birth	Breeding facility	Sex	Age
1	026098069	2015	LZG	F	Adult
2	026055078	2015	SCBI	F	Adult
3	838626554	6/12/2018	LZG	F	Kit
4	838615836	3/30/2018	SCBI	M	Kit
5	836526109	4/17/2018	SCBI	M	Kit
6	838622589	6/12/2018	LZG	F	Kit
7	838631070	6/23/2018	SCBI	M	Kit
8	836543532	2015	SCBI	F	Adult
9	601086803	6/5/2018	NBFFCC	F	Kit
10	838604634	6/23/2018	SCBI	M	Kit
11	838629820	6/23/2018	SCBI	M	Kit
12	600000315	6/21/2018	NBFFCC	F	Kit
13	600000821	6/21/2018	NBFFCC	F	Kit
14	836545317	2015	NBFFCC	F	Adult
15	004578869	2014	NBFFCC	M	Adult
16	838611073	3/30/2018	SCBI	M	Kit
17	838625008	3/30/2018	SCBI	F	Kit
18	838607603	4/17/2018	SCBI	M	Kit
19	836529263	2015	NBFFCC	F	Adult
20	838615267	6/23/2018	SCBI	M	Kit
21	025892524	2014	LZG	M	Adult
22	838624787	6/23/2018	SCBI	F	Kit

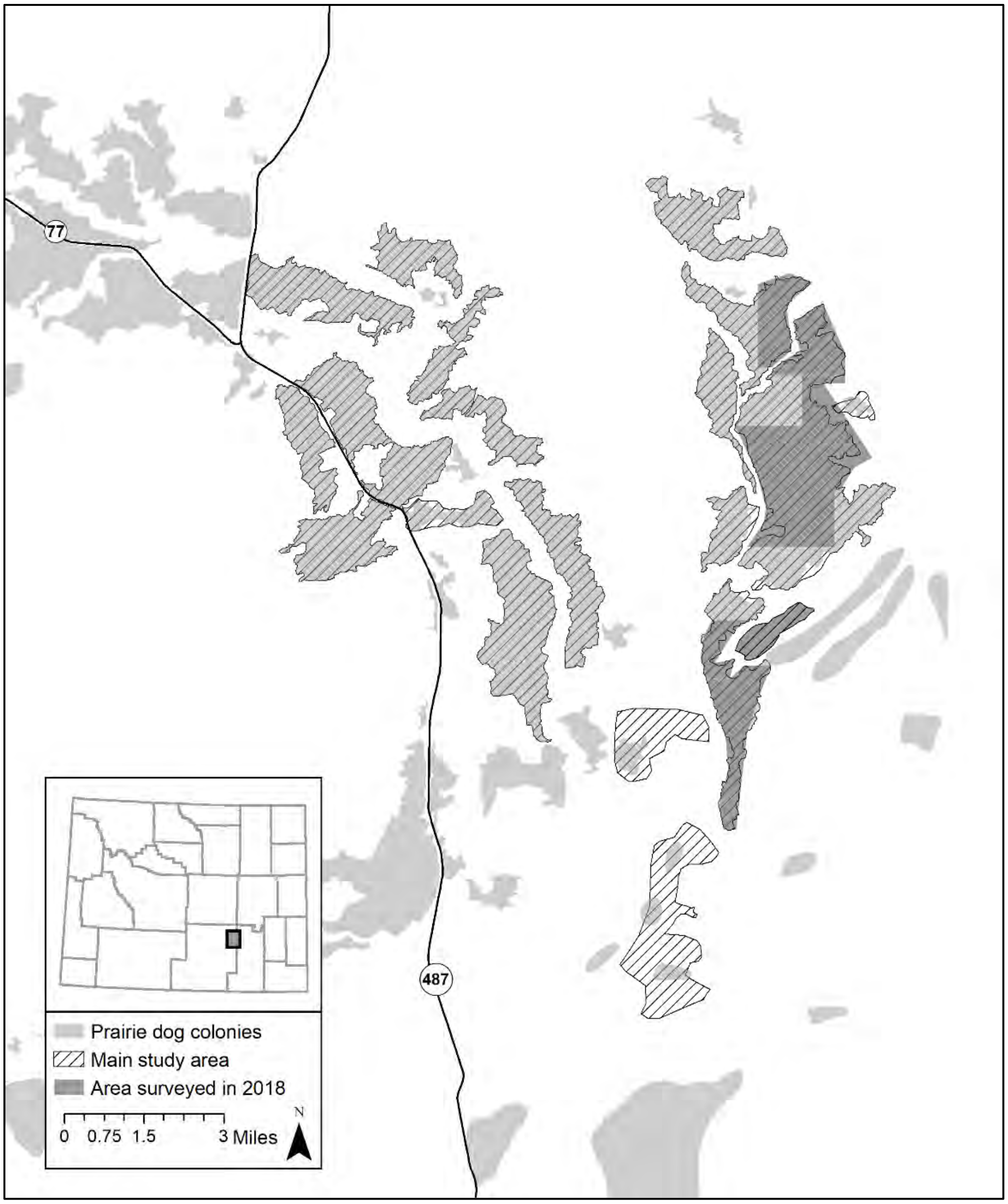

Figure 1. Overview of the main study area within the Shirley Basin Reintroduction Area and the area surveyed for black-footed ferrets (*Mustela nigripes*) in fall of 2018.

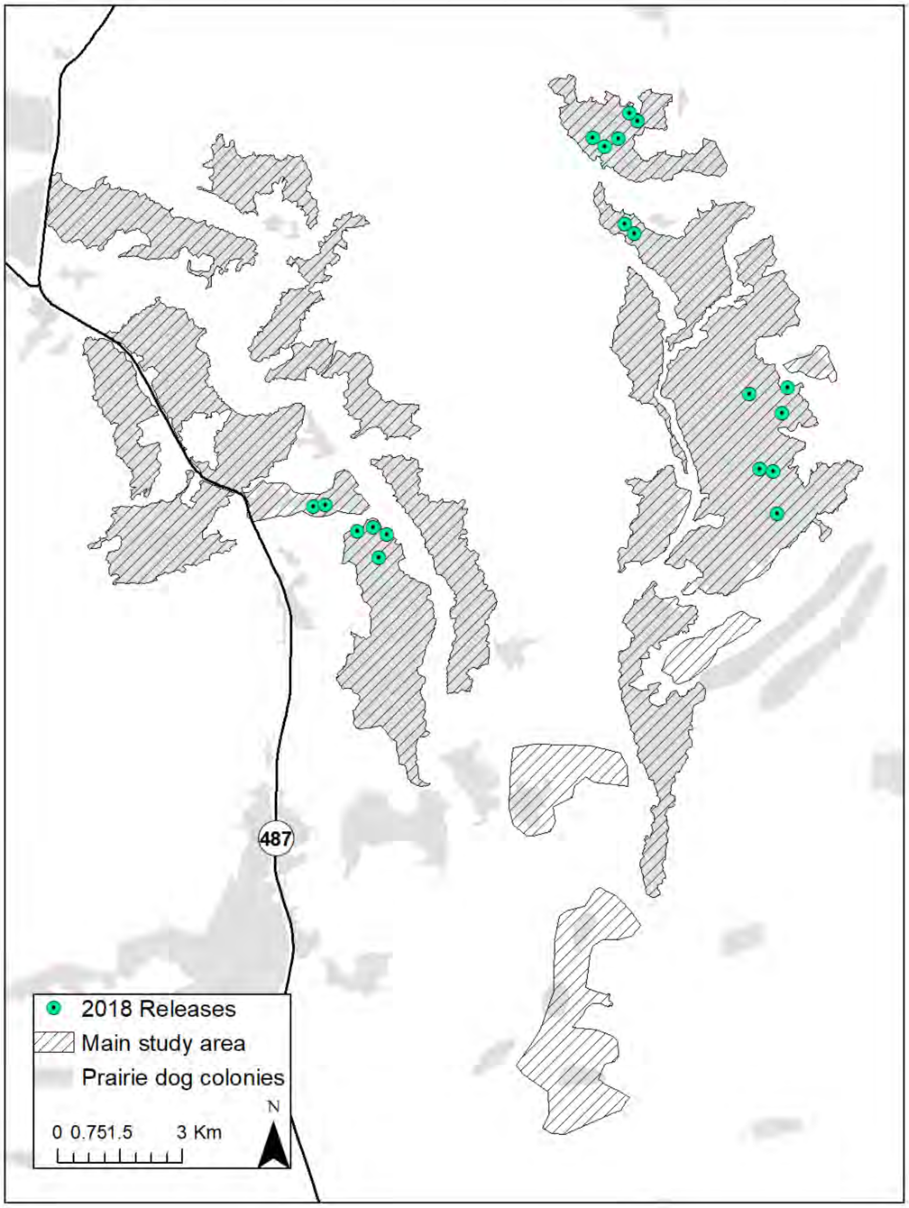

Figure 2. Release locations of 22 captive-reared black-footed ferrets (*Mustela nigripes*) released within the main study area of the Shirley Basin Reintroduction Area on 18 October 2018.

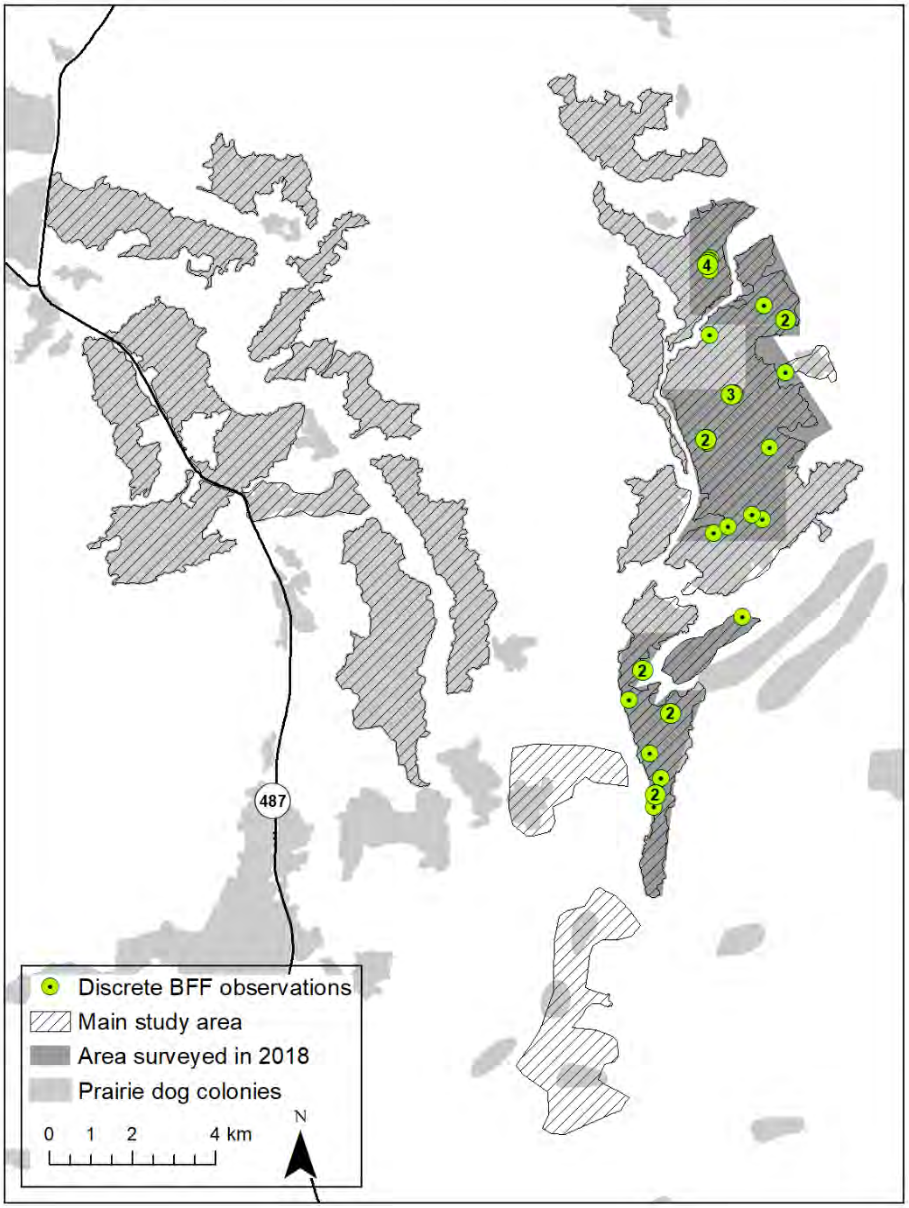

Figure 3. Spatial arrangement of discrete observations of black-footed ferrets (*Mustela nigripes*) and white-tailed prairie dog (*Cynomys leucurus*) colonies that were surveyed in Shirley Basin, Wyoming, 2018. Numbers represent multiple discrete ferrets observed at same location.

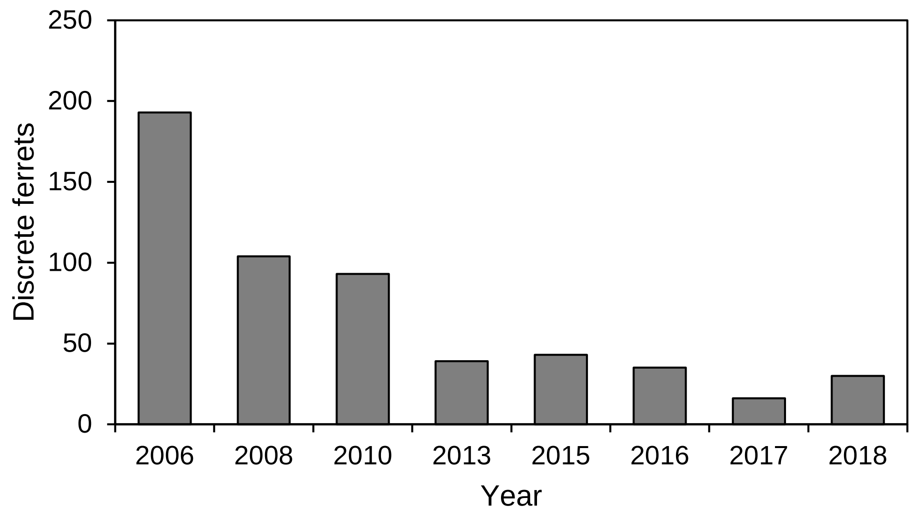

Figure 4. Total numbers of discrete observations of black-footed ferrets (*Mustela nigripes*) within the main study area of the Shirley Basin Reintroduction Area, Wyoming, 2006-2018. Minimum number alive (MNA) for ferrets was calculated by summing the total number of distinct observations (unique ferrets) in a given year of surveys within the main study area.

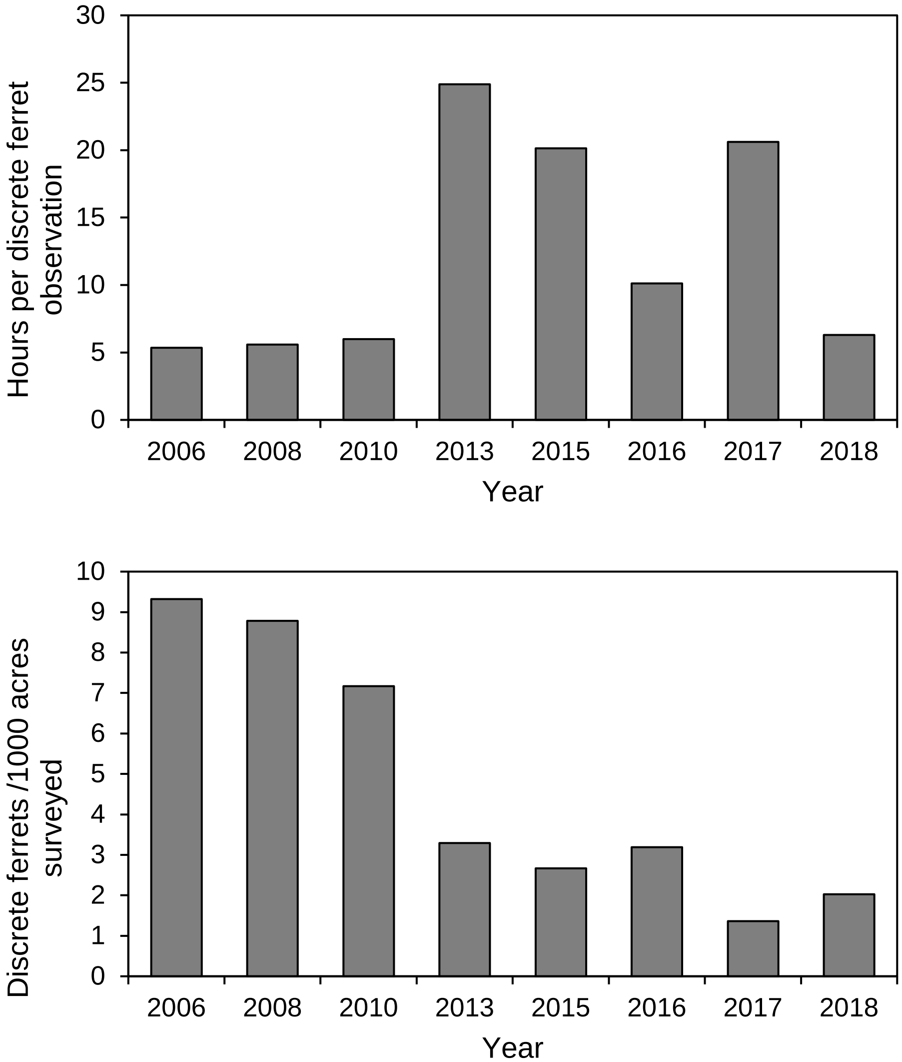

Figure 5. Comparison of discrete observations of black-footed ferrets (*Mustela nigripes*) when standardized by survey effort within the main study area of the Shirley Basin Reintroduction Area, Wyoming, 2006-2018. Top graph: Discrete ferrets per hour calculated by dividing the total number of hours surveyed by the MNA for ferrets (survey hours/MNA). Bottom graph: MNA for ferrets standardized by survey effort (MNA/1000 acres surveyed) in a given area. Surveys were not conducted in the main study area for years not represented in the figure.

MONITORING AND MANAGEMENT OF WHITE-TAILED PRAIRIE DOG POPULATIONS AT THE MEETEETSE AND SHIRLEY BASIN REINTRODUCTION AREAS FOR BLACK-FOOTED FERRETS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need / Endangered Species – White-tailed prairie dog, Black-footed ferret

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funds
United States Fish and Wildlife Service State Wildlife Grants

PROJECTION DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Jesse Boulerice, Nongame Biologist
Dana Nelson, Nongame Biologist

ABSTRACT

Successful recovery of the endangered black-footed ferret (*Mustela nigripes*; ferret) in Wyoming and throughout the historical range of the species is founded on effective monitoring and management of their primary prey species, the prairie dog (*Cynomys* spp.). In 2017, the Wyoming Game and Fish Department developed a series of metrics to collect baseline information on the distribution, status, and density of prairie dogs at both the Meeteetse Reintroduction Area (MRA) and Shirley Basin Reintroduction Area (SBRA) from which population trends could be monitored. In addition, disease management actions were completed at the MRA to mitigate the impact of plague on white-tailed prairie dogs (*C. leucurus*) and ferrets. In June-July 2018, many of the metrics established in 2017 were repeated, suggesting that the prairie dog population at the MRA may have experienced a moderate decline from 2017-2018, while populations at the SBRA seemed to be increasing. Disease management efforts, in the form of deltamethrin and sylvatic plague vaccine (SPV) application were also conducted, and metrics to evaluate the effectiveness of large-scale SPV were established at the MRA. Annual monitoring will continue to be critical to understanding population trends in prairie dog populations at the MRA and SBRA, providing the means to detect and respond to population pressures with appropriate management actions in the context of ferret conservation and recovery.

INTRODUCTION

The success of ongoing efforts to reintroduce and reestablish viable populations of the federally Endangered black-footed ferret (ferret, *Mustela nigripes*) throughout the historical range of the species is inherently linked to the primary prey species of this specialist predator, the prairie dog (*Cynomys* spp). As prairie dogs serve as both a critical source of food and the creator of burrow structures utilized as shelter by ferrets, ferrets only occur within active prairie dog colonies (Hillman and Clark 1980, Biggins et al. 2006). Accordingly, drastic declines in prairie dog populations in North America following decades of disease outbreaks, historical eradication campaigns, and recreational shootings are thought to be directly responsible for corresponding declines in ferret populations (Van Putten and Miller 1999, Miller and Cully 2001). Given this relationship, a leading recovery action for ferrets identified in the USFWS Species Recovery Plan is promoting and managing prairie dog populations (USFWS 2013). Thus, the foundation for successful recovery of ferrets nationwide is reliant on monitoring and management actions that promote populations of prairie dogs at recovery areas, including the 2 populations of ferrets currently existing in Wyoming at the Meeteetse Reintroduction Area (MRA) and Shirley Basin Reintroduction Area (SBRA).

Accordingly, in 2017, the Wyoming Game and Fish Department (Department) initiated a series of efforts to establish protocols for monitoring prairie dog populations and employed those protocols to collect baseline information on distribution, status, and density of prairie dogs at both the MRA and SBRA (Boulerice 2018a). Specifically, a combination of colony mapping, visual count plots, analyses of aerial imagery, and a cursory evaluation of relative density were conducted (Boulerice 2018a). These metrics provided the Department with information necessary to assess population trends for prairie dogs in relation to ferret recovery for the first time since reintroduction at the MRA in 2016 and for the first time in decades at the SBRA. Each of these metrics was intended to be evaluated on an annual basis in order to gauge inter-annual changes and detect population trends that may merit management actions (Boulerice 2018a).

Monitoring prairie dog populations within reintroduction areas also provides necessary information to strategically apply and evaluate management actions, particularly those actions aimed at mitigating effects of sylvatic plague. Epizootics of sylvatic plague (*Yersinia pestis*) can decimate prairie dog colonies and thus eliminate habitat for black-footed ferrets in short time spans (Anderson and Williams 1997). In collaboration with USDA Wildlife Services and the MRA Disease Management Working Group, insecticidal dust (deltamethrin) has been applied to burrows to kill fleas that transmit plague on ≥3,000 acres of the MRA since its inception in 2016 (Boulerice 2018a). In addition to deltamethrin application, the Department has been involved with testing the efficacy of oral sylvatic plague vaccine (SPV) for prairie dogs (Boulerice 2017b). Given the partial protection of prairie dogs that consumed SPV baits made evident from studies at small spatial scales (Boulerice 2017b, Rocke et al. 2017), the Department has followed guidance from the Black-footed Ferret Recovery Implementation Team Disease Subcommittee to apply and evaluate SPV at a large, operational scale (M. Miller, subcommittee chair). In 2018, the Department initiated a longer-term disease management strategy which included plans to treat ≥3,000 acres with deltamethrin and ≤1,000 acres of SPV during 2018-2020. Over this period, data from large areas treated with SPV will contribute to further research on the efficacy of plague management treatments, while monitoring of the entire reintroduction area continues to be necessary to strategically respond to changes in prairie dog density.

In 2018, we employed the same protocols established in 2017 to evaluate population trends for prairie dogs at both the MRA and SBRA. In addition, we conducted disease management actions at the MRA by applying deltamethrin and SPV at large scales. Finally, we established a series of metrics within the area designated for SPV application from which the effectiveness of vaccination could be evaluated, thus enabling the Department to contribute to ongoing research on large-scale SPV usage.

METHODS

Meeteetse Reintroduction Area

During the summer of 2018, we updated boundaries delineating the distribution of white-tailed prairie dog (*C. leucurus*) colonies on portions of the MRA from the maps created in 2017 (Boulerice 2018a). We used a combination of on-the-ground observations and aerial imagery to identify areas where noticeable changes had occurred since similar efforts the previous year. Where changes were identified, we circumscribed active colonies either on foot or by ATV while recording boundaries to GPS units. We assigned the status of colonies as active or inactive by confirming visual presence of prairie dogs above ground during mapping efforts. We uploaded GPS tracks delineating colony boundaries into ArcGIS 10.2 and used these tracks to generate shapefiles. We calculated the total acreage and distribution of colonies.

We completed a series of visual counts to measure annual differences in prairie dog density throughout the MRA. Specifically, we surveyed all 10 visual count plots established in 2017 (Boulerice 2018a). We also created and surveyed 2 new visual count plots at randomly selected locations within the area selected for SPV distribution (described below). All plots consisted of a 200 × 200 m square. We marked all plots at each corner and half way (100 m) between corners and along the outer edge with pin flags. We selected a vantage point that was ≥50 m from the edge of any plot and enabled an observer to view all portions of a plot with binoculars. Once plots were established, we conducted visual counts for 3 consecutive mornings (sessions) between the hours of 0730 and 1030. First, we navigated to the vantage point along a path that did not require the observer to walk through the plot. We allowed 5-10 minutes for prairie dogs within the plot to resume normal behaviors (i.e., return to foraging, cease alarm calling, etc.). We then visually counted the number of prairie dogs aboveground within each plot by scanning with binoculars. For plots surveyed in previous years, we conducted visual counts within approximately 15 minutes of the same time of day as in 2017. We used the highest count achieved over the 3 sessions as an estimate of abundance and divided this count by 4 to determine the density of each plot in terms of prairie dogs per ha. We calculated the percent change in densities from 2017 to 2018 for the 10 plots surveyed in both years to measure annual differences to the population at each visual count plot.

We repeated the cursory evaluation of relative density first conducted in 2017 for the entire reintroduction area. For this evaluation, we indiscriminately navigated throughout mapped colonies by ATV or foot during warm, dry mornings between 0730 and 1030. We assigned portions of colonies into 1 of 3 categories based on the number of prairie dogs observed aboveground without the aid of binoculars at random points along our navigation route. We assigned portions of colonies to the category of "High" if >10 prairie dogs were observed, "Moderate" if 2-10 prairie dogs were observed, and "Few" if <2 prairie dogs were observed aboveground. We then converted our observations into shapefiles to estimate the amount of area designated to each category and compared our results to those collected in 2017 to determine changes in relative density for the MRA.

We selected a portion of the colonies to be treated with deltamethrin (Delta Dust, Bayer Science Corporation, Research Triangle Park, NC) in an effort to reduce the abundance of fleas throughout the MRA. We selected specific areas that encompassed either relatively high densities of prairie dogs, multiple observations of ferrets during the most recent monitoring efforts, portions of colonies previously treated in 2016-17, or a combination thereof (Boulerice 2017c, 2018a). We did not include any State Lands within the treatment areas because permission to apply deltamethrin on these lands was not granted. Application of deltamethrin was contracted to USDA Wildlife Services. Treatment was completed by teams of 4-5 people who navigated along north-south transects throughout the designated areas applying deltamethrin to every hole for which the end could not be seen (BFFRIT 2016). Personnel were equipped with custom-built sprayer units mounted to ATVs.

In addition to treatment with deltamethrin, we also treated approximately 1,000 acres with SPV. We selected areas for treatment with SPV that allowed for large-scale application over a contiguous area of active prairie dog colonies that either entirely encompassed a colony or encompassed a significant portion of a larger colony. Two areas were selected that met these criteria; one 749 acre area within a larger 2,600 acre colony (SPV Area A) and one 215 acre area that encompassed an entire 148 acre colony (SPV Area B). We distributed SPV at a density of 40 baits per ha by ATV using the triple shooter dispensing units designed by R. Matchett (USFWS) and K. Krieger (Model Avionics). To complete distribution, we created 30 m north-south transects throughout each area. We then navigated ATVs along each transects with the triple shooters programmed to dispense 3 SPV baits every 10 m.

We established 3 metrics to be conducted annually to measure the effectiveness of large-scale distribution of SPV at the MRA. These metrics consisted of annual delineation of colony boundaries of all colonies within the distribution area, estimates of prairie dog density derived from 5 visual counts established within the distribution area (3 previously established in 2017 and 2 created in 2018), and estimates of active burrow density derived from burrow transecting conducted over 5% of the distribution area. We conducted boundary delineation and visual counting as described above. We completed burrow transecting by first using ArcGIS to create transects spaced at every 60 m orientated either north-south or east-west depending on the terrain within each area. We then centered a 3 m pole positioned parallel to the ground on the front rack of an ATV. We navigated the ATV along each transect line and recorded the location of every burrow intersected by the pole, designating between active and inactive burrows. We defined an active burrow as any hole >7cm in diameter for which the end could not be seen and was free of cobwebs or other obstructions that would impeded regular movement of a prairie dog. We defined an inactive burrow as any hole >7cm in diameter for which the tunnel had clearly collapsed, cobwebs were intact over the entrances, or other obstructions were present that would impede regular movement of prairie dogs. We then tallied all active and inactive burrows recorded during transecting to estimate the total number of active and inactive burrows per acre for SPV Area A and B.

Shirley Basin Reintroduction Area

We completed a series of visual counts to measure annual differences in prairie dog densities on plots throughout the SBRA. Specifically, we surveyed all 15 visual count plots established in 2017 (Boulerice 2018a) and followed the same protocols to establish plots and implement counts as described above for the MRA.

In addition to visual counts, we conducted a cursory evaluation of relative density for a portion of the SBRA, following the protocols implemented and previously described at the MRA. We completed this analysis on 3 large colonies along the easternmost boundary and for a portion of 2 large colonies in the southwestern region of the main study area of the SBRA where captive-raised ferrets were released in fall of 2017 (Boulerice 2018b).

We continued a large-scale assessment of prairie dog colonies initiated in 2017 with the use of aerial imagery (Boulerice 2018a). We used ArcGIS 10.1 to evaluate the spatial distribution of prairie dog burrows. We expanded the extent of the 500 m × 500 m fishnet grid to match the extent of the entire SBRA. This grid was overlaid on 2017 NAIP imagery. According to methods described by Boulerice (2018a), we assigned each grid cell to a density class of "none", "low", or "high". One deviation from the established protocol was an indication of non-habitat. Because we expanded the effort across the entire basin, we wanted to exclude areas dominated by forest and incapable of supporting prairie dog colonies for future evaluations (i.e., when updated NAIP imagery becomes available). We first focused aerial imagery efforts west of the main study area, specifically on colonies west of state highway 487.

RESULTS

Meeteetse Reintroduction Area

Our mapping efforts updated the current area of prairie dog colonies within the MRA from 6,177 acres mapped in 2017 to 6,256 acres in 2018. The difference in area of 79 acres was due to several small additions made to previous colony boundaries within the southeastern corner of the MRA.

From 19-21 June 2018, we conducted visual counts on 12 plots (10 first surveyed in 2017, 2 established in 2018; Table 1). The average density of prairie dogs over all 12 plots was estimated to be 2.12 individuals per acre (range = 0 – 5.46, SD = 3.58). The average density of prairie dogs on the 10 plots first surveyed in 2017 declined by 1.23 individuals per acre (43% decline) in 2018 (Figure 1). Notably, following visual counts in 2017, flood irrigation occurred throughout the entirety of plot 10 and is likely to have reduced the abundance of prairie dogs between years.

During our assessment of relative abundance of prairie dogs for the entire MRA, we categorized 1754 acres as few (28%), 2427 acres as moderate (39%), and 2077 acres as high (33%) (Figure 2a). From 2017 to 2018, we found the assigned category to decline from moderate to few on 168 acres, from high to moderate on 197 acres, and from high to few on 422 acres (Figure 2b). We reported no change in category on the remaining 5,384 acres mapped in 2017; no increases in density category were recorded. However, 79 acres of colonies classified as high were added that had not been mapped in 2017. In total, we recorded a decline in relative abundance on 787 acres within the colonies boundaries delineated in 2017 (12.7%). Notably, no dead prairie dogs were observed on the portions of colonies that experienced a decline in relative abundance from 2017 to 2018.

From 29 May to 3 July 2018, 2,939 acres of prairie dog colonies were treated with deltamethrin at the MRA (Figure 3). The cost to treat prairie dog colonies with deltamethrin amounted to $21.52 per acre, requiring 599 kg of deltamethrin applied to 68,392 holes (M. Foster, State Director USDA APHIS Wildlife Services – Wyoming, personal communication).

On 22 June 2018, 956 acres of prairie dog colonies were treated with SPV at the MRA (Figure 4). The cost of SPV amounted to $21.38 per acre but only required approximately 32 hours of labor.

To evaluate changes to the prairie dog populations within the acreages where SPV was first applied, we mapped 652 acres of colonies in SPV Area A and 151 acres of colonies within SPV Area B for a total of 803 acres. Our visual counts found an average of 2.18 individuals per acre within SPV Area A (4 plots) and 5.46 individuals per ha within SPV Area B (1 plot). During burrow transecting, we recorded a total of 1,319 active burrows and 133 inactive burrows within transects of SPV Area A for an average of 35.5 active burrows per acre and 3.56 inactive burrows per acre. On SPV Area B, we recorded 501 active burrows and 23 inactive burrows for an average of 46.5 active burrows per acre and 2.14 inactive burrows per acre.

Shirley Basin Reintroduction Area

From 18-21 July 2018, we conducted visual counts on 15 plots. The average density of prairie dogs was estimated to be 2.83 individuals per acre (range 1.11-5.67, SD = 1.3). Average density from these 15 plots increased by 0.51 individuals per acre (26% increase) from 2017 to 2018 (Table 1, Figure 5). From 19-22 July 2018, we conducted a cursory evaluation of relative density of prairie dogs over 8,144 acres of the SBRA (Figure 6). We categorized 966 acres as few (12%), 2,705 acres as moderate (33%), and 4,473 acres as high (55%).

The expanded survey grid for aerial imagery classification of prairie dog burrows now contains 35,308 grid cells representing 2,181,199 acres. From this survey grid, 3,042 cells were evaluated in 2017 and 3,854 were evaluated in 2018 representing 419,090 acres. We have assigned 3,365 cells (50%) and 207,877 acres to the None class, 2,656 cells (39%) and 164,078 acres to the Low class, and 763 cells (11%) and 47,135 acres to the High class. We indicated 162 cells as non-habitat, representing 10,008 acres (Figure 7).

DISCUSSION

Efforts conducted in 2018 directed at monitoring and managing prairie dog populations at the MRA and SBRA fulfilled 3 important roles for ferret recovery in Wyoming. First, repeating several of the analyses first conducted in 2017 enabled an enhanced understanding of the population trends for prairie dogs at both sites. Our results from this newly initiated annual evaluation suggested that while prairie dog populations at the MRA may have experienced a moderate decline from 2017-2018, populations at the SBRA appeared to be improving within the same time interval. Second, our annual efforts to conduct proactive disease management at the MRA with deltamethrin, now combined with large-scale SPV application, are expected to continue to bolster the ferret population at this historically important ferret recovery area by reducing the impact of plague on prairie dogs over a large portion of the MRA. Finally, our efforts to establish the means with which to monitor the impact of large-scale SPV distribution at the MRA will enable the Department to contribute to ongoing research aimed at evaluating the effectiveness of SPV as a tool for plague management.

Data collected from the MRA suggest that the prairie dog population at the MRA may have experienced a moderate decline in abundance and distribution between 2017-2018. Density from 10 visual counts plots declined on average by 43% percent, and relative density evaluation indicated a decline on >300 ha of the site. Although sylvatic plague continues to be the most likely cause of significant declines in the prairie dog population, no dead prairie dogs were observed at the MRA, which precluded the Department from evaluating carcasses to determine cause of death. However, a large proportion of the observed decline in relative density occurred within a portion of the MRA on which no plague management had occurred in recent years, including a 100% decline in prairie dogs within the visual count plot located within this region. Therefore, the possibility exists that an epizootic plague outbreak transpired between the fall of 2017 and the start of surveys in June 2018, during which prairie dogs either died within their burrows or were removed by scavengers before carcasses could be located. Although these declines in prairie dog density are notable, plague management on BLM and private lands is expected to be adequate in maintaining enough prairie dogs (i.e., ≥3,000 acres) to support the nascent population of ferrets at the site.

At the MRA, efforts to manage plague continued to help support populations of both prairie dogs and ferrets. Two years after a localized epizootic plague outbreak, no noticeable expansion of the affected area has been detected, likely because of timely and repeated deltamethrin application. Furthermore, portions of the MRA that did not receive deltamethrin may have experienced plague-related declines in 2018, again highlighting the importance of treatment. The addition of large-scale SPV application to the management regime at the MRA is expected to provide similar benefits to prairie dogs and ferrets and, importantly, provide an alternative treatment option to potentially overcome the concerns related to the development of resistance in fleas after repeated used of deltamethrin (D. Eads, personal communication). As many questions still remain regarding the ability of SPV to combat effects of plague in prairie dogs, the metrics we established at the MRA to monitor prairie dog populations within SPV-treated areas will enable the Department to evaluate the effectiveness of this new treatment method while also contributing to ongoing research on large-scale SPV usage nationwide. In the event of a future epizootic outbreak of plague at the site, the visual count plots, colony boundary delineation, and burrow transecting conducted in 2018 will provide the means by which the response in prairie dog populations can be measured and thus the impact of vaccination can be assessed.

In contrast to populations at the MRA, all indications from our evaluations at SBRA suggested that prairie dog populations are increasing, at least throughout the main study area. Density at 15 visual count plots increased on average by 26%. The exact cause of this increase is uncertain, though it is likely to have been influenced by weather conditions from summer 2017 to 2018 and an absence of epizootic plague. Given that recent survey efforts have noted a decline in ferret densities (Boulerice 2017c, 2018b), continued monitoring of prairie dog populations at the SBRA will be important to assess whether ferret populations will rebound in conjunction with prairie dog populations or if other management actions will be necessary to maintain a viable population of ferrets at the site.

Our efforts to complete a cursory evaluation of relative density for portions of the SBRA will be important for monitoring future population trends and distribution of prairie dogs within the main study area for which regular ferret monitoring occurs. Prior to this effort, the Department has had limited data available on relative density of actual prairie dogs (versus prairie dog burrows) throughout much of the SBRA, aside from a small portion of the main study area that was evaluated in 2017 as part of an effort to ground-truth aerial imagery analyses (Boulerice 2018a). Relative density assessment will continue to allow for further evaluation of trends in prairie dog and ferret abundance. These efforts can be expanded into colonies identified by aerial imagery classification. Given the validation rates reported by Boulerice (2018a), we expect these imagery classifications are indicative of current prairie dog distribution with approximately 80% accuracy. These large-scale assessments of distribution can guide field efforts, saving time and resources as colony activity can be verified in a targeted manner. With potential habitat well within dispersal distances of ferrets, we suggest continued evaluation of aerial imagery over the SBRA. We acknowledge the shortcomings of using aerial imagery classification as the sole evaluation method, as it can be subjective and does not provide colony activity information (BFFRIT 2016). However, given the habitat availability in SBRA, imagery classification with targeted colony activity evaluation in the field is likely to provide the most cost-effective evaluation at a basin-wide scale.

In sum, all efforts completed in 2018 to monitor prairie dog populations at both ferret reintroduction areas in Wyoming represent significant contributions to the conservation and management of ferrets. Annual monitoring has been and will continue to be critical to understanding population trends in prairie dog populations at the MRA and SBRA, providing the means to detect and respond to population pressures with appropriate management actions. Similarly, disease management actions completed in 2018 continue to enable the newly established population of ferrets at the MRA to thrive in the wild in Meeteetse for the first time in decades.

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Table 1. Counts and densities of white-tailed prairie dogs (*Cynomys leucurus*) observed while surveying visual count plots established at the Meeteetse and Shirley Basin Reintroduction Areas in June-July 2018. Each plot was 9.88 acres (4 ha) in size. Prairie dogs were visually counted within each plot for 3 consecutive mornings ("Sessions") to find the greatest count ("High count") used to estimate density per ha ("Density") within each plot. "Percent change in density" indicates the percent change in density from 2017 and 2018 for each plot.

Plot	Session 1	Session 2	Session 3	High count	2018 density (acre)	2017 density (acre)	Percent change in density
Meeteetse Reintroduction Area							
1	0	0	0	0	0.00	5.97	-100%
2	20	37	26	37	3.74	3.34	+12.1%
3	6	4	6	6	0.61	4.15	-85.4%
4	16	26	31	31	3.14	1.21	+158.3%
5	15	25	31	31	3.14	5.06	-38%
6	6	14	17	17	1.72	1.32	+30.8%
7	11	7	11	11	1.11	1.01	+10%
8	5	18	5	18	1.82	1.62	+12.5%
9	54	41	36	54	5.46	3.34	+63.6%
10*	20	17	23	23	2.33	8.40	-72.3%
11**	7	8	12	12	1.21	-	-
12**	12	4	11	12	1.21	-	-
Shirley Basin Reintroduction Area							
1	40	31	26	40	4.05	3.44	+17.6%
2	12	7	12	12	1.21	1.11	+9.1%
3	21	23	18	23	2.33	2.33	0%
4	31	35	30	35	3.54	2.33	+52.2%
5	15	16	14	16	1.62	1.11	+45.5%
6	30	36	21	36	3.64	2.12	+71.4%
7	28	29	9	29	2.93	3.04	-3.3%
8	32	26	14	32	3.24	2.02	+60%
9	17	20	16	20	2.02	2.23	-9.1%
10	10	16	19	19	1.92	2.33	-17.4%
11	47	56	49	56	5.67	4.25	+33.3%
12	11	9	11	11	1.11	1.52	-26.7%
13	24	18	29	29	2.93	2.23	+31.8%
14	17	12	15	17	1.72	2.02	-15.0%
15	41	44	30	44	4.45	2.63	+69.2%

*Plot density in 2018 was likely influenced by flood irrigation following surveys in 2017.
**New plots added in 2018 to evaluate the influence of large-scale SPV application.

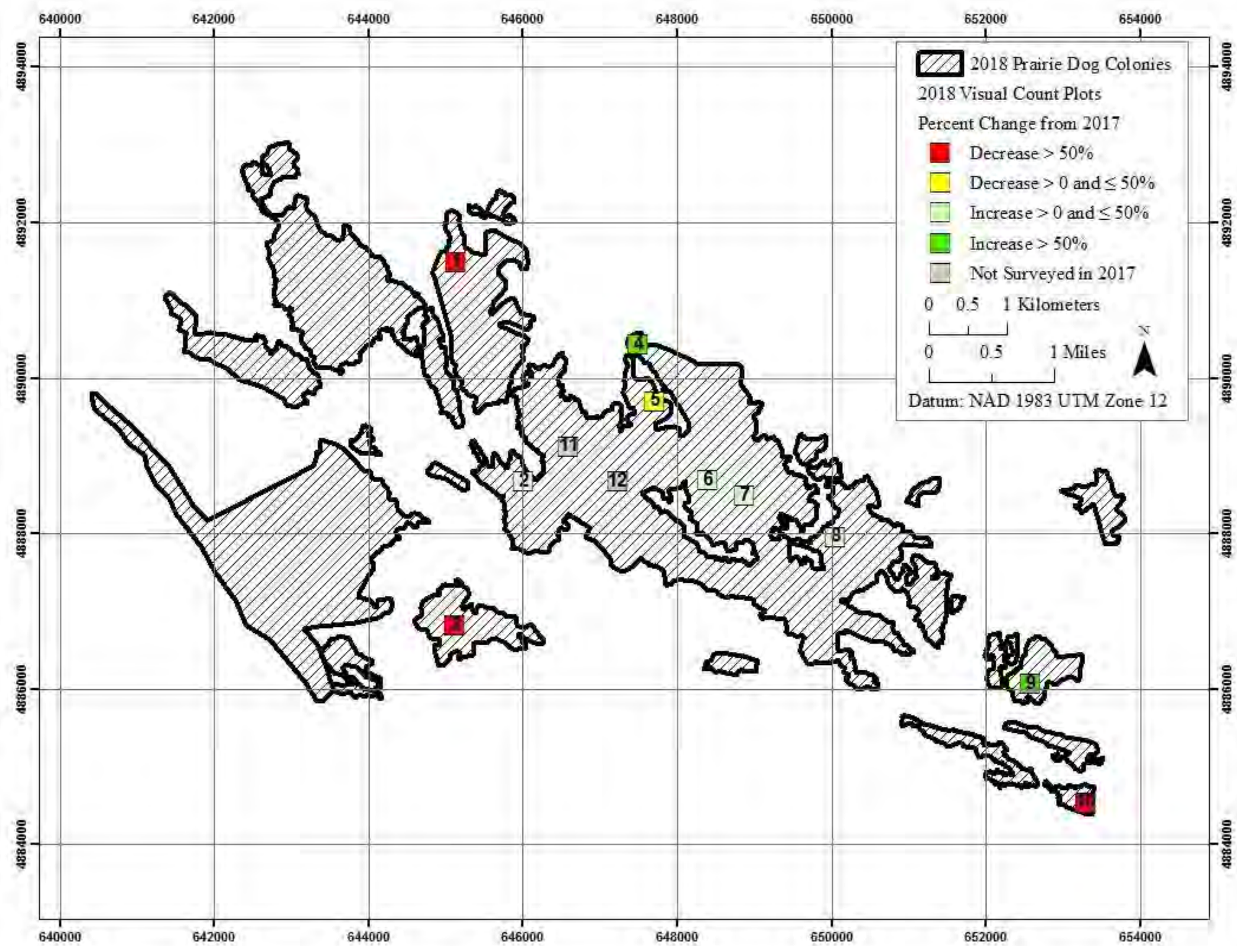

Figure 1. Percent change in white-tailed prairie dog (*Cynomys leucurus*) density for each visual count plot between surveys conducted in summer of 2017 and 2018 at the Meeteetse Reintroduction Area. Plots are numbered 1-12. Density values at each plot are presented in Table 1.

A)

B)

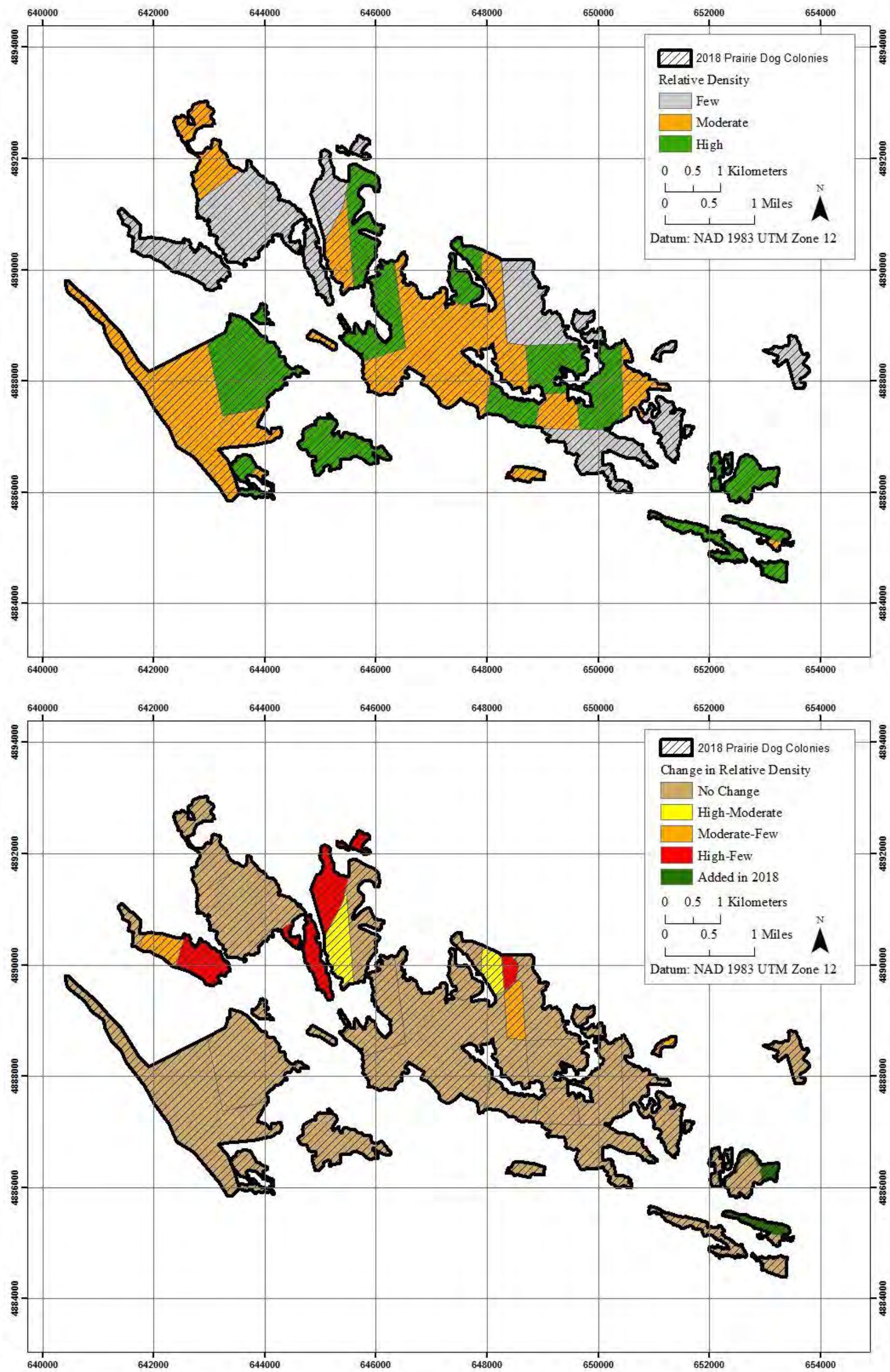

Figure 2. A) Spatial distribution of 3 classes of relative density of white-tailed prairie dogs (*Cynomys leucurus*) at the Meeteetse Reintroduction Area evaluated in June 2018 and B) Change in class of relative density of white-tailed prairie dogs from surveys first conducted in 2017.

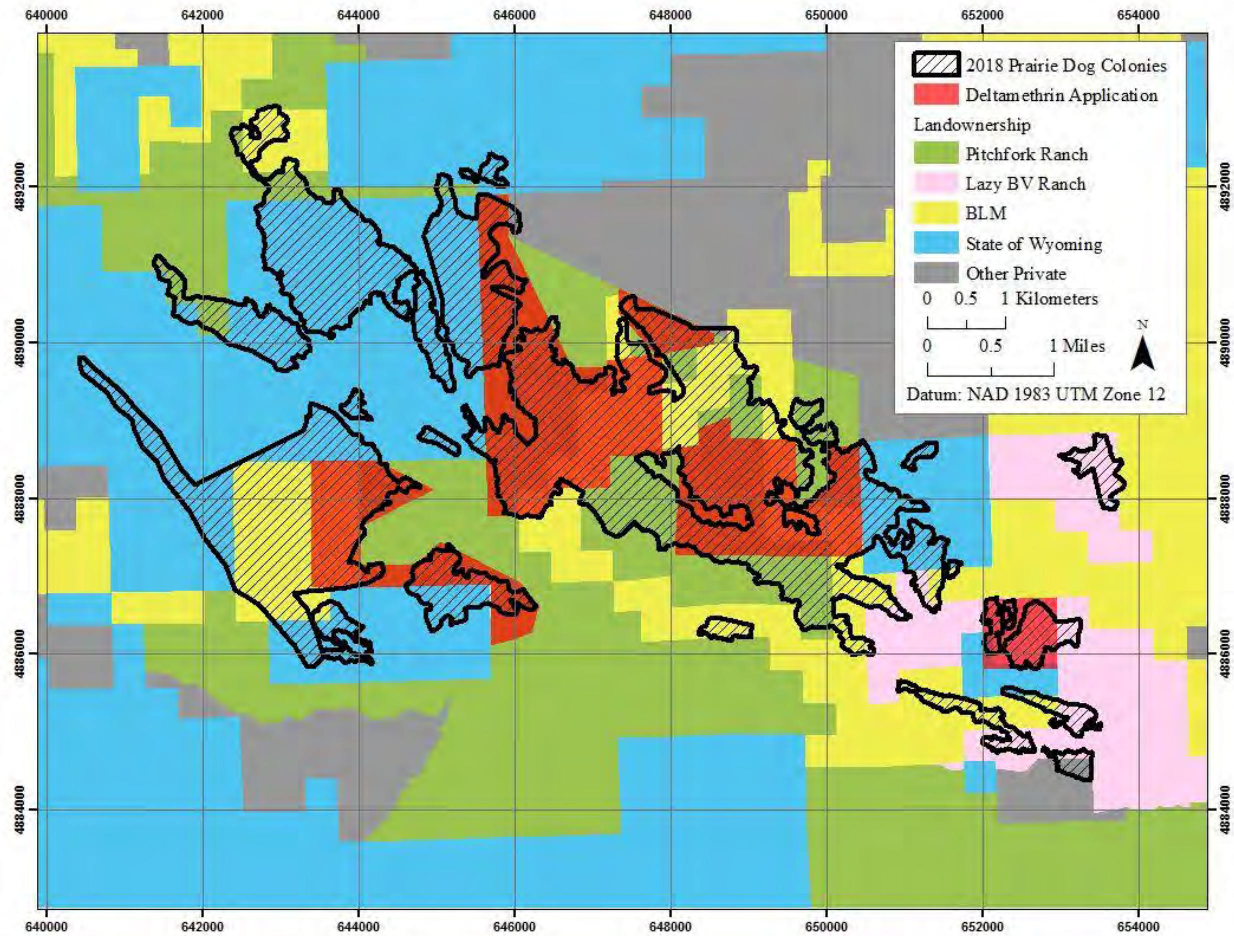

Figure 3. Extent of deltamethrin application from 1 June to 7 July 2018 at the Meeteetse Reintroduction Area. In total, deltamethrin was applied to 2,939 acres of private lands owned by Pitchfork and Lazy BV Ranches and BLM land. Areas selected for application encompassed either relatively high density of white-tailed prairie dogs (*Cynomys leucurus*), multiple observations of black-footed ferrets (*Mustela nigripes*) during the most recent monitoring efforts, portions of colonies previously treated with deltamethrin in 2016-17, or a combination thereof.

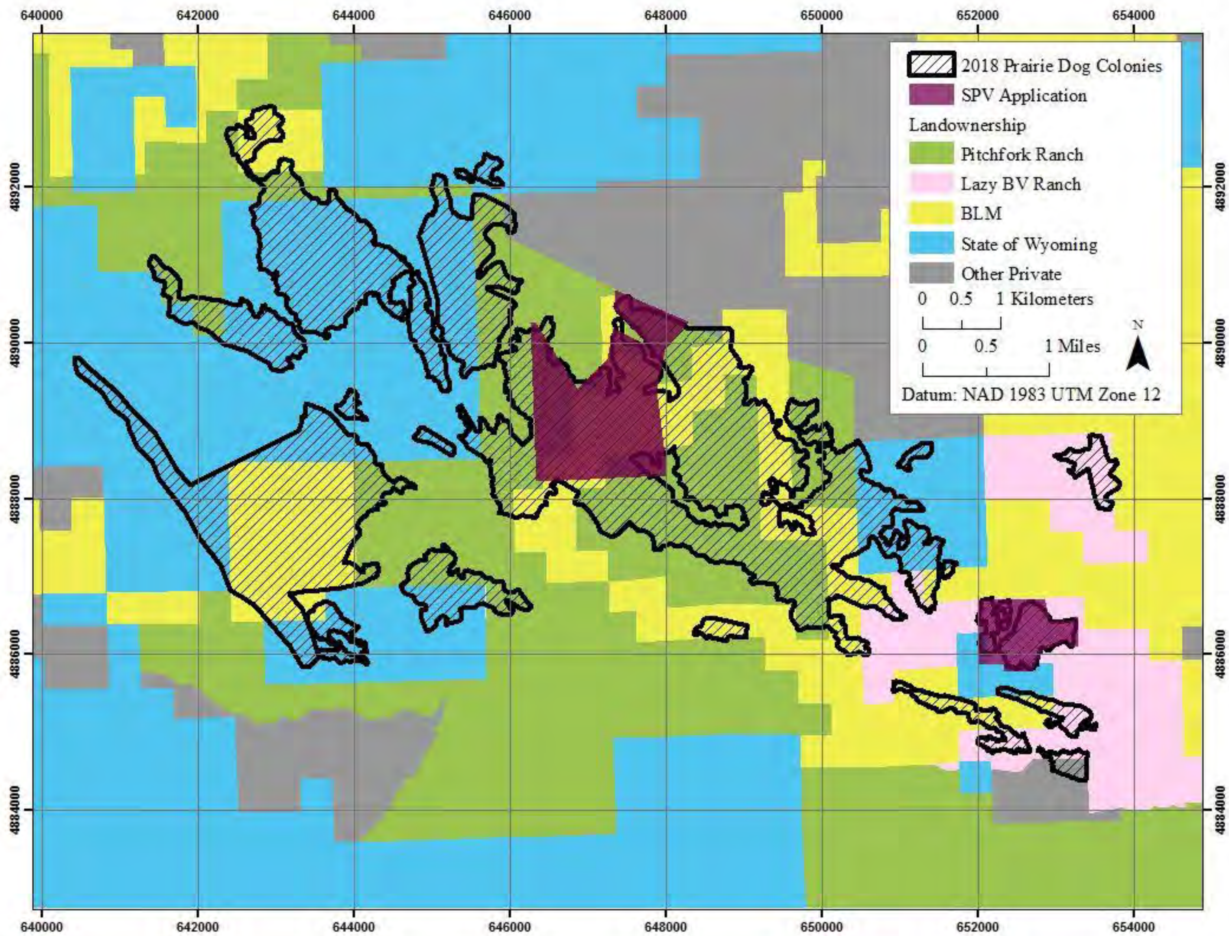

Figure 4. Extent of large-scale sylvatic plague vaccine (SPV) application from on 22 June 2018 at the Meeteetse Reintroduction Area. In total, SPV was applied to 956 acres of private lands owned by Pitchfork and Lazy BV Ranches and Bureau of Land Management land. Three metrics were established to enable the effectiveness of large-scale SPV usage at combating plague.

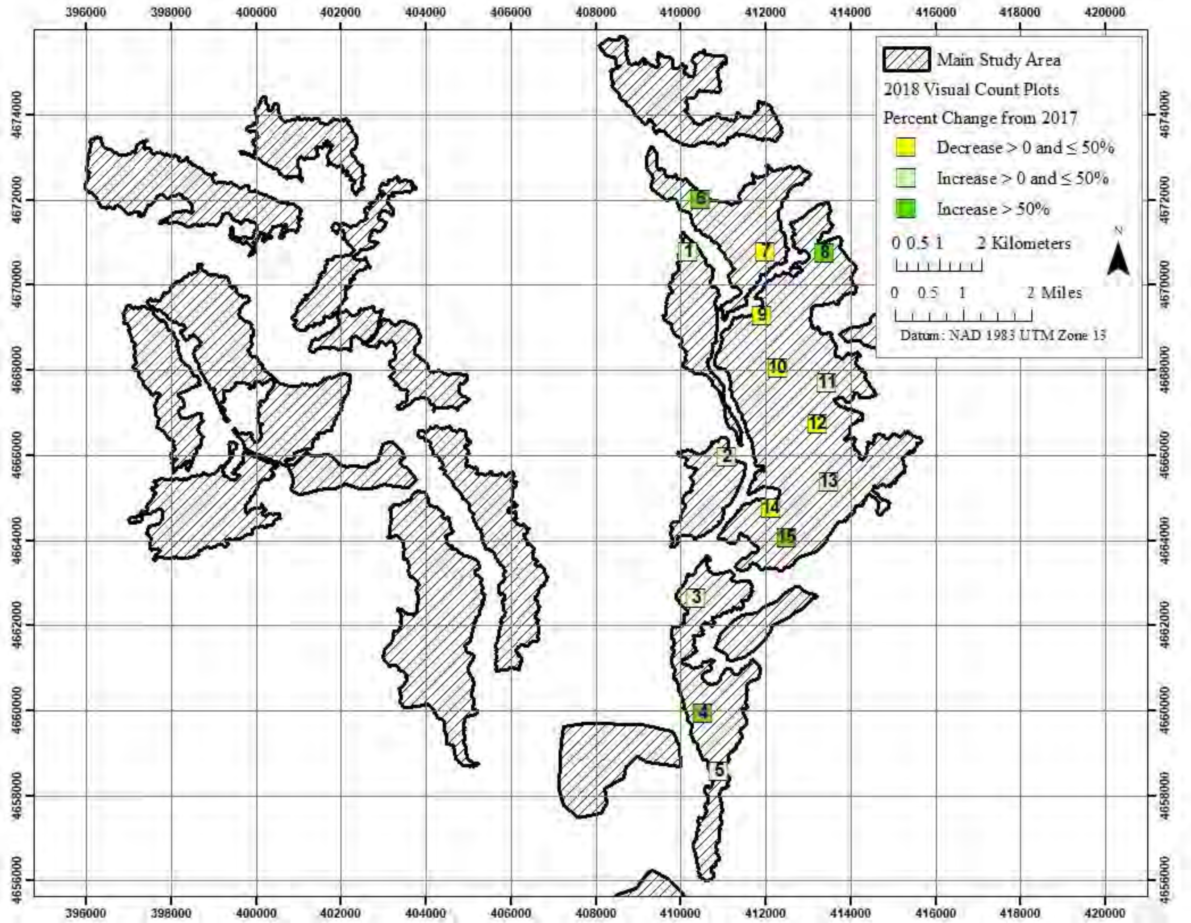

Figure 5. Percent change in white-tailed prairie dog (*Cynomys leucurus*) density for each visual count plot between surveys conducted in summer of 2017 and 2018 at the Shirley Basin Reintroduction Area. Plots are numbered 1-15. Density values at each plot are presented in Table 1.

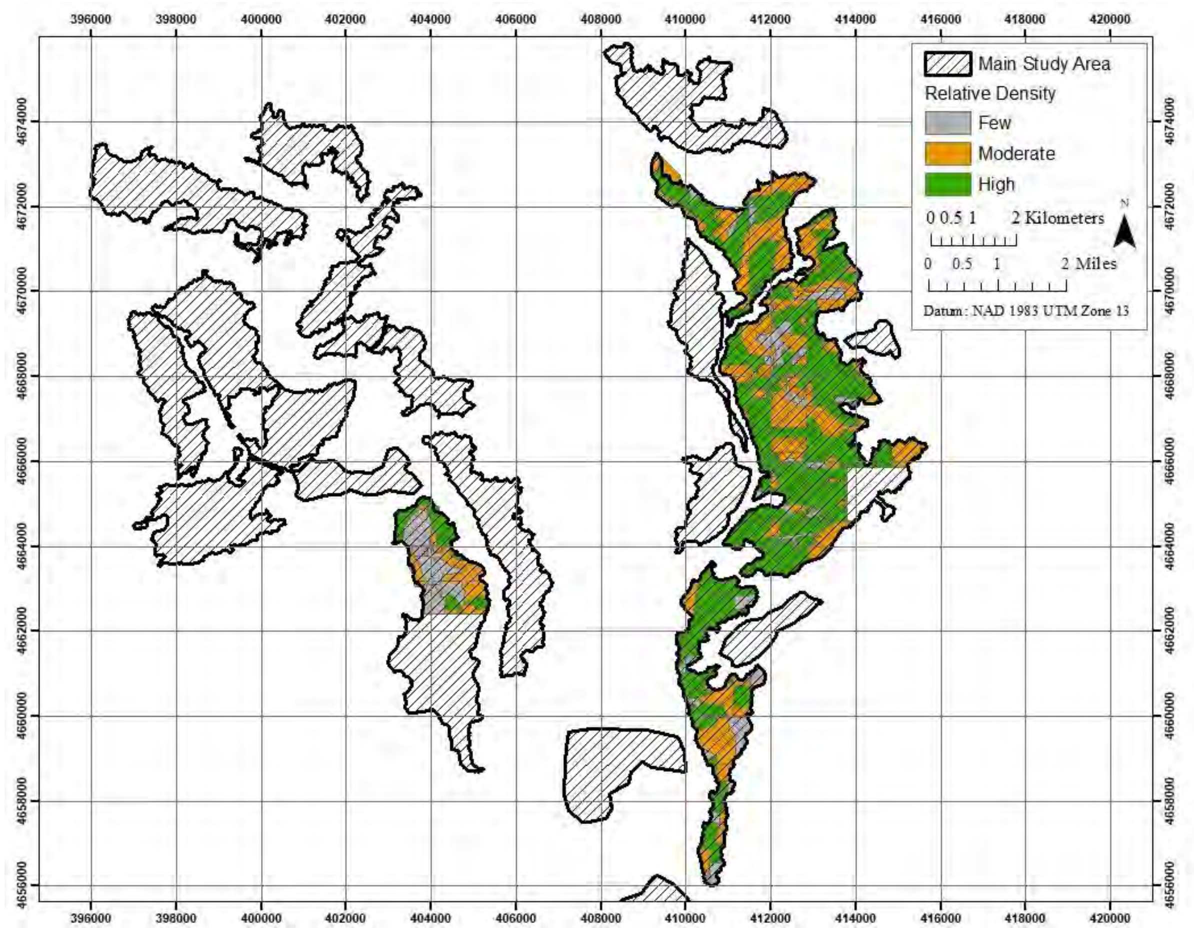

Figure 6. Spatial distribution of 3 classes of relative density of white-tailed prairie dogs (*Cynomys leucurus*) at the Shirley Basin Reintroduction Area evaluated in July 2018.

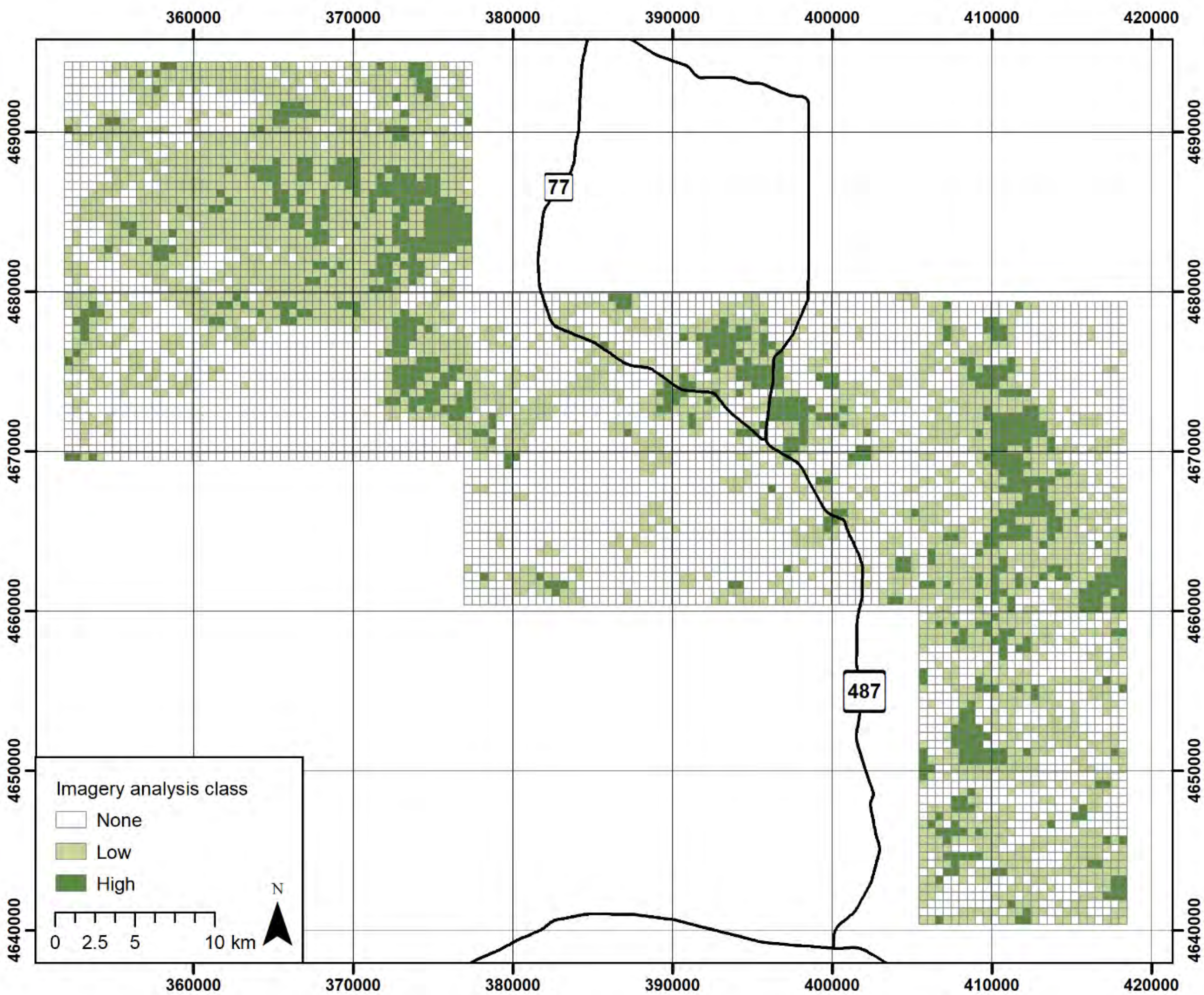

Figure 7. Results of the analysis of 2017 NAIP imagery used to assess large-scale distribution of white-tailed prairie dog (*Cynomys leucurus*) colonies at the Shirley Basin Reintroduction Area from assessments made in 2017 and 2018. Density classes were evaluated by ocular assessment of burrow density within 500 m × 500 m grid cells and include the classes: none (no prairie dog burrows visible), low (area covered with visible burrows is <50% of a cell), or high (area covered with visible burrows ≥50% of a cell).

THE USE OF ENVIRONMENTAL DNA FOR MONITORING BLACK-FOOTED FERRETS

STATE OF WYOMING

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

FUNDING SOURCE: Wyoming Game and Fish Department Commission Funds
Wyoming Governor's Big Game License Coalition

PROJECT DURATION: 1 July 2018 – 30 June 2019

PERIOD COVERED: 1 July 2018 – 30 June 2019

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist

SUMMARY

Environmental DNA (eDNA) is an emerging method for non-invasive surveys that has been successfully used to monitor both plant and wildlife species (e.g., Thomsen and Willerslev 2015, Matsuhashi et al. 2016, Franklin et al. 2019). Through this approach, trace amounts of DNA shed from wildlife in the form of feces, mucus, gametes, skin, hair, etc. is collected from the environment and analyzed using DNA laboratory identification methods to detect species. While this technique is commonly associated with aquatic systems (e.g., Young et al. 2013, Wilcox et al. 2016), the practice also can be used to evaluate samples from terrestrial environments, including eDNA collected from soils (e.g., Anderson et al. 2012, Bienert et al. 2012).

Black-footed ferrets (ferrets; *Mustela nigripes*) are a federally endangered species and a Species of Greatest Conservation Need in Wyoming (USFWS 1967, WGFD 2017). Ferrets are entirely dependent on prairie dogs (*Cynomys spp.*) both for food and shelter in the burrows they create (Hillman and Clark 1980). This dependence on the subterranean burrow system created by prairie dogs makes ferrets a good candidate to monitor through the collection of soil samples for eDNA analyses. Fortunately, ferret eDNA is likely to be concentrated on the landscape at prairie dog burrows, allowing for targeted sample collection. Because current detection techniques for ferrets, namely spotlight surveys, can be costly, time-consuming, and result in low detection rates, there has been a strong interest in developing other techniques that may allow for more efficient monitoring. A myriad of alternative techniques for detecting ferrets has been explored over recent decades, including snow tracking, track stations, remote cameras, and scent detection dogs (Biggins et al. 2004, Reindl-Thompson et al. 2006). Environmental DNA could provide one more technique with which to detect and monitor ferrets.

In 2018, the Wyoming Game and Fish Department (Department) initiated a project to evaluate the potential to use eDNA to detect and monitor ferrets. We collected approximately 1/2 cup of soil from prairie dog burrows where ferrets had been observed. Soil was collected from as far down the burrow as possible in order to collect soil that had not been exposed to direct sunlight, moisture, wind, etc., which can degrade eDNA. All equipment used to collect samples was sanitized with Nolvasan between collections. We transferred the soil to plastic bags and stored all samples in a -20°C freezer. Before submitting samples for analysis, we transferred 10-15 ml of soil into a centrifuge tube, which was then sent to Sirona Dx (Lake Oswego, OR) to develop laboratory analysis techniques to extract eDNA from soil samples, specifically to detect the presence of ferrets. Tissue samples from 2 ferret carcasses and 2 white-tailed prairie dog (*C. leucurus*) carcasses were also collected and submitted to Sirona Dx to serve as reference samples. Laboratory analysis methods are described in the final report provided by Sirona Dx (Appendix 1).

We collected soil samples from 24 prairie dog burrows for analysis: 14 samples were collected from burrows at the Meeteetse Reintroduction Area, and 10 samples were collected from the National Black-footed Ferret Conservation Center (NBFFCC) in Wellington, CO (Table 1). All samples from Meeteetse were collected from burrows where ferrets had been observed via routine spotlighting efforts. Samples from the NBFFCC were collected from pre-conditioning pens used by captive-born ferrets prior to release. Staff at the NBFFCC know exactly how many ferrets used a burrow within a given year, and, given the confined area of the pen, burrow use is likely to be more intense than might be expected in natural conditions.

Of the 24 soil samples collected, 9 were positive for ferrets: 7 positive detections were from samples collected at Meeteetse (50% of samples collected at this site), and 2 positive detections were from samples collected at the NBFFCC (20% of samples collected at this site; Tables 1 and 2). Eleven other species were also detected in soil samples, representing 10 mammalian and 1 avian species (Table 2).

Many non-target species that were detected through eDNA were expected at our sites, including *Homo sapiens*, *Taxidea taxus*, *Odocoileus virginianus*, and *Canis sp.* Several domestic species, including pigs (*Sus scrofa*), cattle (*Bos taurus*), and chickens (*Gallus gallus*), are also known to be present as near as 2 km from the eDNA sampling locations and are thus plausible. As expected, prairie dogs were often confirmed in soil samples. In fact, prairie dogs were confirmed in all soil samples except for 1, and this particular burrow had confirmed ferret use (S016001). However, the confirmation of white-tailed prairie dogs at the NBFFCC were surprising, since the facility is located in the middle of a black-tailed prairie dog (*C. ludovicianus*) colony. The detection of black-tailed prairie dogs and golden hamsters (*Mesocricetus auratus*) at Meeteetse, a white-tailed prairie dog site, may be explained by the concurrent supplemental releases of ferrets who had fed on these species before being released. Perhaps the most surprising detection was that of the oldfield deermouse (*Peromyscus polionotus*), a species not found in Wyoming and whose range is restricted to the extreme southeastern US. Also known as the beach mouse, it is almost certainly not present at Meeteetse; instead, because our effort focused specifically on ferrets, it is more likely that the genetic analyses was not precise enough to detect below the genus level on anything other than our target species. If that is the case, *P. maniculatus* is quite abundant at Meeteetse (Boulerice 2017), which would explain its detection through eDNA and could potentially explain the mismatched detections of prairie dog species.

Ferrets were known to have been present in all 14 burrows for which soil samples were collected at the MRA, but only 7 resulted in positive detections via eDNA analyses. Additionally, only 2 of 10 samples collected from the NBFFCC resulted in positive detection of ferrets via eDNA analyses, although ferret use was expected to be more intense at this site. Interestingly, although one of these positive samples was collected from a burrow with a lot of documented use from 2014-2017, the other was collected from a burrow with no documented use since 2015. Overall, results confirm it is possible to detect eDNA of ferrets in soil samples, but given that 100% of samples should have come back positive for ferret presence, a success rate of 38% is somewhat disappointing. This low success could be due to a number of factors. For example, ferrets may behave differently in different burrows, which could affect the amount of trace DNA left behind to be collected. Additionally, although we standardized our soil collection methods in an attempt to minimize degradation of eDNA, it may be possible to further modify collection techniques to increase the success of collecting usable eDNA. Finally, the technology currently available to evaluate eDNA in soil samples may simply not be advanced enough at this time to detect ferrets reliably. If technology improves, we would suggest working with an additional, independent laboratory to re-evaluate this method.

Should eDNA prove to be a more robust detection tool in the future, it will likely still need to be coupled with alternative detection techniques. Prairie dog burrows can be quite numerous within colonies, and ferrets are unlikely to use every burrow available, so a randomized protocol for sample collection is likely to result in many negative detections. Instead, sample collection should focus on areas where surveyors have a reason to believe ferrets are present, such as previous ferret detections from surveys utilizing spotlighting or scent detection dogs. If laboratory success rates improve to the point where eDNA can be used in the future as a tool to verify ferret presence, it will be important to evaluate the detection probability of this versus other verification techniques (e.g., remote cameras) as well as the financial feasibility of implementation at a large scale.

ACKNOWLEDGEMENTS

This project was funded by the Wyoming Game and Fish Commission and the Wyoming Governor's Big Game License Coalition. J. Boulerice, former Nongame Biologist with the Department, spearheaded and coordinate this effort and collected soil samples at Meeteetse. We also thank the staff at the NBFFCC, particularly T. Tretten, for assistance with collecting tissue samples from ferrets to provide a baseline for which to compare eDNA in soil samples as well as for collecting soil samples at the NBFFCC.

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Table 1. Summary and details of burrow use for all soil samples collected to evaluate the presence of environmental DNA (eDNA) of black-footed ferrets (*Mustela nigripes*). Samples were collected from the Meeteetse Reintroduction Area (MRA) and pre-conditioning pens at the National Black-footed Ferret Conservation Center (NBFFCC) in Wellington, CO. Burrow history numbers (only available for the NBFFCC) represent the number of individual ferrets known to use the burrow from which the sample was collected. Samples for which ferrets were positively detected through eDNA analysis are noted by an asterisk.

Sample ID	Date ferret last observed in burrow	Date sample collected	Location	Comments	Burrow history				
					2018	2017	2016	2015	2014
S016000*	7-Sep-17	7-Sep-17	MRA	Adult male - only ferret in burrow					
S016001*	5-Sep-17	5-Sep-17	MRA	Adult female - only ferret in burrow					
S016002	7-Sep-17	7-Sep-17	MRA	Juvenile male - only ferret in burrow					
S016010*	5-Sep-17	5-Sep-17	MRA	Juvenile male - single ferret in burrow, other ferrets nearby					
S016011*	6-Sep-17	6-Sep-17	MRA	Adult female - single ferret in burrow, 2 kits nearby					
S016012	5-Sep-17	5-Sep-17	MRA	Adult female - single ferret in burrow, 2 kits nearby					
S016020	3-Sep-17	3-Sep-17	MRA	Juvenile female - 2 ferrets in same burrow					
S016021*	5-Sep-17	5-Sep-17	MRA	Adult male - only ferret in burrow					
S016022*	5-Sep-17	5-Sep-17	MRA	Juvenile female - only ferret in burrow					
S016030*	7-Sep-17	7-Sep-17	MRA	Juvenile - only ferret in burrow					
S016031	14-Sep-17	14-Sep-17	MRA	Ferret observed but not captured					

Table 1. Continued.

Sample ID	Date ferret last observed in burrow	Date sample collected	Location	Comments	Burrow history				
					2018	2017	2016	2015	2014
S016032	14-Sep-17	14-Sep-17	MRA	Ferret observed but not captured					
S016040	14-Sep-17	14-Sep-17	MRA	Ferret observed but not captured					
S016041	14-Sep-17	14-Sep-17	MRA	Ferret observed but not captured					
S016042	16-Nov-17	2-May-18	NBFFCC		0	2	3	0	0
S016050*	30-Apr-18	3-May-18	NBFFCC	A lot of ferret use 2014-2017	1	10	10	11	6
S016051	16-Oct-17	4-May-18	NBFFCC		0	1	1	5	2
S016052	3-Nov-17	5-May-18	NBFFCC	A lot of ferret use 2014-2017	0	9	10	5	11
S016060	26-Apr-18	6-May-18	NBFFCC		1	9	2	6	8
S016061	2-Nov-17	7-May-18	NBFFCC		0	1	1	2	5
S016062	14-Oct-17	8-May-18	NBFFCC		0	4	9	1	1
S016070*	2-Nov-15	9-May-18	NBFFCC		0	0	0	2	12
S016071	7-Apr-18	10-May-18	NBFFCC	A lot of ferret use 2014-2017	1	6	10	7	8
S016072	4-Nov-17	11-May-18	NBFFCC	A lot of ferret use 2014-2017	0	11	11	10	10

Table 2. Results of genetic analysis to detect environmental DNA (eDNA) of ferrets in soil samples. Numbers represent the certainty of presence of each species, with higher numbers representing higher certainty; numbers ≥20 indicate positive detections. Sample ID is further described in Table 1. Species codes are as follows:

MUNI – *Mustela nigripes* (black-footed ferret); CYLE – *Cynomys leucurus* (white-tailed prairie dog); CYLU – *C. ludovicianus* (black-tailed prairie dog); SUSC – *Sus scrofa* (wild boar); BOTA – *Bos taurus* (domestic cattle); PEPO – *Peromyscus polionotus* (oldfield deermouse); HOSA – *Homo sapiens* (human); TATA – *Taxidea taxus* (American badger); GAGA – *Gallus gallus* (chicken); CASP – *Canis sp.* (dog species); MEAU – *Mesocricetus auratus* (golden hamster); and ODVI – *Odocoileus virginianus* (white-tailed deer).

Sample ID	MUNI	CYLE	CYLU	SUSC	BOTA	PEPO	HOSA	TATA	GAGA	CASP	MEAU	ODVI
7725_Chippewa_ Female_*M.nigripes*	3,265	19	0	0	0	0	0	0	0	0	0	0
Ferret_2_709	0	0	7,113	0	0	0	0	0	0	0	0	0
Ferret_3_700	0	0	3,402	0	0	0	0	0	0	0	0	0
Ferret_4_701	0	0	3,777	0	0	0	0	0	0	0	0	0
Prairie_dog_1	0	767	0	0	0	0	0	0	0	0	0	0
Prairie_dog_2	0	3,189	0	0	0	0	0	0	0	0	0	0
S016000	48	210	76	2	0	0	2	0	0	0	0	0
S016001	66	0	0	0	0	0	0	0	0	0	0	0
S016002	0	60	659	0	0	0	0	0	0	0	0	0
S016010	1,507	124	188	0	0	0	0	0	0	0	0	0
S016011	191	0	62	0	0	0	0	0	69	0	59	0
S016012	0	0	141	0	0	178	0	0	0	60	0	0
S016020	1	12	276	0	0	0	0	0	0	0	0	0
S016021	42	0	498	0	0	141	0	0	0	0	0	0
S016022	493	1,773	413	0	0	72	0	0	0	0	0	0
S016030	448	266	1,722	0	0	0	0	0	0	0	0	0
S016031	0	448	0	0	0	0	0	0	0	0	0	0
S016032	15	69	0	0	0	0	23	0	0	0	0	0

Table 2. Continued.

Sample ID	MUNI	CYLE	CYLU	SUSC	BOTA	PEPO	HOSA	TATA	GAGA	CASP	MEAU	ODVI
S016040	2	2,155	3,710	0	61	0	0	0	0	0	0	0
S016041	0	481	0	0	0	0	0	0	0	0	0	58
S016042	0	907	0	0	0	0	0	0	0	0	0	0
S016050	160	1,675	0	0	0	0	0	147	0	0	0	0
S016051	0	1,795	0	0	305	0	0	0	0	0	0	0
S016052	2	1,069	0	1	49	0	0	0	0	0	0	0
S016060	0	2,642	0	0	0	0	0	0	0	0	0	0
S016061	0	2,834	1	0	0	0	0	0	0	0	0	0
S016062	0	641	0	0	0	0	0	0	0	0	0	0
S016070	89	1,005	569	0	0	0	318	0	0	0	0	0
S016071	0	2,198	0	0	0	0	0	0	0	0	0	0
S016072	0	280	0	123	0	0	0	0	0	0	0	0
Wild_male_*M.nigripes*	6,224	2	0	0	0	0	0	0	0	0	0	0

Appendix 1. Laboratory methods for black-footed ferret (*Mustela nigripes*) environmental DNA extraction from soil samples.

Sirona Dx

Study for
Wyoming Game and Fish Department
528 South Adams Street
Laramie, WY 82070
518-420-7643

The development of a presence/absence Sequencing assay to determine if the Black-Footed ferret is active in habitat location using soil samples.

Summary of Study:

Project Report Summary:

1. **Assay Design:** The development of a qPCR assay to determine if the Black-Footed Ferret is active in the location where samples were collected was found to be challenging in terms of specificity and sensitivity as compared to an NGS analysis of the DNA samples.
2. **Validation:** We used an NGS sequencing method for the extracted DNA from soil samples. An added benefit of the NGS assay is that it can identify the presence / absence of other species.
3. **Extraction Methodology:** We developed an effective extraction method to isolate DNA from soil samples
4. **Testing:** We utlized the NGS sequencing assay in conjunction with the optimized sample extraction method to monitor soil samples and identify positive samples. See SEQ REPORT tab.
5. **Testing of X number of samples:** We tested 24 soil samples and 6 known tissue samples

Samples ID Table:

Sample Number	Sample ID	Scintillation vial barcode #	Pit Tag	Date Ferret Last Observed in Burrow	Date Sample Collected	Location	Comments
1	MRA	1	S016000	9/7/2017	9/7/2017	Meeteetse, Wyoming	Adult, Male. only ferret in burrow
2	MRA	2	S016001	9/5/2017	9/5/2017	Meeteetse, Wyoming	Adult, female. only ferret in burrow
3	MRA	3	S016002	9/7/2017	9/7/2017	Meeteetse, Wyoming	Juvenile, male. only ferret in burrow
4	MRA	4	S016010	9/5/2017	9/5/2017	Meeteetse, Wyoming	Juvenile, male. Single ferret in burow, other ferrets nearby
5	MRA	5	S016011	9/6/2017	9/6/2017	Meeteetse, Wyoming	Adult, Female. Single ferret in burrow, 2 other ferrets (kits) nearby
6	MRA	6	S016012	9/5/2017	9/5/2017	Meeteetse, Wyoming	Adult, Female. Single ferret in burrow, 2 other ferrets (kits) nearby
7	MRA	7	S016020	9/3/2017	9/3/2017	Meeteetse, Wyoming	Juvenile, Female. 2 ferrets in same burrow
8	MRA	8	S016021	9/5/2017	9/5/2017	Meeteetse, Wyoming	Adult, Male, only ferret in burrow
9	MRA	9	S016022	9/5/2017	9/5/2017	Meeteetse, Wyoming	Juvenile, female. only ferret in burrow
10	MRA	10	S016030	9/7/2017	9/7/2017	Meeteetse, Wyoming	Juvenile, kit. only ferret in burrow
11	MRA	11	S016031	9/14/2017	9/14/2017	Meeteetse, Wyoming	Ferret observed but not captured
12	MRA	12	S016032	9/14/2017	9/14/2017	Meeteetse, Wyoming	Ferret observed but not captured
13	MRA	13	S016040	9/14/2017	9/14/2017	Meeteetse, Wyoming	Ferret observed but not captured
14	MRA	14	S016041	9/14/2017	9/14/2017	Meeteetse, Wyoming	Ferret observed but not captured
A2	NBFFCC	A2	S016042	11/16/2017	5/2/2018	USFWS Captive Breeding Facility, Wellington, CO	
A10	NBFFCC	A10	S016050	4/30/2018	5/3/2018	USFWS Captive Breeding Facility, Wellington, CO	Lots of ferret use 2014-2017
B7	NBFFCC	B1	S016051	10/16/2017	5/4/2018	USFWS Captive Breeding Facility, Wellington, CO	
B12	NBFFCC	B12	S016052	11/3/2017	5/5/2018	USFWS Captive Breeding Facility, Wellington, CO	Lots of ferret use 2014-2017
C1	NBFFCC	C1	S016060	4/26/2018	5/6/2018	USFWS Captive Breeding Facility, Wellington, CO	
C7	NBFFCC	C7	S016061	11/2/2017	5/7/2018	USFWS Captive Breeding Facility, Wellington, CO	
C10	NBFFCC	C10	S016062	10/14/2017	5/8/2018	USFWS Captive Breeding Facility, Wellington, CO	
C11	NBFFCC	C11	S016070	11/2/2015	5/9/2018	USFWS Captive Breeding Facility, Wellington, CO	
D2	NBFFCC	D2	S016071	4/7/2018	5/10/2018	USFWS Captive Breeding Facility, Wellington, CO	Lots of ferret use 2014-2017
D12	NBFFCC	D12	S016072	11/4/2017	5/11/2018	USFWS Captive Breeding Facility, Wellington, CO	Lots of ferret use 2014-2017

Methods:

1. Sample Processing and loading protocol:

Sample barcodes were recorded and assigned a well within the 96-well plate under a laminar flow hood, sterile tweezers and pliers were used to remove a small piece (0.25 grams) of tissue sample. The tissues were placed in the corresponding well. Plates were immediately processed.

2. Extraction: Plate Extraction Protocol (DNeasy)

Genomic DNA from samples was extracted using an optimized protocol of the DNeasy PowerSoil HTP 96 Kit. Approximately 0.25 grams of sample was used for genomic DNA extraction. Genomic DNA was eluted into 100µl and frozen at -20°C.

3. PCR 2-step Protocol:

Forward primer: ACTGGGATTAGATACCCCACTATG
Reverse primer: GAGAGTGACGGGCGGTGT Primer
notes: Ac12SF, Ac12SR

A portion of the Actinopterygii rRNA 12S gene (Ac12S) was PCR amplified. Both forward and reverse primers also contained a 5' adaptor sequence to allow for subsequent indexing and Illumina sequencing. Each 25 µL PCR reaction was mixed according to the Promega PCR Master Mix specifications which included 12.5ul Master Mix, 0.5 µl of each primer, 1.0 µl of gDNA, and 10.5 µl DNase/RNase-free H2O. DNA was PCR amplified using the following conditions:

initial denaturation at 94 °C for 3 minute, followed by 45 cycles of 30 seconds at 94 °C, 30 seconds at 52 °C, and 1 minute at 72 °C, and a final elongation at 72 °C for 10 minutes.

4. Gel Electrophoresis Protocol

To determine amplicon size and PCR efficiency, each reaction was visually inspected using a 2% agarose gel with 5µl of each sample as input.

5. PCR Amplicon Clean-up using Exo1/SAP protocol

Amplicons were then cleaned by incubating amplicons with Exo1/SAP for 30 minutes at 37 °C following by inactivation at 95 °C for 5 minutes and stored at -20°C.

6. Barcoding PCR Protocol

A second round of PCR was performed to give each sample a unique 12-nucleotide index sequence. The indexing PCR included Promega Master mix, 0.5 µM of each primer and 2 µl of template DNA (cleaned amplicon from the first PCR reaction) and consisted of an initial denaturation of 95 °C for 3 minutes followed by 8 cycles of 95 °C for 30 sec, 55 °C for 30 seconds and 72 °C for 30 seconds.

7. Gel Electrophoresis Protocol

5µl of indexing PCR product of each sample were visualized on a 2% agarose gel to ensure the success of the barcoding PCR.

8. PCR Normalization and Pooling Protocol

Final indexed amplicons from each sample were cleaned and normalized using SequalPrep Normalization Plates. Samples are then pooled together by adding 5µl of each normalized sample to the pool.

9. Sequencing 500-cycle Protocol

Sample library pools were sent for sequencing on an Illumina MiSeq. Necessary quality control measures were performed prior to sequencing.

10. Bioinformatics Protocol

The following table summarizes how the Ac12S amplicons were processed via a joint QIIME pipeline. with the following modification;
Sequences were demultiplexed by taking advantage of Golay barcodes via QIIME. The following options were used to output raw unfiltered fastq files for both forward and reverse reads:
Primer sequences were trimmed in 'paired-end mode' to remove the primers. Trimmed paired-ends where then merged. From here, the general quality filtering and OTU construction was completed, with the following modifications:

- OTUs were generated by clustering the reads at 99% sequence similarity,
- The OTU table was generated by mapping quality filtered reads back to the OTU seeds by performing an exhaustive search
- This ensures that individual reads are correctly mapped to their respective OTUs.
- Taxonomy was assigned by recording the top BLAST hit for any sequence in which the query coverage and identity exceeded 95% and 80% respectively.
- GenBank was used as the reference database.
- Any OTUs with taxonomy assignments not meeting these criteria were removed from the OTU table.

PILOT STUDY TO EVALUATE THE EFFECTIVENESS OF SCENT DETECTION DOGS FOR MONITORING BLACK-FOOTED FERRETS

STATE OF WYOMING

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

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ABSTRACT

Monitoring and management of black-footed ferrets (*Mustela nigripes*) in Wyoming and throughout the range of the species has relied primarily on a single technique: spotlight surveys. While spotlight surveys are currently considered the most effective method for detecting ferrets, the technique suffers from low detection rates, difficulties in implementation, high costs, and limited spatial scale. As the Wyoming Game and Fish Department strives to meet recovery goals for ferrets in Wyoming, a monitoring program based solely on spotlight survey methods may not be sustainable. Scent detection dogs have been used to survey a variety of plant and wildlife species in recent decades and have previously shown potential utility as a tool to detect ferrets. In 2017 and 2018, the Department conducted a pilot project to evaluate the effectiveness of dogs for monitoring ferrets at the Meeteetse Reintroduction Area. We worked in partnership with a professional scent detection dog organization (Working Dogs for Conservation, Bozeman, MT), who trained dogs and performed all surveys. We developed metrics to evaluate whether dogs could successfully locate prairie dog (*Cynomys* spp.) burrows that contained ferrets and identify areas of use by ferrets. Remote cameras detected ferret presence at 33 burrows where dogs indicated and detected 2 unique ferrets not counted in spotlight surveys. We found that 67% of dog indications fell ≤250 m of a known ferret location, and 44% of all indications were ≤100 m of a ferret. Dog-based surveys overcome many of the challenges associated with spotlight surveys, particularly in terms of improved search rate and systematic coverage of large areas. These results suggest scent detection dogs are an effective tool for assessing ferret presence-

absence and, in conjunction with spotlight survey methods, can contribute to more streamlined monitoring of ferret populations.

INTRODUCTION

Since the discovery of a single extant population of black-footed ferrets (ferrets; *Mustela nigripes*) in 1981 near Meeteetse, involvement of the Wyoming Game and Fish Department (Department) in ferret recovery and monitoring has been essential to the reestablishment of ferrets in the wild. Since 1991, Wyoming has been inhabited by the first reintroduced population of ferrets in the world at the Shirley Basin Reintroduction Area (SBRA) where regular monitoring has confirmed that the species has persisted for >25 years (e.g., Grenier 2008, Van Fleet and Grenier 2011, Boulerice and Grenier 2014, Boulerice 2016). In 2016, the Department again made further progress toward ferret recovery by reintroducing ferrets back to Meeteetse (Meeteetse Reintroduction Area; MRA), where short-term post-establishment surveys have suggested that the population was successfully surviving and reproducing in the wild at this historic location (Boulerice 2017, 2018a; Nelson 2019). The success of both these reintroduction sites are founded in efforts dedicated to regular monitoring conducted by the Department on an annual basis. However, in order for Wyoming's contributions to ferret recovery to continue to expand, current monitoring techniques may need to be reevaluated and adapted.

Monitoring and management of ferret populations throughout western North America has historically relied primarily on a single monitoring technique for detecting this notoriously elusive species. Specifically, spotlight surveys are conducted by repeatedly navigating throughout portions of prairie dog (*Cynomys* spp.) colonies using high-powered handheld or vehicle mounted spotlights to attempt to detect ferrets aboveground during night hours (Biggins et al. 2004, Grenier et al. 2009, BFFRIT 2016). Managers employ annual spotlight surveys to monitor reintroduced populations, an approach that is currently considered "the most efficient and effective way to monitor black-footed ferrets" by the USFWS (BFFRIT 2016). The Department has utilized spotlighting to survey for ferrets within the SBRA since the populations was first established in 1991 to regularly survey 4,000-6,000 ha of prairie dog colonies per year (e.g., Luce et al. 1994, Luce 1997, Van Fleet and Grenier 2009, 2011; Boulerice and Grenier 2014; Boulerice 2016). Similarly, as of 2016, spotlighting is used to survey 2,000-4,000 ha annually at the MRA (Boulerice 2017, 2018a; Nelson 2019).

While spotlight surveys are currently considered the most effective method for detecting ferrets, the technique suffers from low detection rates, difficulties in implementation, high costs, and limited spatial scale. Studies from the reintroduction area for ferrets in Conata Basin, South Dakota found the probability of detection using spotlight surveys for male and female ferrets to be <60% and 75% respectively during the fall months when ferret surveys typically occur (Eads et al. 2012). Similarly, preliminary analysis of 10 years of monitoring data from the SBRA suggested occupancy-based detection rates can be as low as 30-40% for both sexes combined, with lower rates expected during years when ferret abundance was reduced (J. Boulerice, unpublished data). Reasons for failing to detect a ferret when present using the spotlight survey technique are numerous, as many factors influence surveyor ability to detect ferrets as well as ferret activity and ability to be observed (Boulerice 2018b). In addition to relatively low detection rates, resources consistently limit the time and costs associated with annual monitoring, as spotlight surveys require 1 person to spend three 8-10 hour nights surveying per 100-200 ha. For these reasons, the Department is able to survey only a small portion (i.e., <10%) of the approximately 60,000 ha of potential habitat for ferrets in the SBRA each year. With the addition of a 2nd reintroduction site at MRA in 2016, limited resources must be divided to ensure sufficient monitoring occurs for both populations of ferrets in Wyoming. Failure to obtain comprehensive annual estimates of ferrets in either SBRA or MRA precludes the Department from monitoring population trends and prevents an accurate count of ferrets present to achieve federal and state recovery and delisting goals (USFWS 2013, WGFC 2018). As such, the spotlight survey approach as the sole method for monitoring ferret populations in Wyoming may not be sustainable, especially as the Department pursues additional reintroduction sites as recommended in the management plan for ferret recovery (WGFC 2018).

Given the limitations of spotlight surveys, interest in developing other techniques that may allow for more effective monitoring of ferret populations has been generated not only within the Department, but also across agencies tasked with managing reintroduction sites nationwide (BFFRIT 2016). A myriad of alternative techniques for surveying ferrets has been explored over the past several decades, many of which have been found to be less effective than spotlight surveys, including snow tracking, track stations, and camera traps (Luce et al. 1994, Biggins et al. 2004). However, 1 technique that has received brief attention and may hold promise is the use of scent detection dogs (hereafter, dogs) as a tool for ferret monitoring. Professionally trained dogs have been used effectively for decades for wildlife-related research, spanning species such as endangered whales (Rolland et al. 2006, Ayres et al. 2012), bears (Wasser et al. 2004), foxes (Smith et al. 2003), invasive snakes (Engeman et al. 1998), desert tortoises (Cablk and Healton 2005), Franklin's ground squirrels (Duggan 2011), and importantly, ferrets (Reindl-Thompson et al. 2006). Previous efforts to evaluate the use of dogs for monitoring ferrets suggested that dogs could produce greater ferret detection rates while also decreasing the time and personnel investment needed to complete surveys when compared to traditional spotlight methods, at comparable costs (Reindl-Thompson et al. 2006). However, despite the results that seemed to indicate the benefits of dogs over traditional methods, few additional efforts to pursue scent detection dogs as a tool for monitoring ferrets have occurred for unknown reasons (P. Gober, personal communication).

In an effort to find more effective and efficient methods for monitoring and managing ferret populations in Wyoming, the Department initiated a pilot project to assess the effectiveness of scent detection dogs for detecting ferrets. In collaboration with a professional scent detection dog training organization, Working Dogs for Conservation (Bozeman, MT), and the USFWS National Black-footed Ferret Conservation Center (NBFFCC; Wellington, CO) dogs were trained to detect live ferrets and then deployed to survey for ferrets at the MRA. These efforts were completed in conjunction with the 2017 and 2018 annual spotlight surveys for ferrets to compare the effectiveness of scent detection dogs to traditional survey methods. We were specifically interested in determining whether dogs could be trained and deployed at ferret reintroduction sites to locate burrows being used by ferrets and identify areas of high use by ferrets. We developed metrics for evaluating these abilities and discuss our findings in terms of future applications and considerations for use. This project represents the 1st substantial effort to evaluate the effectiveness of dogs as a tool for ferret monitoring in over a decade.

METHODS

Each of the dogs working on this project completed preliminary training exercises to prepare for the task of actively searching prairie dog burrows for ferrets. For these exercises, ferret scats were secured in small retrievable containers and placed down prairie dog burrows. These scats were collected from captive-raised ferrets at the NBFFCC that had been consuming prairie dogs for >2 weeks prior to scat collection. Dogs were than trained to seek out the hidden scats by locating and sniffing burrow openings.

Following protocols outlined by Boulerice (2018b), training involved the use of 5 captive-raised adult ferrets. We first presented dogs with a variety of settings to indicate ferret presence in a controlled environment at the NBFFCC. Specifically, 1 captive ferret was placed in a corrugated plastic tube (i.e., ferret transfer tube) among 3 other transfer tubes that were empty or, in later sessions, contained a live prairie dog. Different lengths and arrangements of PVC piping were used to emulate burrow depth and connectivity. During training, handlers observed the behavior of the dog when approaching the tube containing the ferret for a dog's indication of ferret presence. Indications are classified as either a "change of behavior" or an "alert". Change of behavior is an innate behavior in response to a scent of interest, characterized by increased excitement and focus on the object, which typically presents as increased tail wagging and increased sniffing rate. Alert is a trained behavior to sit or lie down near the object, often furthered by pointing with the nose. If a change of behavior occurred at a PVC pipe containing a ferret, handlers provided verbal, positive reinforcement to dogs to encourage a full alert signal. If an alert occurred, dogs were immediately rewarded with a dog toy and short play session with the handler.

After 2 days of training with the assistance of USFWS staff, we traveled to the MRA for field trainings. We coordinated the timing of this training session with the 1st of 2 supplemental releases of ferrets at the MRA in 2018 (Nelson 2019). The 5 ferrets we used during earlier training sessions, as well 3 additional adults, were utilized for 1 morning for training before being released in the evening. Again, ferrets were placed in corrugated plastic tubes and located in prairie dog burrows large enough such that the tube could be placed entirely within a burrow and thus out of sight from >2 m away. Handlers navigated dogs through the area to search for ferrets in this natural setting and rewarded the dogs when successful. Due to the later timing of spotlight surveys in 2018, the 4th phase of training described by Boulerice (2018b), which involved ferrets located by spotlight surveyors, served as a training refresher in the middle of dog surveys rather than a final pre-survey training period. Handlers were also supplied with retrievable containers holding pieces of dried ferret hair and skin provided by the NBFFCC that they placed in known burrows to periodically refresh and reward the dog when it indicated the correct burrow.

Following formal training on scats and live ferrets, dogs and handlers began surveys throughout the MRA. Handlers were provided with the boundaries for the same survey routes used during spotlighting survey efforts conducted in 2018 to compare the scent dogs to traditional survey methods. Within these boundaries, dog and handler teams walked a series of transects that covered the entirety of the survey route. Surveys took place at 2 scales in 2018 to compare the efficacy of a single dog-handler team with the 3 teams per route approach used in 2018 (Boulerice 2018b). Fine scale surveys involved 3 dog and handler teams per route with transects spaced approximately 100 m apart. Coarse scale surveys involved 1 dog and handler team per route but used 300 m spacing between transects in order to cover more area in a single morning. Handlers directed dogs along transects throughout each route, although the dog was free to choose a path that enabled the dog to investigate burrows and scents of interest. Handlers observed dogs for indications throughout the survey period (Figure 1). Burrows of interest where the dog indicated and whether the indication was a change of behavior or an alert were recorded with a GPS. Dogs were also equipped with GPS units that recorded the track of the dog throughout survey efforts.

All GPS locations of burrows of interest indicated by dogs were downloaded immediately after the completion of surveys. In an effort to confirm ferret presence, we placed infrared cameras aimed towards the burrow of interest. Due to limited availability of remote cameras, we selected ≥66% of the points of interest to receive a remote camera. We adjusted the selection if all 3 dog and handler teams were not represented in the initial sample of randomly selected points. Cameras were attached to a 0.5 m rebar stake approximately 2 m from the burrow opening. Cameras remained at the burrow of interest for ≥7 nights following fine scale surveys and ≥3 nights following coarse scale surveys. We programmed cameras to take 3 photos following each trigger with 1 second between photos. All cameras were placed before sunset on the same day surveys took place. Photos were downloaded upon retrieval and saved into folders denoting the dog survey point. In addition to those aimed at burrows of interest, we placed 1-4 cameras at random locations within each survey route to prevent attracting predators only to burrows with suspected ferret presence and to determine whether ferrets would be captured on camera in areas without dog indications of presence. We identified and recorded all wildlife species detected by remote cameras and examined all photos of ferrets from cameras deployed concurrently with spotlight surveys to determine whether any individuals would be considered unique ferrets according to methods outlined by Grenier (2008).

We verified indications in 3 ways. Any ferrets detected on camera were a positive confirmation of ferret presence. In addition, we considered burrows of interest ≤50 m of a known ferret location as positive confirmations. We selected 50 m as the distance for confirmation based on observations during training in 2017, when dogs frequently indicated ≤50 m of a known ferret location (AH, unpublished data). Known ferret locations came from 3 sources: spotlight surveys within 14 days of dog surveys, ferrets released before dog surveys, or photographs of ferrets at another burrow ≤50 meters. Finally, if ferrets were observed at the burrow entrance or heard by handlers, these locations were considered confirmed. Indications were considered unconfirmed when none of these requirements were met for the area of interest.

We examined factors that may influence confirmation rates by comparing proportions of confirmed versus unconfirmed indications between coarse scale and fine scale surveys on routes that received both levels of effort as well as between changes of behaviors and alerts using exact binomial tests. We compared the ratio of confirmed and unconfirmed indications between individual dogs for both years using multinomial exact tests. Using multinomial goodness-of-fit procedures, we tested the null hypothesis that the total number of indications produced by each dog would be proportional to the amount of time they spent surveying. We computed expected values by multiplying the proportion of total time spent surveying per dog by the total number of indications produced. Significance of differences between total indications by each dog was determined from pairwise comparisons and using the Bonferroni correction for multiple comparisons. All statistical analyses were performed using R version 3.4.3.

We examined distances between known ferret locations and burrows of interest were calculated to determine whether most of the dogs' areas of interest were within areas of probable use by ferrets. We created 25, 50, 100, and 250 m buffers around every known ferret location and calculated the total and proportion of burrows of interest falling within each of these distance classes for both years of surveys in ArcGIS 10. For comparison, we also examined the proportion of random points that would fall within these distances to a known ferret by measuring the distances between 7,000 points placed randomly over the survey area and known ferret locations. To determine whether number of indications per route would be a useful metric for managers, we tested the relationship between the numbers of indications per survey route with the number of unique ferrets per survey route using Kendall's correlation tests. Because some routes were surveyed with both levels of effort, we tested correlation for fine and coarse scale surveys separately.

We compared the search rates between dogs and traditional spotlight surveys for the portion of the MRA surveyed by dogs by determining the number of ha surveyed per hour for fine scale, coarse scale, and spotlight surveys. For dogs, we summed total area of all survey routes covered during surveys and divided this area by the total time for all dog-handler teams required to survey all routes. For spotlight surveys, we similarly used the summation of area for the same survey routes divided by total time required to survey with traditional spotlight methods. We calculated the time to complete the same routes based on the standard 3 consecutive night survey schedule. We used the amount of time surveyors are expected to be in the field for surveys rather than the amount of time spent physically surveying for ferrets since the former more accurately represents the required survey effort for spotlight surveys. Therefore, total survey time for spotlight surveys was calculated simply as 9 hours per night (based on a standard 2100-0600 survey period) multiplied by 3 nights multiplied by the number of survey routes. In order to compare these rates to traditional spotlight surveys, we did not incorporate a unique facet of spotlight surveys at the MRA whereby surveys are typically conducted in pairs in an effort to increase surveyor safety related to grizzly bears (*Ursus arctos*). In addition to search rates, we compared cost of surveys for spotlighting relative to both fine and coarse scale surveys. Spotlighting costs include the estimated salary, lodging, gas, consumable equipment, and coordination time required per ha. Costs for dog surveys were calculated by allocating the total amount spend by the Department proportionally to the amount of time surveyed during fine scale and coarse scale efforts, and thus accounts for all funds required for training, lodging, and supplies.

In an effort to understand more about cues dogs use to identify ferret presence, we investigated the dogs' ability to detect ferret scat over time. We created 3 "courses" on an inactive prairie dog colony on the border of the reintroduction area by placing pin flags next to 12 burrows per course. From these 12 burrows, we randomly selected 5 burrows in which to place ferret scat. Care was taken to minimize the amount of human scent deposited near each flag by wearing nitrile gloves and avoiding contact with the burrow or soil. Handlers were not informed of which burrows contained scats. Dog and handler teams surveyed 2 courses on each day of trials. Department personnel followed each team to record the dogs' behavior at each burrow and inform the handler whether the dogs' indication of ferret scat was correct. The dogs were rewarded if correct by playing approximately 5 m away from the flagged location. In an effort to minimize dog and handler learning of scat locations, the teams alternated the direction from which they approached each course and alternated the courses they visited each trial. Flags and scats were removed after the final trial. We compared the proportion of correct indications by dogs (relative to availability) with days since scat placement and tested for significance with a linear regression model.

RESULTS

Four dogs and 3 handlers completed all 4 stages of training. Training on live ferrets at the NBFFCC required 9 hours, and on-site training at the MRA required approximately 4 hours. Handlers guided dogs to 5 locations where ferrets had been trapped the previous night during spotlight surveys for a live ferret refresher on 21, 22, and 27 September; these training refreshers required 4 hours.

From 9-29 September 2018, 4 dogs and 3 handlers surveyed 14 of the survey routes used during spotlight survey efforts (Figure 1). An example of the transecting pattern deployed by dog/handlers teams is displayed in Figure 2. During 2018 surveys, dogs were able to survey 5,848 ha in 164.1 hours. Handlers recorded 60 changes of behavior and 95 alerts. At least 1 indication was recorded on each of 14 survey routes.

A total of 114 cameras were placed at burrows of interest, and 36 cameras were placed at random locations within survey routes. Of these, 143 collected 109,501 photos while 7 malfunctioned and did not collect any photos. Cameras captured 3,676 photos of ferrets at 33 burrows indicated by dogs. The 1st detection of ferrets took place on the 1st or 2nd night of deployment on 58% of the cameras (range: 1-9 nights to 1st detection; Figure 6). No ferrets were detected at randomly placed cameras. Cameras were deployed for 893 trap nights for a mean of 5.95 nights per burrow. Other species encountered on camera are presented in Table 1. Mustelid species such as long-tailed weasels (*M. frenata*; n = 4) and badger (*Taxidea taxus*; n = 54) were present in burrows indicated by dogs, but ferrets were also present at 21 of these locations.

Photos from cameras deployed concurrently with spotlight surveys detected additional ferrets not observed during spotlight surveys. At least 2 ferrets documented on camera would have been considered discrete according to methods used by Grenier (2008) for the MRA. In 1 instance, a ferret was detected by cameras on a route in which spotlight surveyors failed to detect any ferrets. The other discrete ferret was unmarked in photos and located on a route in which all previously observed ferrets had been captured and marked. Other ferrets detected by cameras were not determined to be discrete.

Including the ferrets detected with remote cameras, we confirmed ferret presence at 54 (34.8%) of the 155 burrows indicated by dogs (Table 2). We considered 19 burrows confirmed by distance, as these were <50 m from a burrow with known ferret presence. Handlers recorded 6 instances in which they either saw or heard a ferret within the burrow, and 4 of those burrows were also confirmed by either photo or distance from a known ferret location (Figure 7). The proportion of confirmed burrows indicated by an alert (0.34) was significantly higher than burrows indicated by a change of behavior (0.17) across both years ($p = 0.002$).

Fine scale surveys with 100 m spacing between transects were completed on 9 of the 14 routes and took place between 0-10 days before spotlight survey efforts were completed for the same route. Coarse scale surveys with 300 m spacing were conducted on all 14 routes. Coarse scale surveys were conducted concurrently with and ≤3 days before or after spotlight surveys of the same route. Of the 155 areas of interest, 101 (65%) were recorded during the fine scale surveys while 54 (35%) were recorded during coarse scale surveys. The proportion of burrows selected during coarse scale surveys (0.50) that were confirmed was significantly higher ($p = 0.02$) than the proportion of confirmed burrows during fine scale surveys (0.29) on routes that received both levels of survey effort. However, the raw number of confirmed areas of interest during fine scale ($n = 29$) and coarse scale surveys ($n = 23$) was similar. The number of areas identified by dogs per route was not significantly correlated to the number of unique ferrets per route during fine scale surveys ($tau = 0.30$, $p = 0.28$) or during coarse scale surveys ($tau = 0.29$, $p = 0.17$).

No significant differences in proportions of confirmed indications between individual dogs were present in 2017 ($p = 0.36$) or 2018 ($p = 0.62$). The total number of indications per dog differed from equal proportions expected by survey effort in 2018 ($p = 0.01$) and in 2017 ($p = 0.007$). Pairwise comparisons for dogs in 2017 revealed that 1 of 3 dogs had significantly fewer indications ($p < 0.001$) than expected by survey effort. In 2018, the same dog had significantly fewer indications ($p = 0.01$) relative to expected based on survey effort, while other indications by 3 other dogs were statistically similar to number of indications expected by survey effort.

In 2018, 34% of areas of interest indicated by dogs were ≤50 m of a known ferret location and 44% were ≤100 m (Figure 3). The median distance between areas of interest and known ferrets was 145 m, providing a 2-year median distance from known ferrets of 198 m (Figure 4). While the total number of areas identified by dogs was similar between years, a significantly higher proportion of indications was confirmed in 2018 ($p < 0.001$). The proportion of areas of interest falling within several distance classes was similar between 2017 and 2018 when known ferret locations only included those observed by spotlight or released ≤3 weeks before surveys (Figure 5). When ferret detections by camera were considered, 67% of all areas of interest were ≤250 m of a known ferret, relative to 24% of random points. Of the 7,000 random points, 6.1% were ≤100 m of a known ferret location.

The mean number of hectares surveyed per hour by dogs was higher for both scales of survey effort, as spotlight surveyors covered 54% fewer hectares per hour than dogs during fine scale surveys and 85% fewer hectares per hour than dogs during coarse scale surveys (Table 1). Total cost of spotlight surveys was estimated at $24,000. The total cost of fine scale surveys in 2018 was calculated to be $22,498, while coarse scale surveys cost $11,353. When adjusted per hectare surveyed, fine scale dog surveys cost more per hectare than spotlighting, but coarse scale dog surveys cost 50% less than spotlight surveys per hectare (Table 3).

Trials for evaluating the ability of dogs to detect scat over time took place 7-29 September. Scats were placed in burrows across courses created on 6 and 8 September. Dog and handler teams visited courses on 7 occasions representing 11 time intervals since placement. There was no relationship between percent of correct indications at each visit and time since scat placement (p = 0.26; Figure 8). On average, dogs had a correct indication rate of 72% throughout the experiment and had a false positive rate of 12%.

DISCUSSION

At the conclusion of the pilot project to evaluate the effectiveness of scent detection dogs at locating ferrets, our results suggest that dogs continue to have potential as a useful tool for ferret monitoring. In our limited study, we found evidence that dogs were able to locate prairie dog burrows in which ferret presence was confirmed at 71 locations across both years. According to the distances between dog areas of interest and known ferrets, dogs are capable of identifying areas of use by ferrets. These findings, coupled with several additional benefits this survey technique provides over traditional spotlighting methods, indicate the utility of a dog-based survey approach for ferrets. However, our ability to evaluate dogs was somewhat constrained by the short duration of this project and challenges associated with the inherent difficulties in attempting to evaluate the success of dogs on locating a fossorial species, namely a limited ability to verify the presence or absence of ferrets at burrows selected by dogs.

Our rate of 35% of all areas of interest confirmed suggests that the dogs are identifying areas used by ferrets. Further evidence is supplied by the majority of all areas of interest falling ≤250 m of a known ferret location, a distance much smaller than the average home range for both female and male ferrets (Biggins et al. 1986, Jachowski et al. 2010). The contrasting unconfirmed indications can be an artifact of several processes and should not always be considered false positives. Our definition of confirmed indications included known ferret locations from spotlight surveys and cameras, both of which require ferrets to be aboveground. Ferret activity aboveground is often characterized as brief temporary excursions, and ferrets can remain underground for multiple consecutive days (Biggins et al. 1986, 2011). Further, the trials in which dogs surveyed for scat at various times since placement suggest that under perfect conditions (i.e., no disturbance by prairie dogs), dogs are capable of detecting scat with a 72% success rate for >3 weeks. Unconfirmed indications may indicate ferret scat rather than presence during camera deployment or spotlight surveys. Further, in order to compare the results of spotlighting with dog surveys, we conducted surveys concurrently. However, the advantages of spotlighting in the period of peak kit emergence and dispersal (Eads et al. 2012) may serve as a disadvantage for evaluating dog surveys. Emerging kits may be depositing scent at multiple burrows as they explore and learn to hunt. Dispersing kits may exhibit long distance movements (Forrest et al. 1988), thus not remaining in the burrow in which the dog indicated. Surveys at a different stages in ferret life history involving less aboveground activity and less burrow use, such as early spring during parturition, may limit the number of unconfirmed areas of interest and provide additional information on which scent cues are influencing dog behavior. Given these facets of ferret behavior and our reliance on aboveground movement for confirmation, we suspect that our proportion of correct indications by dogs is deflated.

Methods to confirm areas indicated for ferret presence by dogs varied between 2017 and 2018 due to timing considerations for spotlight surveys and the availability of remote cameras. Remote cameras were less labor intensive and were able to collect data from more locations than follow-up spotlight surveys. Remote cameras provided concrete evidence that dogs located burrows in which a ferret was present on 33 occasions and added to the count of total ferrets in the MRA. The additional known ferret locations provided by remote cameras are likely driving the differences between confirmation rates between years and are demonstrably reducing the median distance between known ferrets and dog areas of interest, as shown in Figure 4. In addition to recording ferret presence, cameras also detected other species using burrows indicated by dogs, providing information on the rate at which dogs may be detecting other mustelid species. Only 4 cameras detected long-tailed weasel, the species most closely related to ferrets present at the MRA. Badgers were detected by many cameras, but several images were of badgers travelling through the area but not interacting with the target burrow. Further, unlike ferrets, badgers were detected on randomly placed cameras in addition to target cameras. While we do not know mustelid behavior before cameras were placed, the presence of ferrets at 38% of these burrows suggests that the dogs are not indicating solely due to scent from other members of the weasel family.

However, while remote cameras supplemented this pilot project and our knowledge of wildlife presence at the MRA, cameras do not produce perfect detection rates for ferrets. Evidence from camera data suggests that while a majority of ferret detections occurred on the 1st or 2nd night, the unpredictable aboveground activity of ferrets led to some without detection until much later. This is problematic for cameras that were deployed for a shorter period or may have malfunctioned before retrieval, potentially allowing ferrets to go undetected by remote cameras. Although remote cameras have been implemented previously as a detection tool for ferrets (Hinckley and Crawford 1973, Hammer and Anderson 1985), we do not have robust data on the probability of detection or on the ideal configuration of remote cameras. We determined a distance of 2 m from burrows after brief trials were conducted in the Shirley Basin Reintroduction Area (DN, unpublished data) and elected to place 1 camera per dog area of interest to maximize area covered. While this camera array was capable of detecting multiple burrow entrances on many occasions, it is certainly possible that other burrow entrances were not captured allowing a ferret to exit the burrow system undetected. Additional research into camera configurations and deployment strategies is warranted to more effectively use cameras to validate other surveys and to collect ferret presence data.

Behavior upon indication and tendencies of individual dogs should be accounted for when interpreting maps with areas of interest after a survey. We observed the proportion of areas of interest confirmed was higher when dogs indicated with a full alert rather than a change of behavior, suggesting that changes of behavior should be weighted less when making management or survey direction decisions. Duggan et al. (2011) recorded an increase in false positives on another cryptic, burrowing species when interpreting changes of behaviors as indications but importantly noted that these weaker indications are useful in understanding where visits have been made by the focal species and thus recolonization or dispersal into those areas may be possible. While individual dogs were equally successful in their proportion of confirmed indications in both years of surveys, the total number of indications were not equal in both years, even when standardized by time surveyed. One dog produced fewer than expected indications than other dogs in both years. Similar to spotlight surveyors, whose detections can vary with factors related to an individual's energy level, motivation, experience, etc., scent detection dogs can produce varying detection rates due to physiological and environmental conditions (e.g., increased panting rate; Smith et al. 2003). One way to overcome this variability is to work with a professional detection dog organization whose extensive training and experience with individual dogs offer researchers the ability to adjust their survey design or process the results based upon knowledge of individual dogs' tendencies (Reed et al. 2011).

Variation in total number of indications per dog can at least partially explain the lack of correlation between the number of indications and number of unique ferrets per route, as routes surveyed by one dog may have received more indications than those by another dog given the same number of ferrets. The number of unique ferrets only includes those found with spotlights or those released prior to surveys, and given the imperfect detection rates of spotlight surveyors (e.g., varying levels of experience, motivation, route coverage, etc.), may not be a perfect representation of ferret distribution. The correlation between route and number of ferrets obviously increases when all known ferret locations (i.e., including those detected on camera following dog indications) are compared to total number of dog indications per route, but this metric is confounded. Rather than testing correlation with survey routes designed for spotlight surveys, we suggest future analyses compare ferret and dog indication densities using an appropriately sized grid cell overlaid on the reintroduction area.

Survey costs were approximated and did not capture potential inter-annual variability in spotlighting expenses or the availability of joint fundraising to offset the costs of scent dog surveys. Still, coarse scale surveys offer nearly 7× the area covered per hour with a lower cost per ha than spotlight surveys. Relative to fine scale surveys in the same areas, transects with 300 m spacing produced similar numbers of confirmed burrows and a surprisingly higher confirmation rate. Larger areas were covered in less time without a reduction in accuracy. While inference should be made cautiously given the limitations associated with our confirmation methods, these results suggest that wider spacing between transects is optimal for rapid assessment of large areas for ferret presence. Additional research with more robust confirmation methods or at a different time of the year would benefit our knowledge on factors influencing dog identification of ferret presence. However, similar to results from previously published efforts (Reindl-Thompson et al. 2006), our project found scent detection dogs to be capable of detecting ferrets at a level that allows managers to decide on additional survey effort.

Given the benefits that dogs provide over traditional spotlight surveys, we suggest that scent detection dogs can be used for rapid assessment of ferret presence over large areas. Potential applications within Wyoming including using professional detection dogs as a tool to indicate potential habitat where dispersal may have occurred or where traditional spotlighting efforts have been hampered due to limited resources. In SBRA specifically, large-scale presence surveys by dogs would be particularly useful for streamlining survey effort. A combination of dog surveys over wide areas with targeted, follow-up spotlighting and cameras would not only produce a faster assessment of ferret presence in an area with the magnitude of Shirley Basin, but would substantially reduce the number of expensive nights spent using spotlights for the same information. Mark-recapture efforts from spotlighting are still required for to measure population size for recovery goals, but surveys by scent detection dogs can help streamline and guide these efforts. We are hopeful that with our contributions to research and development of dogs as a survey method for ferrets, the Department will be able to use this alternative technique to overcome many of the challenges associated with spotlight surveys and enable more effective management of current and future reintroduction sites for ferrets in Wyoming.

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Table 1. Number and proportion of remote cameras with mesocarnivore detections during scent detection dog surveys for black-footed ferret (*Mustela nigripes*) presence in the Meeteetse Reintroduction Area in September 2018. Totals and proportions are presented separately for functioning cameras placed at target burrows identified by the dogs (*n* = 107) and cameras placed at random locations within survey routes (*n* = 36).

Species	Number (proportion) of cameras with detections	
	Target burrows	Random sites
Taxidea taxus	51 (0.28)	3 (0.08)
Mustela nigripes	33 (0.31)	0
Vulpes velox	30 (0.32)	4 (0.11)
Canis latrans	7 (0.07)	2 (0.06)
Mustela frenata	4 (0.04)	0

Table 2. Details for 155 indications by scent detection dogs during surveys for black-footed ferrets (*Mustela nigripes*) at the Meeteetse Reintroduction Area in September 2018. Scent detection dogs indicated ferret presence at specific burrows. These were confirmed as positive for ferret presence by detection on remote cameras aimed directly at the burrow of interest or by falling ≤50 m of a known ferret location. Known ferret locations included those found by spotlight surveyors, those detected on a different camera, handler observations, and ferrets released prior to scent dog surveys.

	Photo at target burrow	Handler observed	Known ferret ≤50 m			Not confirmed
			Spotlight	Photo	Release	
Alert	22	2	6	6	2	57
Change of behavior	11	0	3	0	2	44
Total	33	2	9	6	4	101

Table 3. Comparison of cost and search rate for 3 methods of detecting black-footed ferrets (*Mustela nigripes*) at the Meeteetse Reintroduction Area in September 2018. Scent detection dogs surveyed at 2 scales: fine scale with 100 m spacing between transects and coarse scale with 300 m spacing between transects. Dollar amounts for scent dog surveys includes cost of training and survey time. Cost of spotlighting was estimated from 2017-2018 surveys (D. Nelson, unpublished data).

	Area surveyed (ha)	Total hours	Cost per ha	Ha per hour
Dogs: fine scale	2,245	109	$10.02	20.6
Dogs: coarse scale	3,603	55	$3.15	65
Spotlight surveys	3,603	378	$6.73	9.5

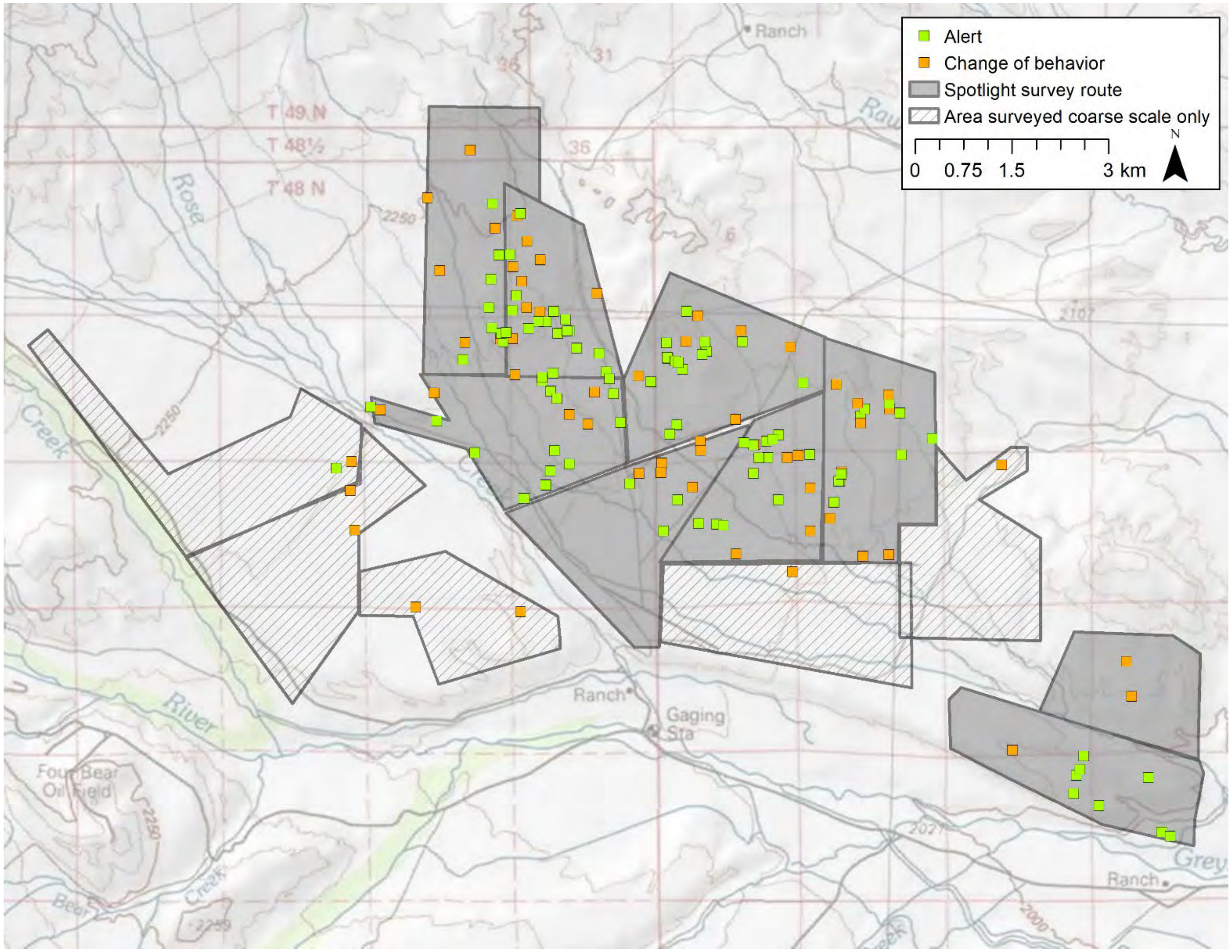

Figure 1. Area surveyed and distribution of scent detection dog indications from surveys for black-footed ferret (*Mustela nigripes*) presence at the Meeteetse Reintroduction Area during September 2018. Indications are classified as full alerts or as changes of behavior.

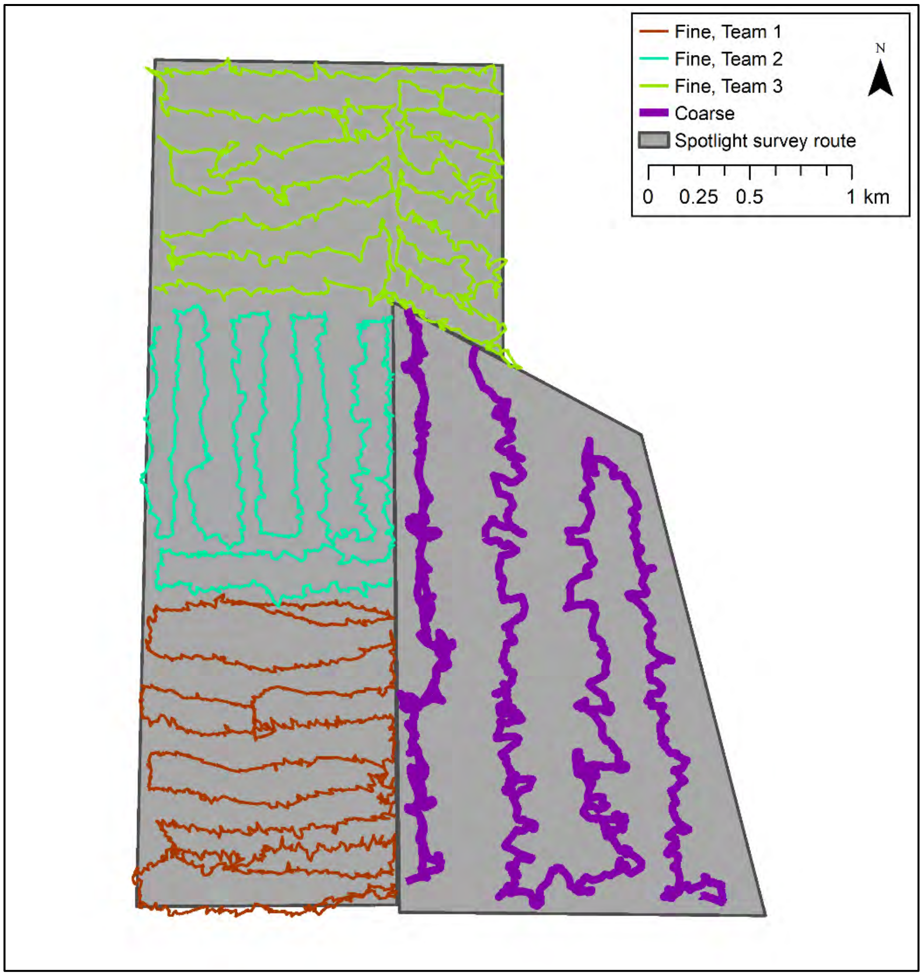

Figure 2. Example of transects used by scent detection dog and handler teams during surveys for black-footed ferret (*Mustela nigripes*) presence within the Meeteetse Reintroduction Area in September 2018. The route on the left shows typical transects for fine scale surveys with 100 m spacing while the route on the right contains typical coarse scale spacing of 300 m.

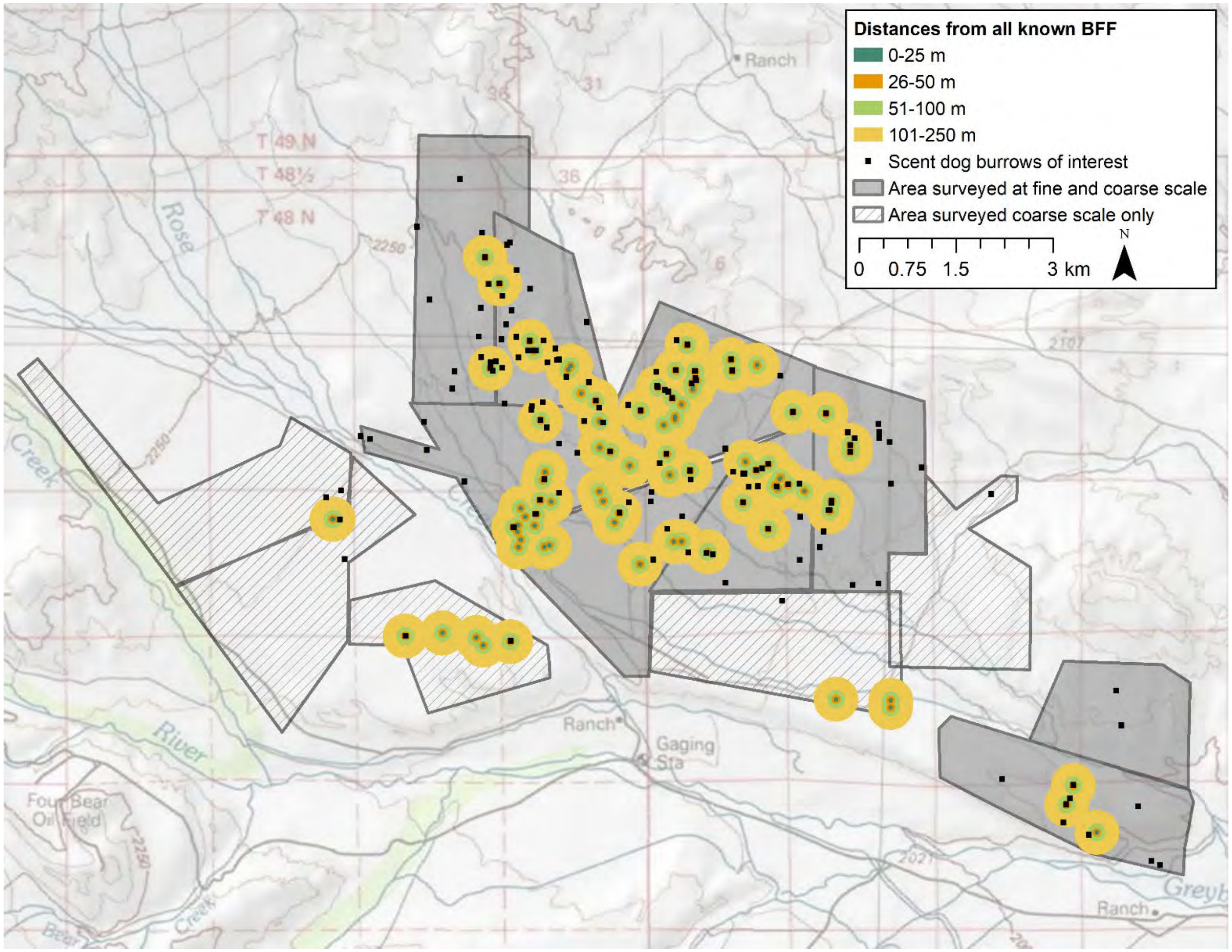

Figure 3. Locations of scent dog burrows of interest relative to the locations of known locations of black-footed ferrets (*Mustela nigripes;* BFF) with 4 distance buffers at the Meeteetse Reintroduction Area in September 2018. Known ferret locations include spotlight observations, remote camera detections, handler observation, and release sites of ferrets released before dog surveys.

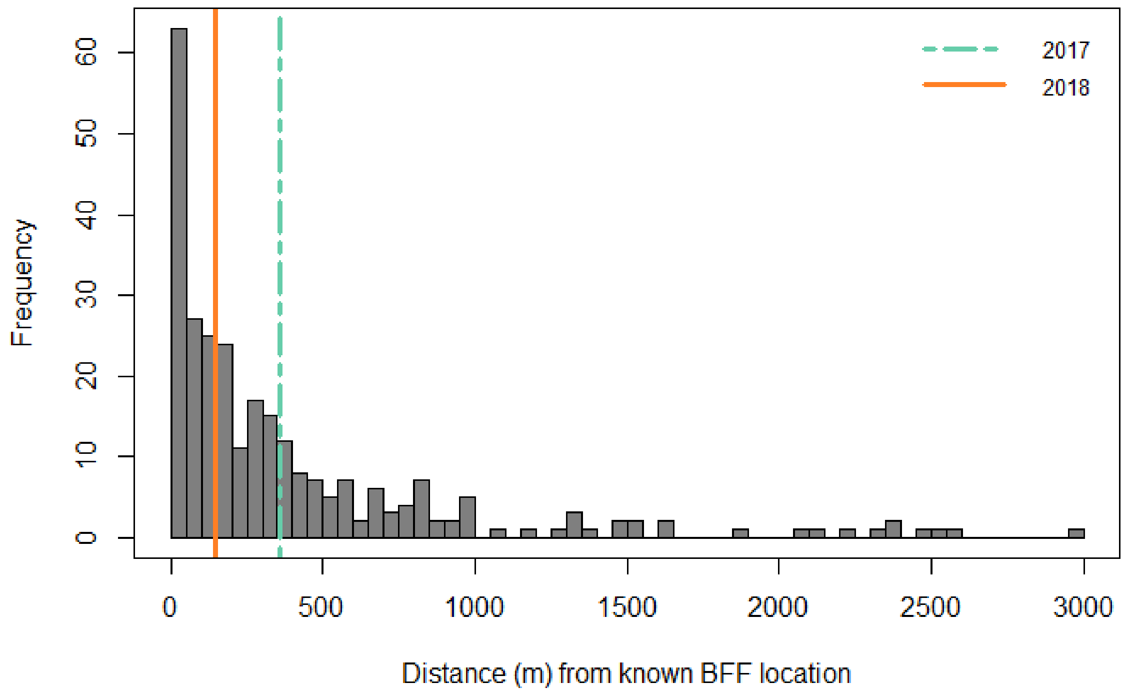

Figure 4. Distribution of indications made by scent detection dogs for black-footed ferret (*Mustela nigripes*) presence across the range of distances from known ferret locations within the Meeteetse Reintroduction Area from surveys conducted in 2017 and 2018. Dog and handler teams recorded 121 areas of interest in 2017 and 155 areas of interest in 2018. The median distance from a known ferret location for each year and across both years is indicated on the graph. Each bar represents an interval of 50 m.

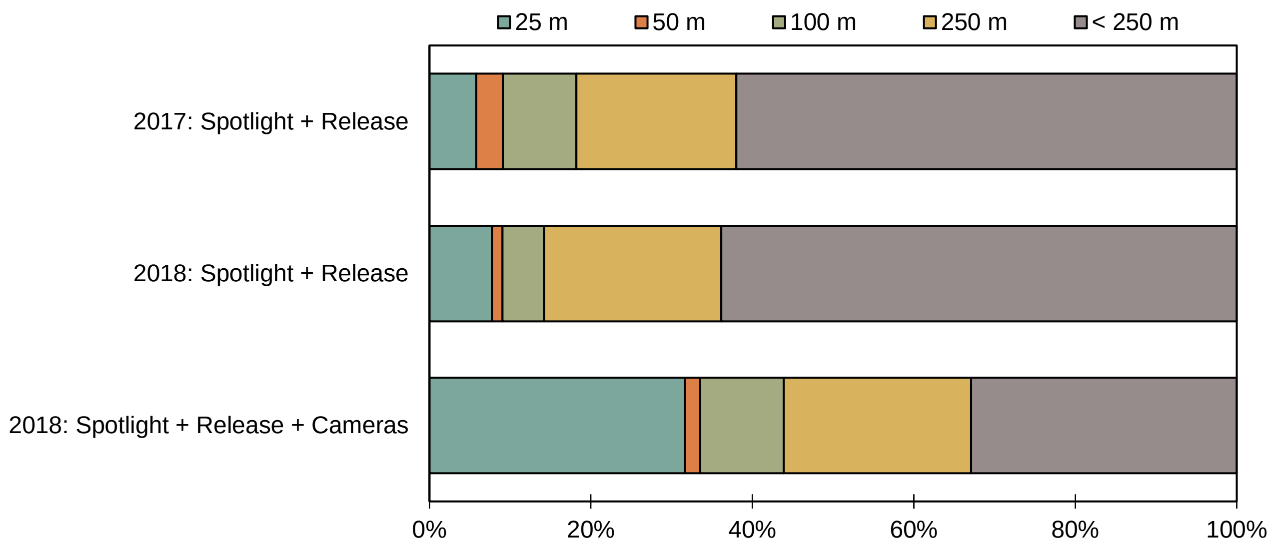

Figure 5. Proportion of indications identified by scent detection dogs falling within 5 distance classes from known black-footed ferret locations (*Mustela nigripes*) at the Meeteetse Reintroduction Area in 2017 and 2018.

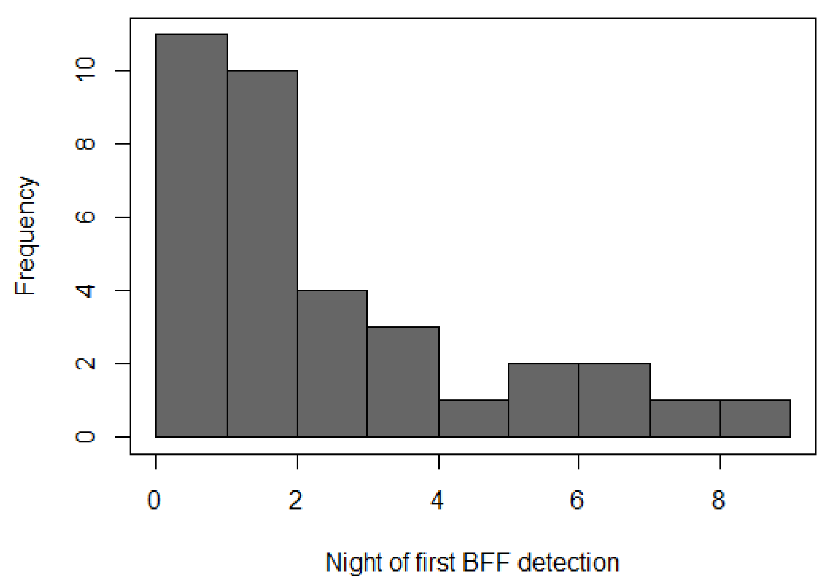

Figure 6. Distribution of night of 1st detection of black-footed ferrets (*Mustela nigripes*; BFF) by remote cameras deployed at scent dog areas of interest within the Meeteetse Reintroduction Area in September 2018.

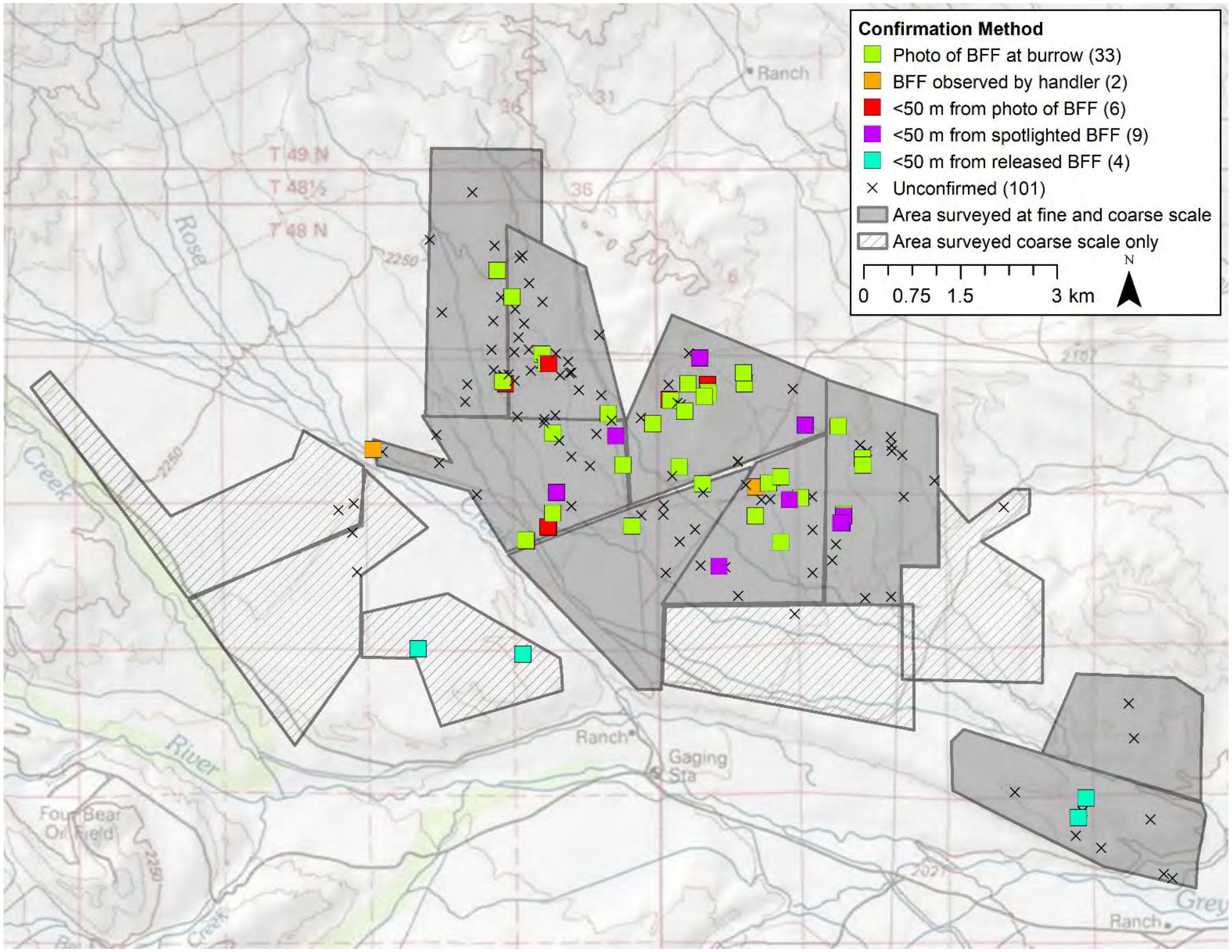

Figure 7. Location of all burrows of interest indicated by scent detection dogs across the Meeteetse Reintroduction Areas surveyed for black-footed ferret (*Mustela nigripes*) presence in September 2018. Ferret presence was confirmed by remote cameras aimed directly at the burrow of interest or by ferret locations recorded ≤50 m of the burrow of interest.

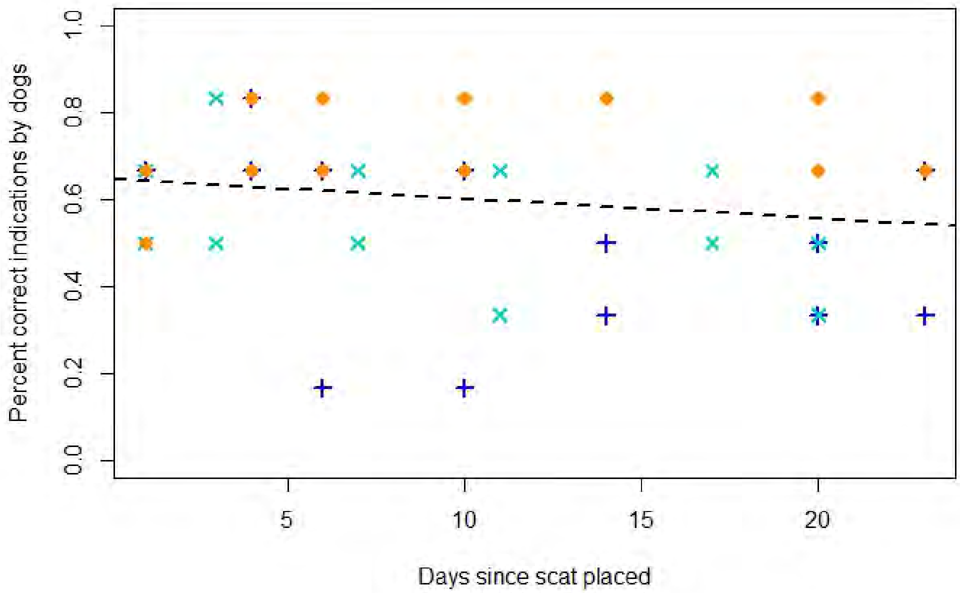

Figure 8. Relationship between the percent of correct indications of black-footed ferret (*Mustela nigripes*) scat by scent detection dogs and time since scat placement from trials conducted at the Meeteetse Reintroduction Area in September 2018. Symbols represent the 3 courses over which scent detection dogs surveyed for presence of scat within burrows.

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 Game and Fish Department
United States Fish and Wildlife Service Cooperative Agreement

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Susan Patla, Nongame Biologist
Frank Stetler, Nongame Technician

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 3 survey flights to collect census data on total number of adults and young in summer and to document occupancy and productivity of all known nest sites. In the 2018 fall population count, we counted 19 fewer adults and 9 fewer cygnet Trumpeter Swans in Wyoming outside of Yellowstone National Park compared to the previous year. Numbers in 2015 and 2016 represented record high numbers for the state but exponential growth observed in previous years in the Green River basin leveled off in 2016 and dropped in 2017-2018. The number of adult/subadult swans in the Green River expansion area comprised 68.2% of the breeding population in 2018. Distribution continues to slowly increase in the Green River Basin, with pairs occupying and testing out new sites: a pair occurred as far south as the town of Green River again but did not produce cygnets this year. We remain concerned over low productivity of swan nest sites and lack of population growth 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. 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 obtained a standard North American Wetlands Conservation Act grant developed with The Conservation Fund and other partners to obtain $1 million for conservation easements and wetland habitat projects in the Green River Basin in 2012. Another project started in 2012 and completed in 2015 in partnership with The Nature Conservancy and Wyoming Natural Diversity Database was the first basin-wide wetland assessment funded by the Environmental Protection Agency states program in Wyoming for the Green River Basin. A new partnership with the newly established Northern Rockies Trumpeter Swan Stewards (Northern Rockies Conservation Cooperative) resulted in additional monitoring and establishing nest platforms at some nesting territories in 2017.

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 2017). Although swans have never been 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) or the Tri-State Area 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 greatly since that time, hitting a low of 239 white birds (adults and subadults) in 1994. The total number of adult birds in the GYA exceeded 500 white birds in 2015 for the first time since 1967 (Olson 2018). 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-governmental 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 2018 nesting season. The annual coordinated winter survey, which would have occurred in February 2019, has not been flown since 2018 due to lack of funding. The winter survey provided a count of the total number of swans wintering in in the Greater Yellowstone area. Subtracting the fall count from the winter count provided an estimate of the nesting population in interior Canada.

METHODS

We conducted 3 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 swan nesting areas on 2 and 3 June to determine occupancy, and again on 19 and 20 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 19 and 20 September 2018. Additional data were collected through site-specific ground surveys, reports provided by federal agencies, and observations from the public. The USFWS Mountain-Prairie Region Migratory Bird Office produced reports summarizing results for the coordinated RMP surveys that included data collected in Wyoming (Olson 2015, 2018).

RESULTS

In fall 2018, we counted 9.6% fewer white swans (adults and subadults) in Wyoming outside of YNP compared to the previous year (Table 2, Figure 3). The rate of growth in Wyoming (1993-2016) has increased by 3.5% per year ($P < 0.01$) for white birds and 7.4% ($P < 0.01$) for cygnets (Olson 2018). However, the long-term trend for total number of swans in the traditional Snake River core area (1999-2017) showed no trend ($p = 0.39$; Olson 2018). Conversely, in the Green River expansion area, the number of swans has increased by 10% ($P < 0.01$) over this 17-year time period (Olson 2018). However, number of white birds in the Green River flock has declined now for 2 years in a row in the survey area (down 6.9% from 2017-2018).

The number of nest sites occupied in 2018 in Wyoming outside of YNP ($n = 48$) decreased compared to the previous year, but still exceeded the 10-year average (Table 3, Figure 2). The number of young hatched in Wyoming outside YNP in 2018 was below the 10-year average ($n = 64$) down 12 individuals from 2017(Table 3). Of the 48 sites occupied in 2018, 72.9% of pairs initiated nesting, 50% hatched young, and 41.7% fledged at least 1 young. Overall, swans in the Green River Basin accounted for 68.8% of occupied sites and 75.5% of fledged young (Table 4).

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 25 nest sites in the Snake River core area where swans attempted to nest at least once during the 12-year period (2004-2015) showed that only 3 territories produced young more than half of the years during this period (WGFD unpublished data). Twenty percent of the sites (n = 5) produced no young. Pairs on the National Elk Refuge accounted for 35% of all productivity over this time period.

Summary of mortality data from 1991-2018 are presented in Table 5. Overall since 1998, the Department has documented a total of 438 swan mortalities. The cause of mortality could be identified in 34.2% of the specimens, with collisions accounting for 50.7%, predation 20.7%, shooting 16%, and disease/parasites 12.7% (Table 5). Many swan carcasses found during winter and early spring are in emaciated condition or have been scavenged or decayed to the degree that necropsies are not possible.

RESULTS AND DISCUSSION

The 2018 nesting season was successful, with swan numbers and productivity in Wyoming outside of YNP exceeding the 10-year means (Table 3), but high run-off and cool spring resulted in a lower number of pairs that initiated nesting. Nest sites, especially those located adjacent to river corridors, were flooded at nesting time (Figure 4). 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 at many sites in the Snake River core area. We have documented a dramatic increase in the number of migrant swans from interior Canada wintering in the core area over recent decades. 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 years with cold, late springs, 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 in the core area negatively impacts resident pairs 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.

In contrast, although the number of swans wintering along the Green River south of Fontenelle Dam has been increasing annually since 2003, we were seeing exponential growth in resident swan numbers and increasing productivity in the Green River expansion area. In 2016 and 2017, number of resident birds and productivity has leveled off. Results in future years will provide evidence if this is only a temporary hiatus or if perhaps swans have now occupied most high quality nesting wetland habitat and limits to growth are being reached in this area. A habitat analysis of nest sites using remote sensing is planned for the future, which should provide a method for estimating the amount of available but unused potential nesting habitat.

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 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 2017). 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 2017, swans used wetland sites developed by the Department as cooperative projects with landowners at 4 locations in the Pinedale area. Funding for these projects was obtained through the WLCI, WWNRT, NRCS programs, and USFWS Partners Program. Construction was completed in fall 2015 on a wetland restoration project near Daniel, which was funded by a standard North American Wetlands Conservation Act grant that was awarded to the Department, the USFWS, and 14 other partners in 2012 for a total of $1 million for conservation easements and wetland habitat projects in the Upper Green River Basin (Figure 2). In 2012, we also obtained a state grant from the Environmental Protection Agency, in partnership with The Nature Conservancy of Wyoming, to conduct the first basin-wide assessment of wetland habitat in the state for the Green River Basin. The final report, completed in 2015, provides a more complete understanding of the types and condition of wetlands in the basin and help to focus future conservation and restoration work (Tibbets et al 2015).

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.

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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 2004 through 2015 plus 2018. No coordinated Pacific Flyway winter surveys were conducted after February 2015 due to budget constraints. In winter 2018, the Wyoming Game and Fish Department obtained funding from the Teton Conservation District to conduct winter surveys in the Jackson region. Department funding was used to survey the Green River and Salt River drainage. US Fish and Wildlife Service personal provided data for Yellowstone National Park and the Wind River Reservation near Lander. 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 from 2019 are not yet compiled, so are not provided.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	124	367	61	102	31	685
2005	Cygnet	30	109	20	35	2	196
	Total	154	476	81	137	33	881
	Adult	121	413	100	124	18	776
2006	Cygnet	14	58	13	37	3	125
	Total	135	471	113	161	21	901
	Adult	144	420	116	158	6	844
2007	Cygnet	25	84	30	35	6	180
	Total	169	504	146	193	12	1024
	Adult	65	316	109	174	4	668
2008	Cygnet	7	63	30	43	6	149
	Total	72	379	139	217	10	817
	Adult	88	321	160	133	24	726
2009	Cygnet	2	63	27	8	12	112
	Total	90	384	187	141	36	838
	Adult	18	369	160	85	16	648
2010	Cygnet	5	56	30	12	8	111
	Total	23	425	190	97	24	759

Table 1. Continued.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	125	467	168	150	27	937
2011	Cygnet	42	138	51	32	8	271
	Total	167	605	219	182	35	1208
	Adult	51	488	210	109	27	885
2012	Cygnet	4	99	20	29	24	176
	Total	55	587	230	138	51	1061
	Adult	2	548	212	120	15	897
2013	Cygnet	0	120	30	20	8	178
	Total	2	668	242	140	23	1075
	Adult	24	411	261	123	41	860
2014	Cygnet	7	50	45	21	6	129
	Total	31	461	306	144	47	989
	Adult	111	472	211	93	39	926
2015	Cygnet	33	96	33	26	8	196
	Total	144	568	244	119	47	1122
	Adult	168	370	204	191	52	985
2018	Cygnet	27	45	30	26	19	147
	Total	195	415	234	217	71	1132

Table 2. Fall survey results for the Tri-State Area Flocks (RMP name change to Greater Yellowstone Flocks) of the Rocky Mountain Population of Trumpeter Swan (*Cygnus buccinator*) that are resident year-round in the Greater Yellowstone core and expansion areas in the states of Idaho, Montana, and Wyoming, 2009-2018 (Olson 2018). YNP represents Yellowstone National Park.

Year	Age group	Montana	Idaho	Wyoming YNP	Wyoming outside YNP	Tri-State total
	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
	Adult	212	104	20	212	548
2015	Cygnet	60	47	6	65	178
	Total	272	151	26	277	726
	Adult	215	127	23	213	578
2016	Cygnet	48	28	6	61	143
	Total	263	155	29	273	721
	Adult	260	114	23	198	595
2017	Cygnet	29	28	0	58	115
	Total	289	142	23	256	710
	Adult	512	140	24	179	855
2018	Cygnet	147	30	0	49	226
	Total	659	170	24	228	1081

Table 3. Occupancy and productivity data for Trumpeter Swans (*Cygnus buccinator*) nesting in Wyoming outside of Yellowstone National Park, 1992-2017. 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 4 fledged, and again in 2001, of which 5 fledged. Mean and standard deviation are shown for the 10-year period 2008-2017.

Year	Sites occupied (*n*)	Nesting pairs (*n*)	Pairs with hatchlings (*n*)	Pairs with fledglings (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)
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
2015	57	40	28	23	81	65
2016	49	35	28	24	78	61
2017	58	35	25	21	76	58
2018	48	35	24	20	64	49
10-year mean	46	29	21.2	17.2	65.2	49.1
SD	8.68	6.74	5.67	4.64	14.48	10.58

Table 4. Comparison of Trumpeter Swan (*Cygnus buccinator*) nest-site occupancy and productivity data for the Snake River core and Green River expansion areas in Wyoming outside of Yellowstone National Park, 2007-2017. In the Green River, 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. Mean and standard deviation (SD) are shown for the 10-year period 2008-2017.

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	3.50
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	2.73
2014	14	9	8	27	19	3.38
2015	17	10	6	17	10	2.83
2016	17	9	9	26	16	2.89
2017	16	9	7	22	14	3.14
2018	14	9	6	16	12	2.67
10-year mean	16.3	9.3	7	22	13.5	3.19
SD	1.68	1.27	1.84	4.82	2.84	0.36
Green River Expansion						
2007	16	13	11	37	28	3.36
2008	18	9	8	26	21	3.25
2009	18	14	9	29	21	3.22
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
2015	38	28	22	64	55	2.91
2016	31	26	19	52	45	2.74
2017	40	25	17	52	43	3.05
2018	33	25	17	46	37	2.71

Table 4. Continued.

10-year mean	28.3	18.9	14	42.8	35.4	3.09
SD	8.01	5.92	4.47	12.50	10.57	0.31

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 1 year of age; likely some yearlings are included in this group.

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	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	37	18	11	8	2		1		24
2013-2014	13	8	0	5	1		3	2	7
2014-2015	11	5	1	1	2			3	5
2015-2016	14	9	1	4	2	1	0	1	8
2016-2017	9	2	0	7	1	0	0	0	6

Table 5. Continued

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)
2017-2018	29	19	1	9	7	0	0	0	22
2018-2019	5	5	0	0	0				5
Total	438	254	40	124	76	31	24	19	268

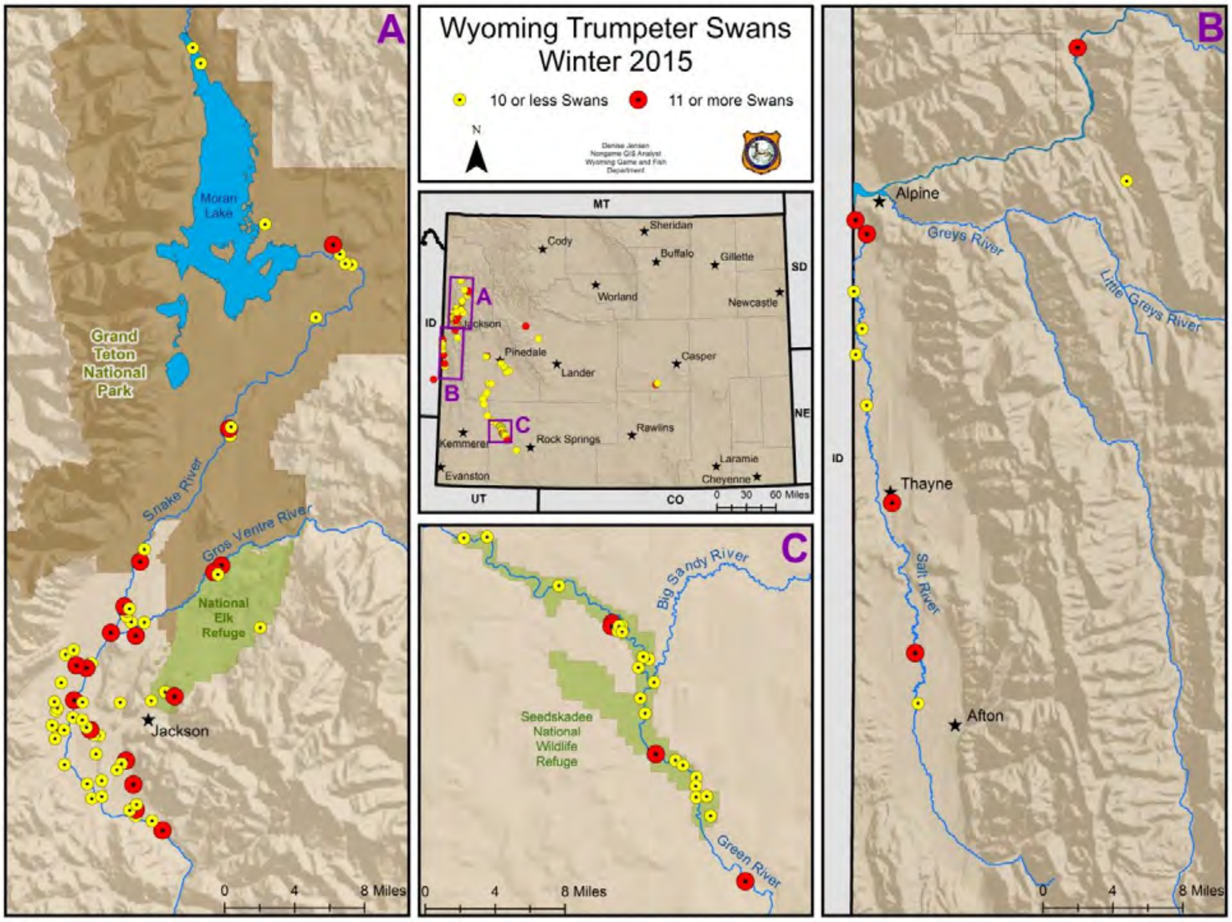

Figure 1. Locations of wintering Trumpeter Swans (*Cygnus buccinator*) in Wyoming documented during the annual winter aerial survey flown 11 February 2015 (Green River) and 12 February 2015 (Snake and Salt River drainages). Prior to management efforts beginning in the late 1980s to increase the distribution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

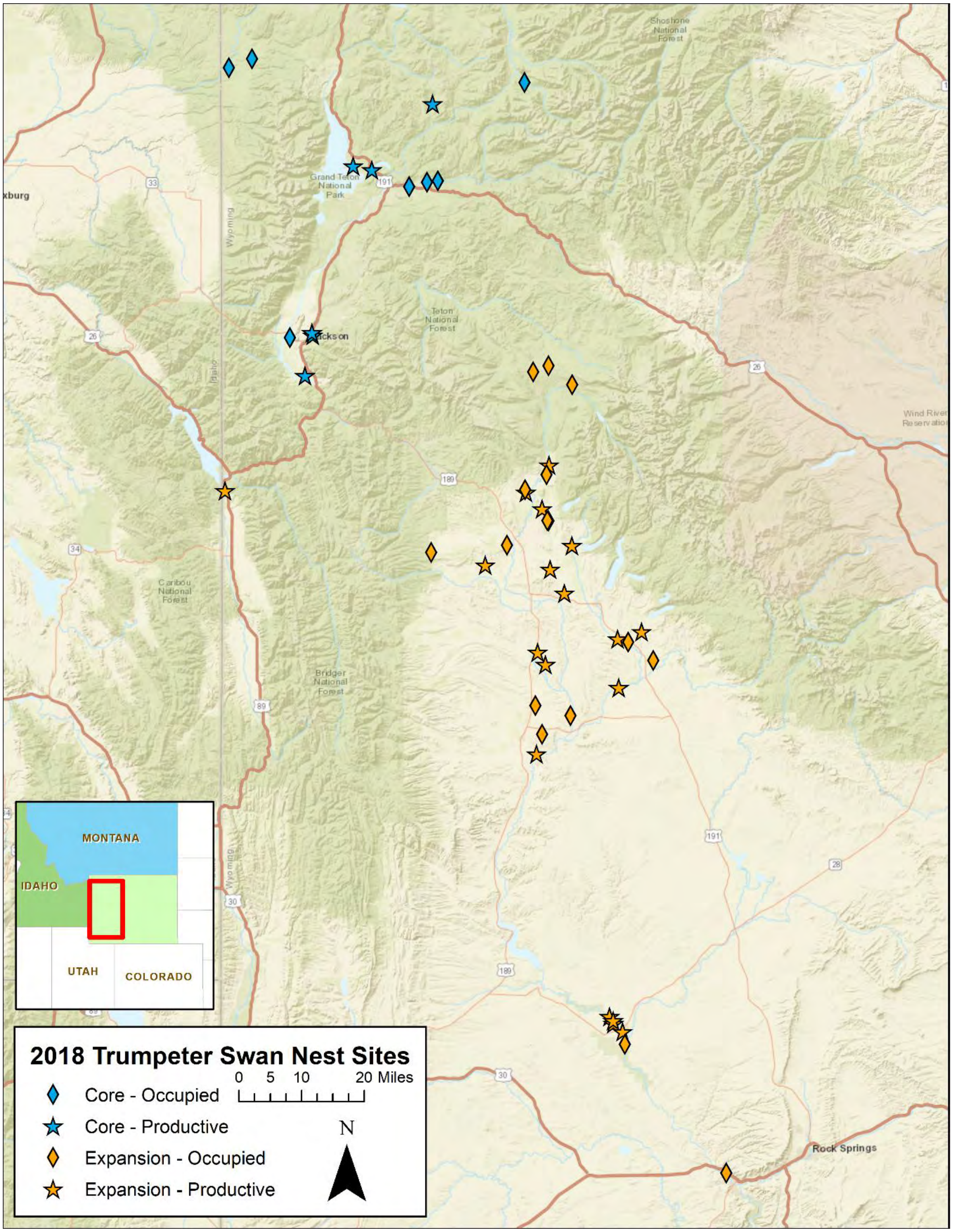

Figure 2. Locations of all wetland sites occupied in 2018 by a pair of Trumpeter Swans (*Cygnus buccinator*) in Wyoming. Pairs did not build nests and lay eggs at all occupied sites. Blue symbols indicate sites located in the core Snake River area and orange symbols show sites found in the range expansion area of Wyoming.

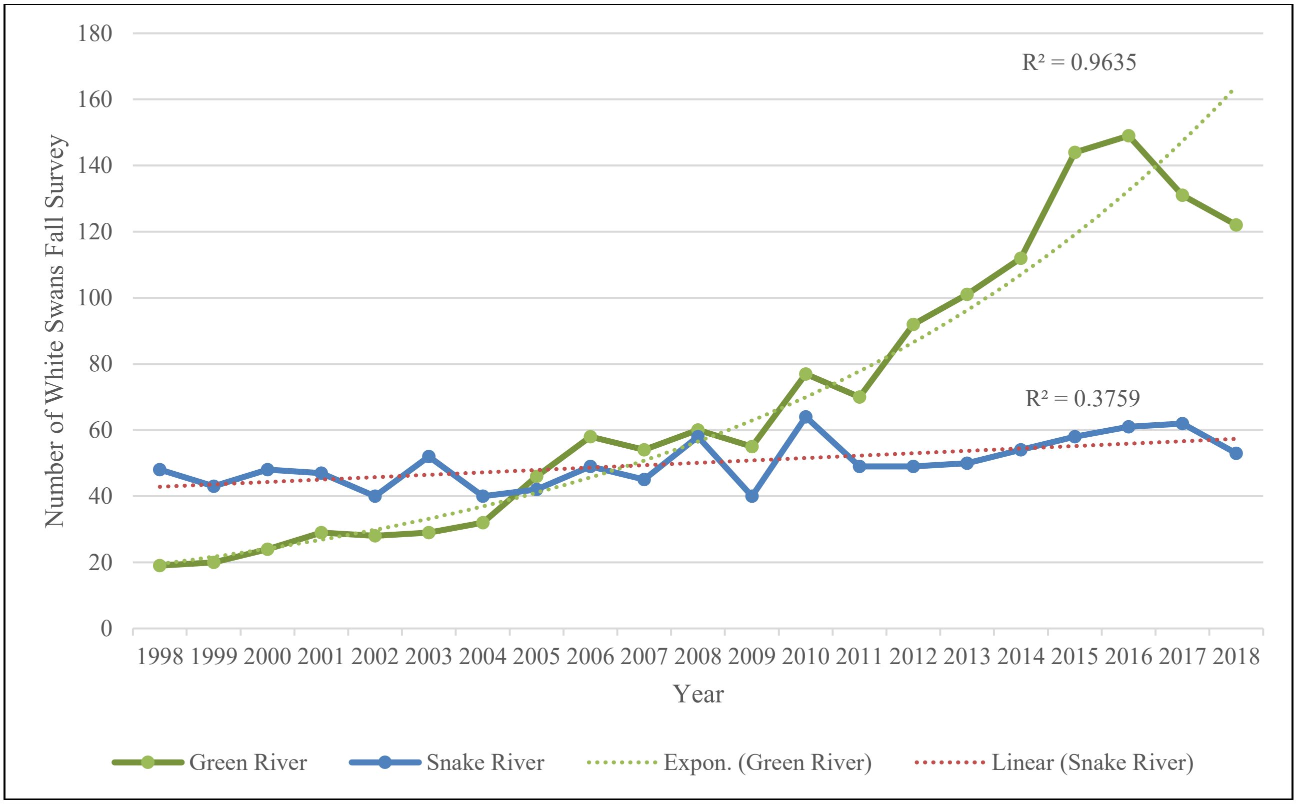

Figure 3. Comparison of the number of white swans (adults and subadults combined) counted on the annual fall aerial survey in September in the Snake River core area and the Green River expansion area in western Wyoming, 1998-2018.

Figure 4. Aerial photo of a flooded swan nesting area in Grand Teton National Park along the Snake River north of Jackson Lake taken on June 1. (Photo by S. Patla)

Appendix I. Annual summary of occupancy and production status for all known Trumpeter Swan (*Cygnus buccinator*) nests in Wyoming outside Yellowstone National Park, 2007-2018 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	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
CTNF												
Ernest Lake	---	---	---	---	---	---	---	---	---	---	---	
Bergman Marsh	---	---	---	---	---	---	---	---	---	---	---	
Indian Lake	N44	O	N40	N30	N30	N41	O	OL	NB	NB	---	OL
Widget Lake	---	---	---	---	---	---	---	---	---	---	---	
Winegar Creek			N30	N20	N30	1A	N20	N40	N10	O	1A	N00
Winegar Creek East	New in 2016									N20	N00	---
Loon Lake	---	---	---	OL	---	---	---	---	---	F	---	
Rock Lake	---	O	---	---	---	---	---	---	---	F	---	
Rock Lake Slough				N41	---	---	---	1A	---	---	---	---
Junco Lake	---	---	O	---	---	---	---	---	F	---	O	O
Fish Lake	---	---	---	---	---	---	---	---	---	---	---	
Squirrel Meadows	---	---	---	---	---	---	---	---	---	---	---	
Moose Lake	---	---	---	---	---	---	---	---	---	---	---	
GTNP												
Upper Glade	---	---	---	---	---	---	---	---	---	---	---	
Steamboat Mountain	O	O	OL	O	O	OL	N21	O	---	---	1A	---
Glade Cliff Slough	O	N00	O	O	O	N11	N22	N00	N33	N32	O	1A
Glade South	O	---	---	---	---	---	O	---	F	NB	---	
Flagg Gravel Pit Ponds					---	---	O	---	---	---	---	---

Appendix I. Continued.

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Arizona Lake	N00	N00	N30	N20	N20	N00	---	O	OM	OL	---	---
Emma Matilda	---	1A	OL	OL	OL	OL	O	---	O	OL	---	N11
Swan Lake	OM	N22	O	OM	N55	O	O	O	OM	N21	N21	N22
Colter Slough	New in 2016									N00	N00	---
Christian Pond	---	---	---	---	---	---	---	---	---	---	---	N33
Hedrick Pond	O	---	---	---	---	---	---	---	---	---	---	
Elk Ranch	O	O	O	OL	OL	O	O	OM	OM	O	O	1A
Spread Creek Ponds	---	---	---	---	---	---	N20	1A	---	---	---	---
Halfmoon BV GTNP					N44	----	OL	---	1A	OL	1A	---
NER												
Highway Pond NER	N55	---	---	N00	---	---	---	---	---	---	---	
NE Marsh NER	NB	O	---	---	O		N22	---	OM	NB	---	
Flat Creek Island NER			N00	N10	N00	N00	N20	N53	N30	---	---	N33
SE Marsh NER	N42	N00	N11	---	O	N11		N11		N22	---	
Central Marsh NER	N57	N33	O	N55	N00	N11	N22	N22	N32	N21	N22	
Elk Jump Pond NER						N00	N00	N44	N00	N24	N63	N43
Pierre's Ponds	---	---	---	NB	O	---	---	OL	F	NB	O	---
Romney Ponds	N44	N44	N43	NB	O	NB	1A	OL	OM	O	O	
Bill's Bayou							OL	---	---	---	---	
Jackson area												
Skyline/Puzzleface	---	---	---	NB	NB	NB	OL	NB	O	O	O	O
WGF South Park	OM	OM	N44	N66	N44	N55	N43	N55	N55	O	N65	N22
Pinto Pond Buffalo Valley	N66	N44	N54	OM	N11	N00	N44	N44	N40	N44	N42	N00
Blackrock Slough BTNF						N60	N60	N20	N00	---	---	---
Tracy Lake BTNF		OL	OL	OL	OL	NB	NB	NB	NB	O	O	O

Appendix I. Continued.

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Teton Wilderness												
Enos Lake BTNF	NB	NB-3	---	NB	NB	NB	1A	1A	---	---	OL	OL
Atlantic Creek BTNF	---	---	NC	OUID	O	N00	N22	NC	N00	O	N01	N00
Gravel Lake BTNF										N?2	N20	N21
Salt River												
Clark's Barn Area Pond									OL	O	O	---
Alpine Wetland North	N00	---	NB	NB	NB	NB	NB	NB	NB	---	---	---
Alpine Wetland South	NB	O	N00	N00	N21	N00	O	N00	N00	O	N21	N20
Jacknife Creek Area						O	---	---	---	---	---	OL
Grover Site									N00	---	---	OL
Gros Ventre River												
Lower Slide Lake	---	---	---	NB	NB	---	NB	---	NB	---	---	
Upper Slide Lake	OM	OM	OM	OM	O	O	O	O	O	O	O	---
Blue Miner Pond BTNF	New in 2016									N50	OL	OL
Burnt Fork	---	---	NB	---	---	---	---	---	---	---	---	
Soda Lake	---	---	---	---	---	---	---	---	---	---	---	
Green/New Fork Rivers												
Wagon Creek Lake	---	NB	---	---	---	---	---	---	---	NB	---	OL
Rock Crib	---	NB	---	---	---	---	---	O	---	NB	---	O
Wagon Creek Pothole	N00	---	---	N42	O	O	---	---	---	---	---	
Mosquito Lake	N32	N00	N00	O	OL	O	O	N22	N44	O	OL	O
Pothole north of Mosquito									O	O	O	
Roaring Fork Pond	---	---	---	---	---	---	---	---	---	---	---	
Mud Lake	N52	OE	---	OL	O	N00	O	O	N33	N40	N00	O
Dollar Lake Slough									O	1A	---	---

Appendix I. Continued.

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Circle S Slough				N00	---	NB	---	N11	N22	N00	O	---
Jensen Pond, Green River						O	---	---	---	NB	---	N11
Carney Oxbow	N44	N00	N00	N22	N00	O	O	O	N22	N11	O	
Carney Pond			N30	---	---	---	---	O	N11	N00	N11	N00
O Bar Y Reservoir	O	O	---	---	---	---	---	---	---	---	---	1A
O Bar Y Pond	New in 2012					N44	N33	N44	N32	N33	N00	N55
Marsh Creek Pothole	N22	---	---	---	---	---	---	---	---	---	O	---
Kendall Wetland	OL	N11	N33	OM	O	N44	N00	N22	N32	N00	N21	N00
Blatt Res. Willow Creek						NB	O	O	NB	O	O	N42
Kitchen Main	N54	N53	N11	N22	N32	N43	N00	N33	N44	N22	N40	N00
Kitchen Middle	OM	O	N22	N55	N43	---	---	N43	O	O	O	
Fenn Duck Creek Pond								O	N10	N00	N00	N11
Seven Mile Ranch pond									O	---	O	---
40 Rod Creek Slough				F	NB	NB	N20	O	---	O	---	---
Vichory Reservoir						NB	N11	NB	O	N20	N20	O
Webb Draw				F	N00	N10	N22	N20	N20	N22	N00	N20
MoCroft Lane, Pinedale						N00	---	O	N22	N33	N44	
Fayette New Fork	N33	N40	N00	---	N33	N55	N52	---	---	---	---	---
Boulder Creek Slough												N11
Swift New Fork		N54	OL	N33	OL	NB	NB	N00	N22	N11	N33	N00
Barden Slough	---		---	---	---	---	---	---	---	---	---	---
Swift Reservoir	OL	NB	NB	OL	O	N21	N33	N11	N21	N33	N22	
EF Hunt Club/FH					N11	N21	N33	N00	N66	NB	O	---
Jensen Slough North Fork		OL	O	N22	O	N21	O	N11	N00	N33	OL	N44
Sommers Green River						O	N30	NB	---	---	O	---

Appendix I. Continued.

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cottonwood Creek Mouth						NB	---	---	---	NB	---	---
Rimfire Rendezvous						NB	NB	NB	NB	---	---	---
Rimfire Sophia/ Alexander						OL	NB	O	NB	---	---	N11
Soaphole BLM Pond						NB	N44	NB	N44	N00	O	N44
Muddy Creek, North Big Piney						NB	---	O	N44	N66	N54	O
Piney Cutoff Reservoir										N22	N10	O
Ferry Island	N22	N33	N00	N44	OL	N22	N22	N22	N43	N33	O	N22
Shafer Slough	---	---	NB	NB	---	NB	---	---	O	OL	OL	
Reardon Draw					N11	NB	---	OL	---	---	---	
Voorhees Pond	---	OL	---	N00	O	O	N40	O	NB	O	N22	---
LaBarge Creek Pond					O	----	---	---			---	---
Steed Canyon	New in 2015								N00	N00	O	---
Hoback Rim Pond	New in 2017										O	---
Big Sandy River												
Big Sandy Reservoir	---	NC	---	---	---	---	---	NC	NB	---	---	
Eden Reservoir				1A	1A	NB2	---	NC	---	---	---	
Farson area				N22	O	O	---	NC	NB	NB	N00	
Seedskadee NWR												
Hamp Unit	O	N00	N00	N42	N42	N00	N22	N65	N55	N33	N55	N00
Block House Isle	New in 2015								N00	---	---	---
Hawley 1	N22	N33	N43	NB	O	N55	O	O	O	N22	N22	N43
Hawley 2	N33	N66	N44	N55	N44	N66	N44	N20	N41	N33	N24	N11
Hawley 2 S				N43	N33	---	N33	O	N00	O	---	
Hawley 3	NB	NB	---	NB	O	---	---	---	O	NB	O	---

Appendix I. Continued.

Site	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Hawley 4												N44
Hawley 5			N33	NB	NB	---	---	---	O		---	
Hawley 6	NB	NB	---	N44	N22	N55	N22	N66	N44	N33	N00	---
Sage Pools	N31	N33	N75	N42	N22	N77	N55	N55	N22	N43	N33	N55
Dunkle Wetland									N11	N?0	N66	O
Big Island									NB	NB	1A	---
Phosphate plant											N?2	
Green River Town										N?2	O	O
Other Wyoming												
Swamp Lake, Cody	---	NC	NC	NC	---	---	NC	NC	NC	NC	NC	
Trail Lake, Dubois	---	---	---	---	---	---	---	---	NC	NC	NC	
Dinwoody Lake				F	---	---	---	---	NC	NC	O	
Lake Julia				O	1A	---	---	---	NC	NC	NC	
Martens Pond, Wind River					O	---	N55	N33	---	1A	O	
Alkali Lake, Wind River								NB	NB	NB	O	
Colony, Eastern WY	---	---	NC	NC	OL	NB	---	NC	NC	NC	NC	

IMPLEMENTATION OF THE STANDARDIZED NORTH AMERICAN MARSH BIRD MONITORING PROTOCOLS FOR SPECIES OF GREATEST CONSERVATION NEED IN WYOMING: YEAR 4 SUMMARY

STATE OF WYOMING

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

FUNDING SOURCE: Wyoming Game and Fish Department Commission Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

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. 2016) 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 2017). 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 along 5 survey routes on the Cokeville Meadows National Wildlife Refuge (CMNWR; Refuge) in western Wyoming to determine presence and evaluate population trend of American Bitterns over time.

In 2015, we eliminated 3 of the survey routes on the CMNWR 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 along which these surveys were located. However, due to willing participation by 2 landowners with property adjacent to the Refuge, we were able to add 2 new routes in place of the routes we eliminated for a total of 4 routes on the Refuge (Figure 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 7 new survey routes (Yellowtail Wildlife Habitat Management Area [WHMA], *n* = 3; Table

Mountain WHMA, *n* = 1; Ocean Lake WHMA, *n* = 1; Dad Wetland, *n* = 1; and Hutton Lake NWR, *n* = 1) for a total of 11 routes in 6 wetland sites across Wyoming (Figures 2-13).

In 2015, we initiated an annual monitoring program for the American Bittern at these sites, and included 3 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 occupancy in Wyoming. Furthermore, the Virginia Rail is classified as a SGCN NSSU, Tier III in Wyoming due to restricted population size and distribution (WGFD 2017).

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. A summary of the species detected in 2018, the 4th survey year, is presented in Table 1.

ACKNOWLEDGEMENTS

Funding for these surveys is provided by the Wyoming Game and Fish Department Commission, for which we are extremely grateful. We would 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. Special thanks are extended to E. Pope and T. Teichert for supporting this monitoring program by giving us permission to conduct surveys on their private lands. Thanks to C. Conway, US Geological Survey, for assistance with questions regarding the Standardized North American Marsh Bird Monitoring Protocols. We thank Department GIS Analysts D. Jensen and N. Whitford for producing the survey maps. Lastly, we greatly appreciate the survey efforts of J. Altermatt, F. Calderon, and S. Rhine, Wyoming Game and Fish Department.

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Wyoming Game and Fish Department [WGFD]. 2017. State Wildlife Action Plan. Wyoming Game and Fish Department, Cheyenne, Wyoming, USA.

Table 1. Target species we detected during secretive marsh bird surveys on 11 routes in Wyoming, 2018. Surveys were conducted between 17 May and 29 June 2018. We attempted to conduct 3 replicates per survey route, with a minimum of 2 weeks between each replicate. Morning surveys started by 0530 and ended by 0730. Evening surveys started by 2015 and ended by 2145.

Route name (surveyor)	1st replicate 2018	Target species (number)	2nd replicate 2018	Target species (number)	3rd replicate 2018	Target species (number)
Dad Wetland (Brad Rogers)	Not conducted due to inclement weather	--	Not conducted due to inclement weather	--	Not conducted due to inclement weather	--
Ocean Lake (Andrea Orabona; Stephanie Rhine)	Not conducted due to other surveys	--	30 May	AMBI (0) PBGR (2) SORA (0) VIRA (0)	30 June	AMBI (0) PBGR (1) SORA (2) VIRA (2)
Pixley (Andrea Orabona)	Not conducted due to other surveys	--	Not conducted due to other surveys	--	29 June	AMBI (2) PBGR (0) SORA (10) VIRA (0)
Pope (Andrea Orabona)	Not conducted due to other surveys	--	Not conducted due to other surveys	--	Not conducted due to flooded conditions	--
Rush Lake (Flor Calderon)	25 May	AMBI (1) PBGR (2) SORA (0) VIRA (1)	8 June	AMBI (0) PBGR (7) SORA (0) VIRA (0)	26 June	AMBI (0) PBGR (6) SORA (0) VIRA (0)
Table Mountain (Flor Calderon)	25 May	AMBI (0) PBGR (10) SORA (6) VIRA (3)	8 June	AMBI (0) PBGR (11) SORA (1) VIRA (1)	27 June	AMBI (0) PBGR (3) SORA (0) VIRA (2)
Teichert (Andrea Orabona)	Not conducted due to other surveys	--	Not conducted due to other surveys	--	Not conducted due to flooded conditions	AMBI (2) PBGR (0) SORA (4) VIRA (0)

Table 1. Continued.

Route name (surveyor)	1st replicate 2018	Target species (number)	2nd replicate 2018	Target species (number)	3rd replicate 2018	Target species (number)
Thornock (Andrea Orabona)	Not conducted due to other surveys	--	Not conducted due to other surveys	--	28 June	AMBI (7) PBGR (0) SORA (14) VIRA (5)
Yellowtail East (Jerry Altermatt)	17 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	26 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	8 June	AMBI (0) PBGR (0) SORA (0) VIRA (0)
Yellowtail South (Jerry Altermatt)	31 May	AMBI (0) PBGR (0) SORA (0) VIRA (0)	15 June	AMBI (0) PBGR (0) SORA (0) VIRA (0)	29 June	AMBI (0) PBGR (0) SORA (2) VIRA (0)
Yellowtail West (Jerry Altermatt)	25 May	AMBI (0) PBGR (0) SORA (0) VIRA (2)	15 June	AMBI (0) PBGR (0) SORA (0) VIRA (0)	29 June	AMBI (0) PBGR (0) SORA (3) VIRA (0)
Total routes = 11 *Total replicates conducted out of 33 = 19*	*Highest total count of target species for all routes combined: AMBI = 12, PBGR = 20, SORA = 41, VIRA = 13*					

Key to species codes:

Species codes – target species	Common name	Scientific name
AMBI	American Bittern	*Botaurus lentiginosus*
PBGR	Pied-billed Grebe	*Podilymbus podiceps*
SORA	Sora	*Porzana carolina*
VIRA	Virginia Rail	*Rallus limicola*

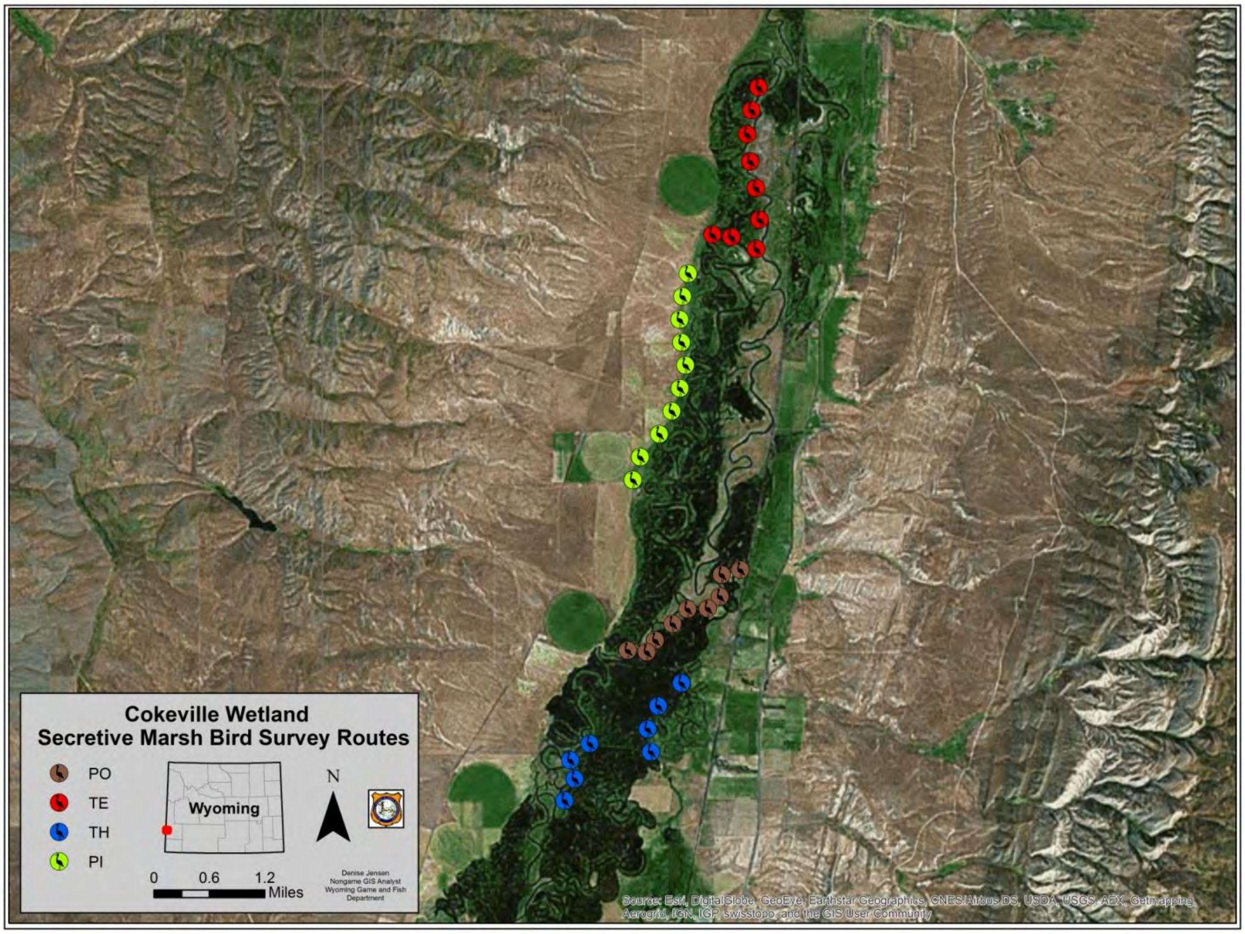

Figure 1. Locations of secretive marsh bird survey routes we established on and adjacent to the Cokeville Meadows National Wildlife Refuge (CMNWR) in Wyoming using the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). PO = Pope route (private land), TE = Teichert route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

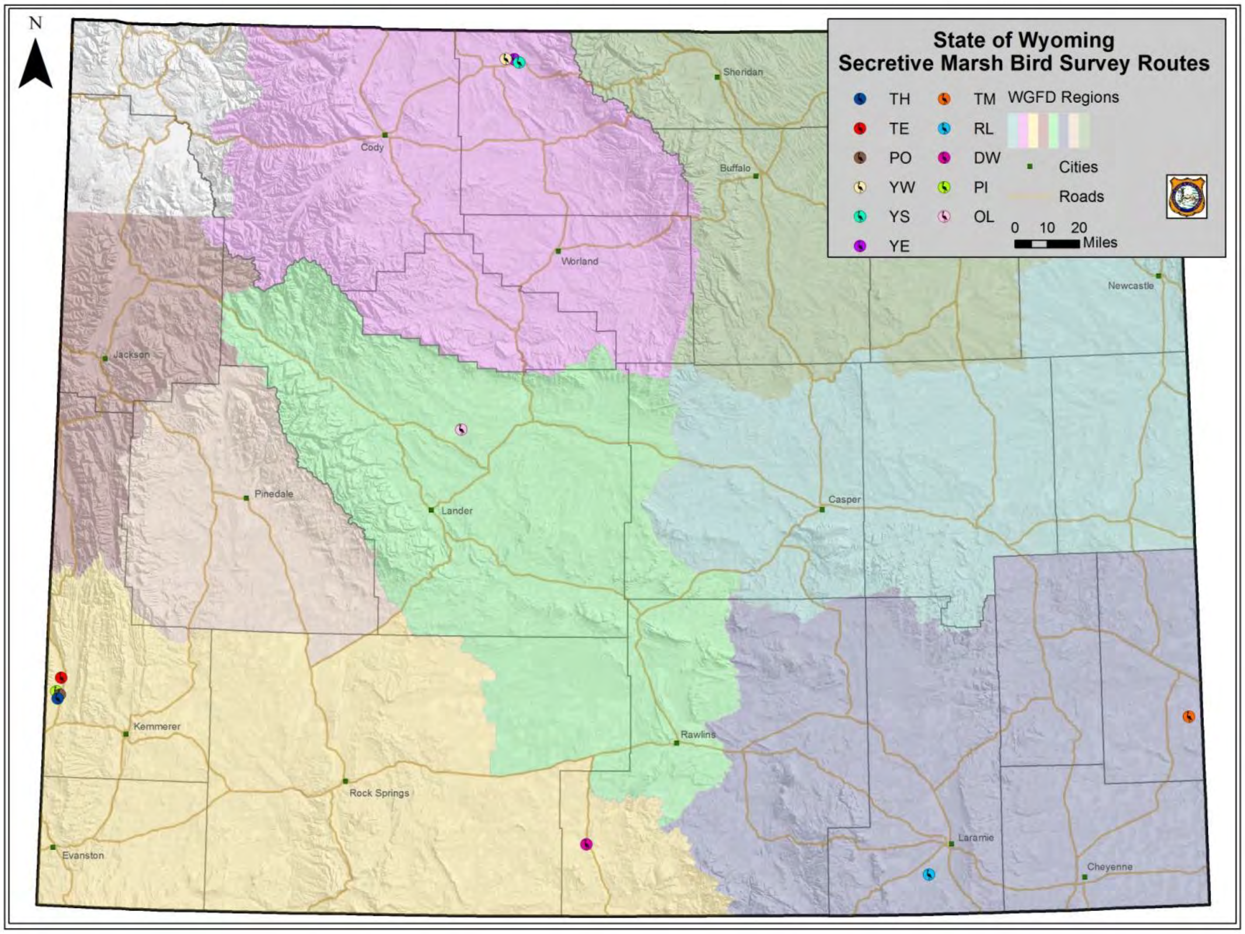

Figure 2. Statewide secretive marsh bird survey route locations we established in 2014 and 2016 in suitable wetland habitat for implementing the Standardized North American Marsh Bird Monitoring Protocol (Conway et al. 2009). DW = Dad Wetland route, PI = Pixley route, PO = Pope route, OL = Ocean Lake route, RL = Rush Lake route, TE = Teichert route, TH = Thornock route, TM = Table Mountain route, YE = Yellowtail East route, YS = Yellowtail South route, YW = Yellowtail West route.

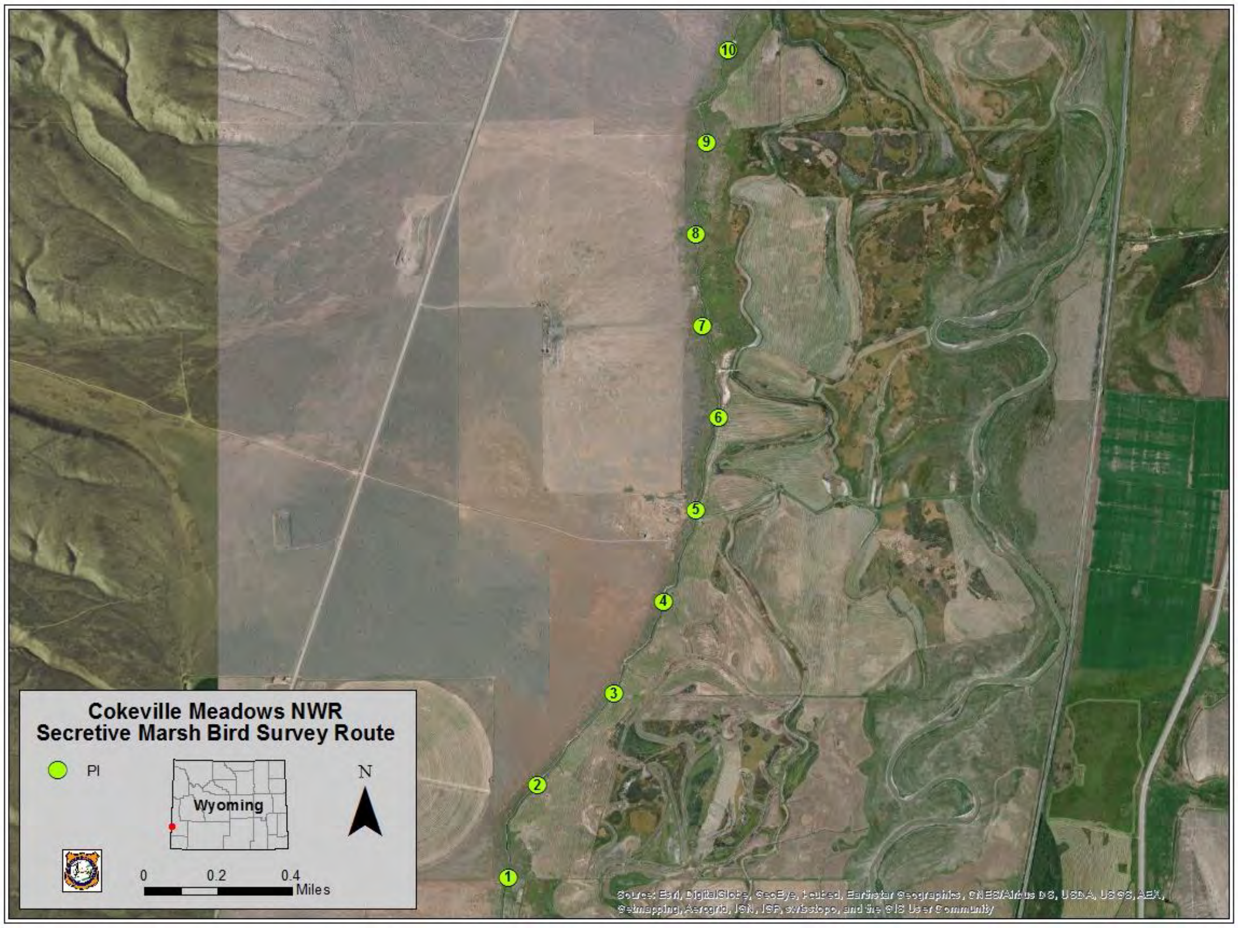

Figure 3. Location of the Pixley secretive marsh bird survey route we established on the Cokeville Meadows National Wildlife Refuge, Wyoming.

Figure 4. Location of the Pope secretive marsh bird survey route we established near the Cokeville Meadows National Wildlife Refuge, Wyoming.

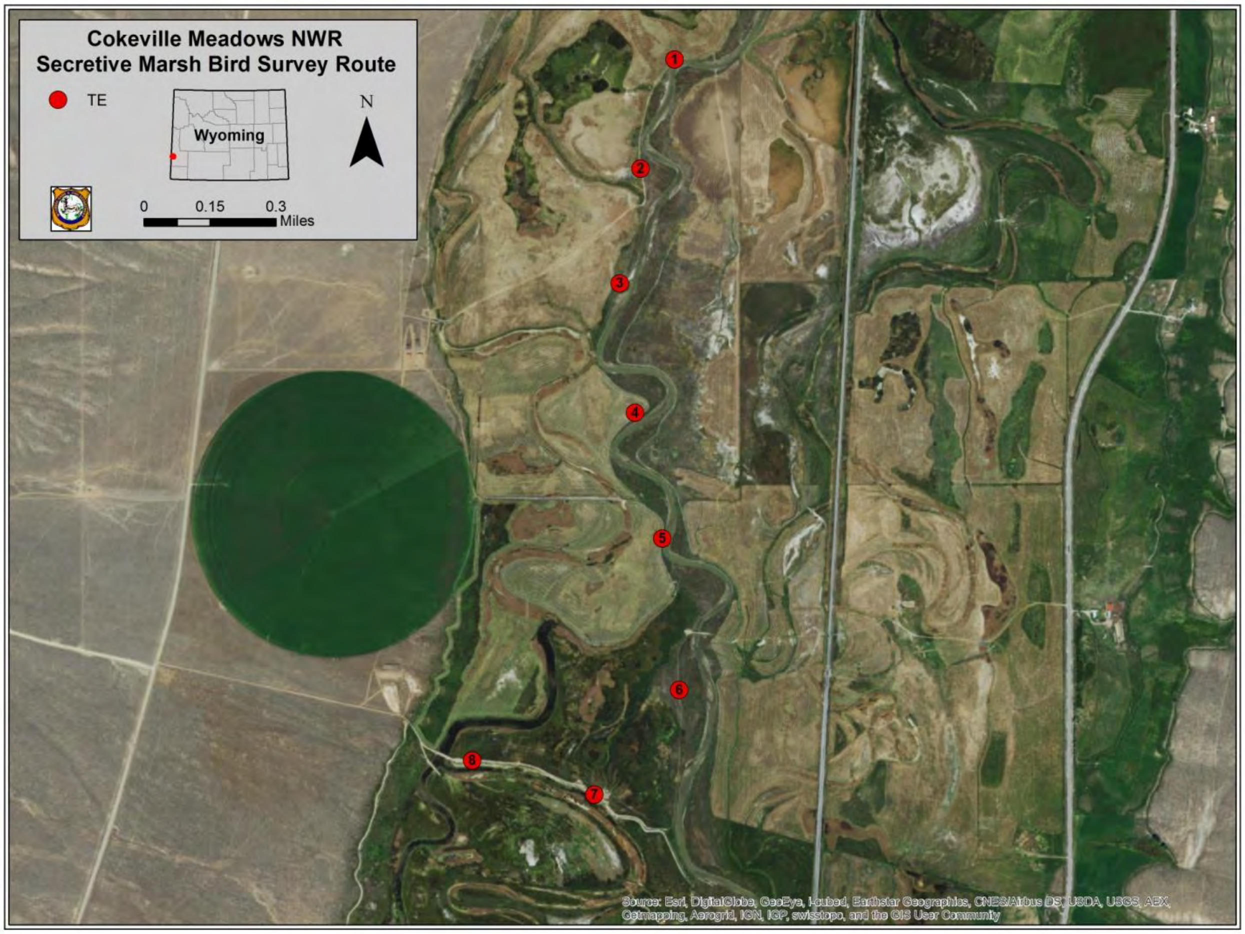

Figure 5. Location of the Teichert secretive marsh bird survey route we established near the Cokeville Meadows National Wildlife Refuge, Wyoming.

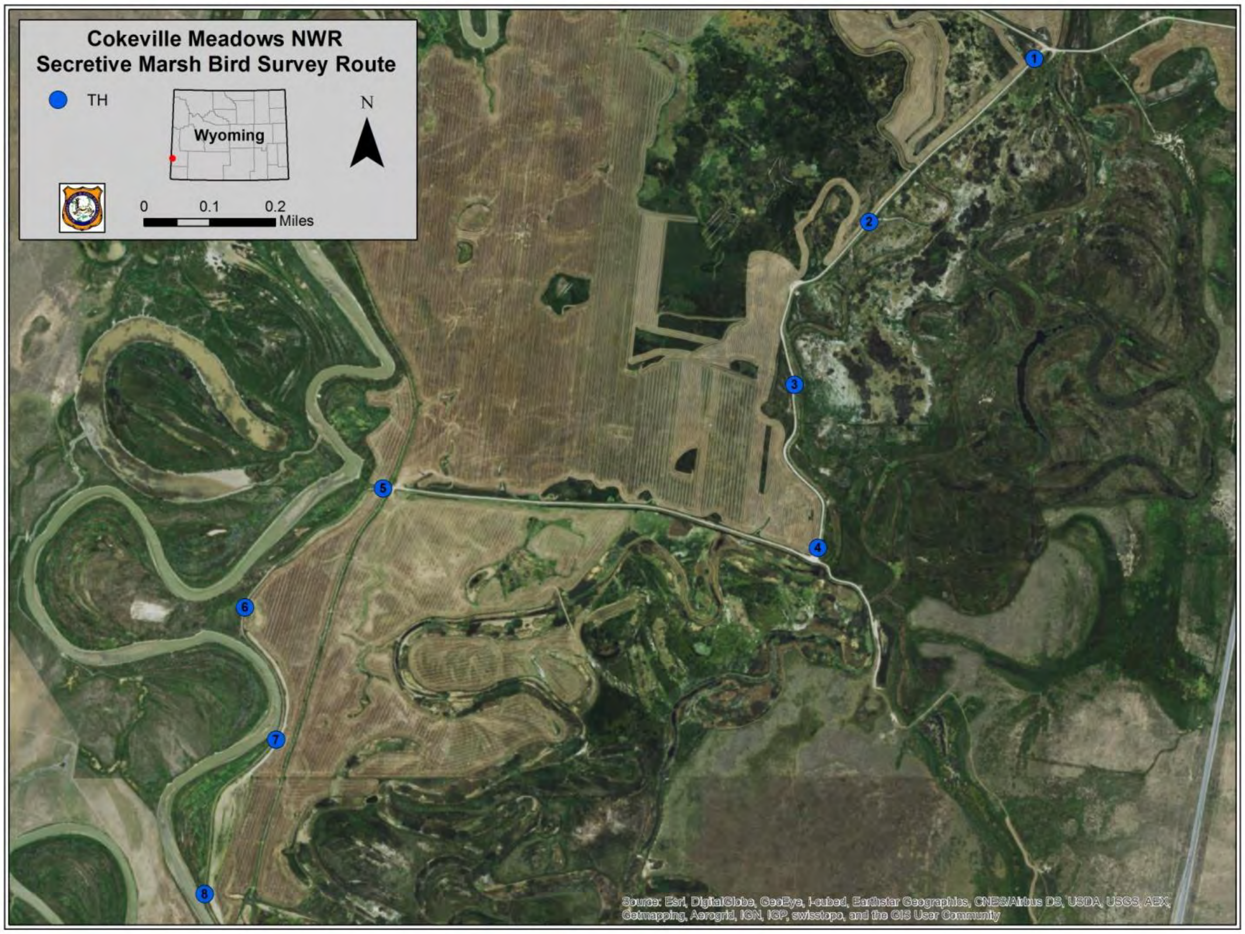

Figure 6. Location of the Thornock secretive marsh bird survey route we established on the Cokeville Meadows National Wildlife Refuge, Wyoming.

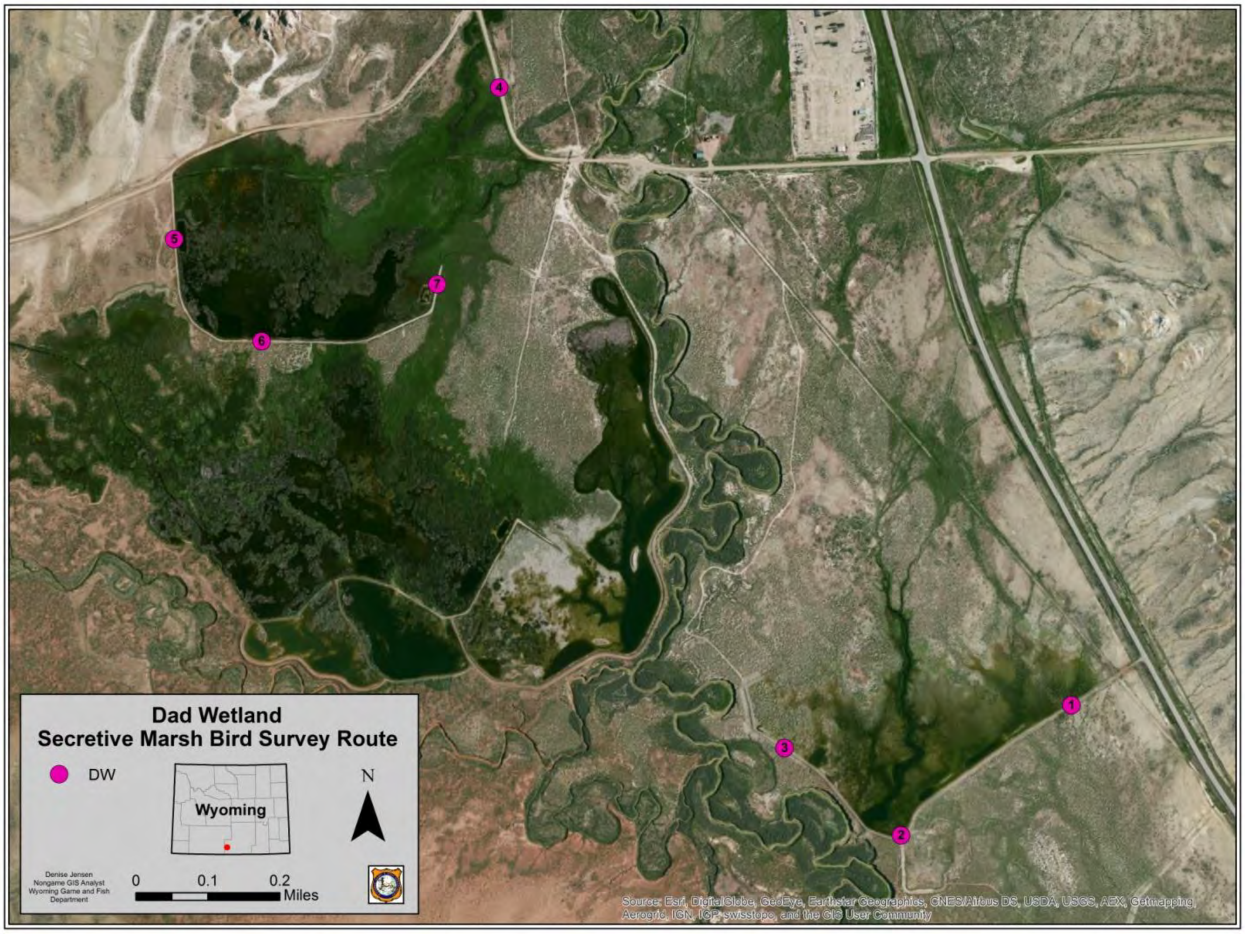

Figure 7. Location of the Dad Wetland secretive marsh bird survey route we established near Baggs, Wyoming.

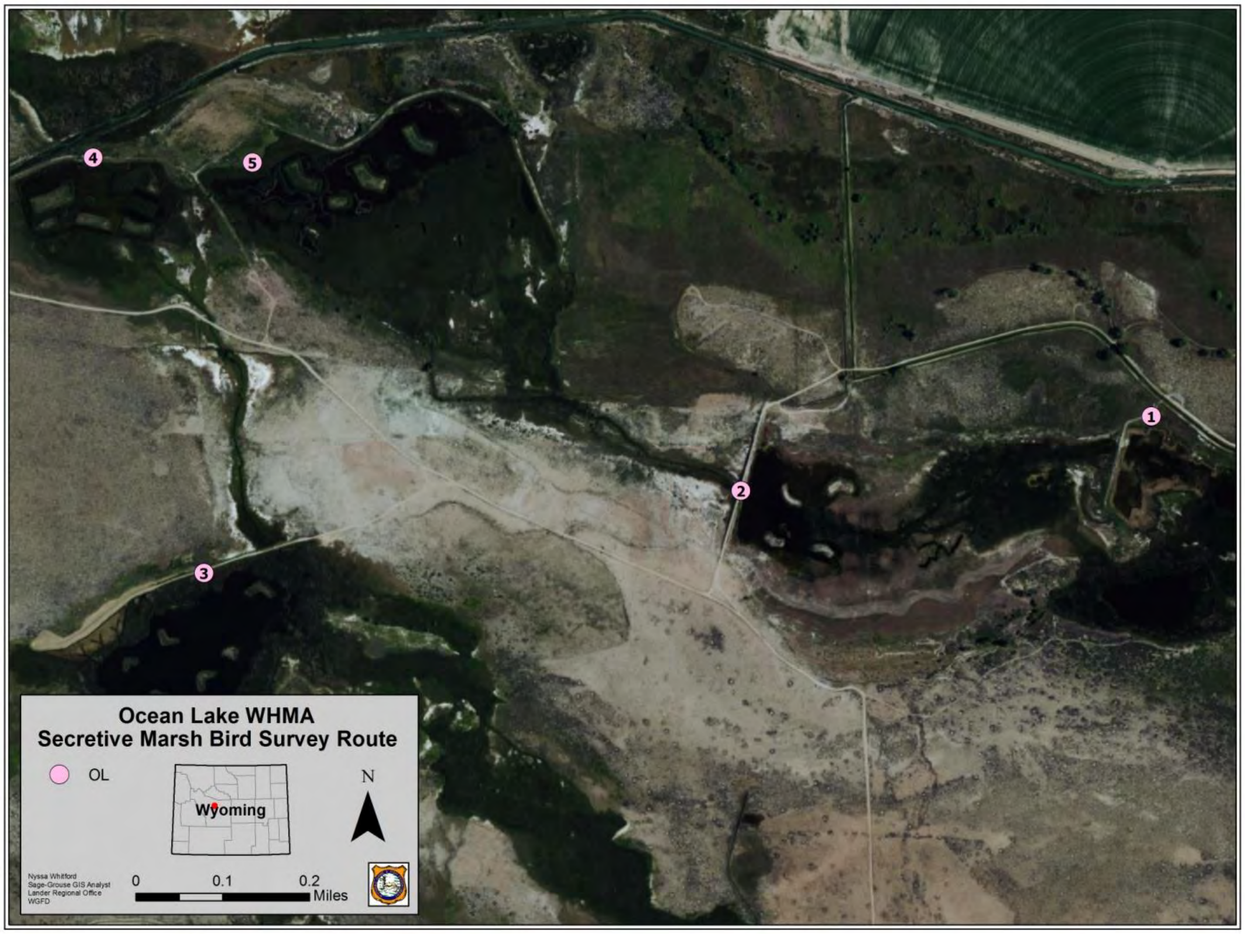

Figure 8. Location of the Ocean Lake secretive marsh bird survey route we established on the Ocean Lake Wildlife Habitat Management Area, Wyoming.

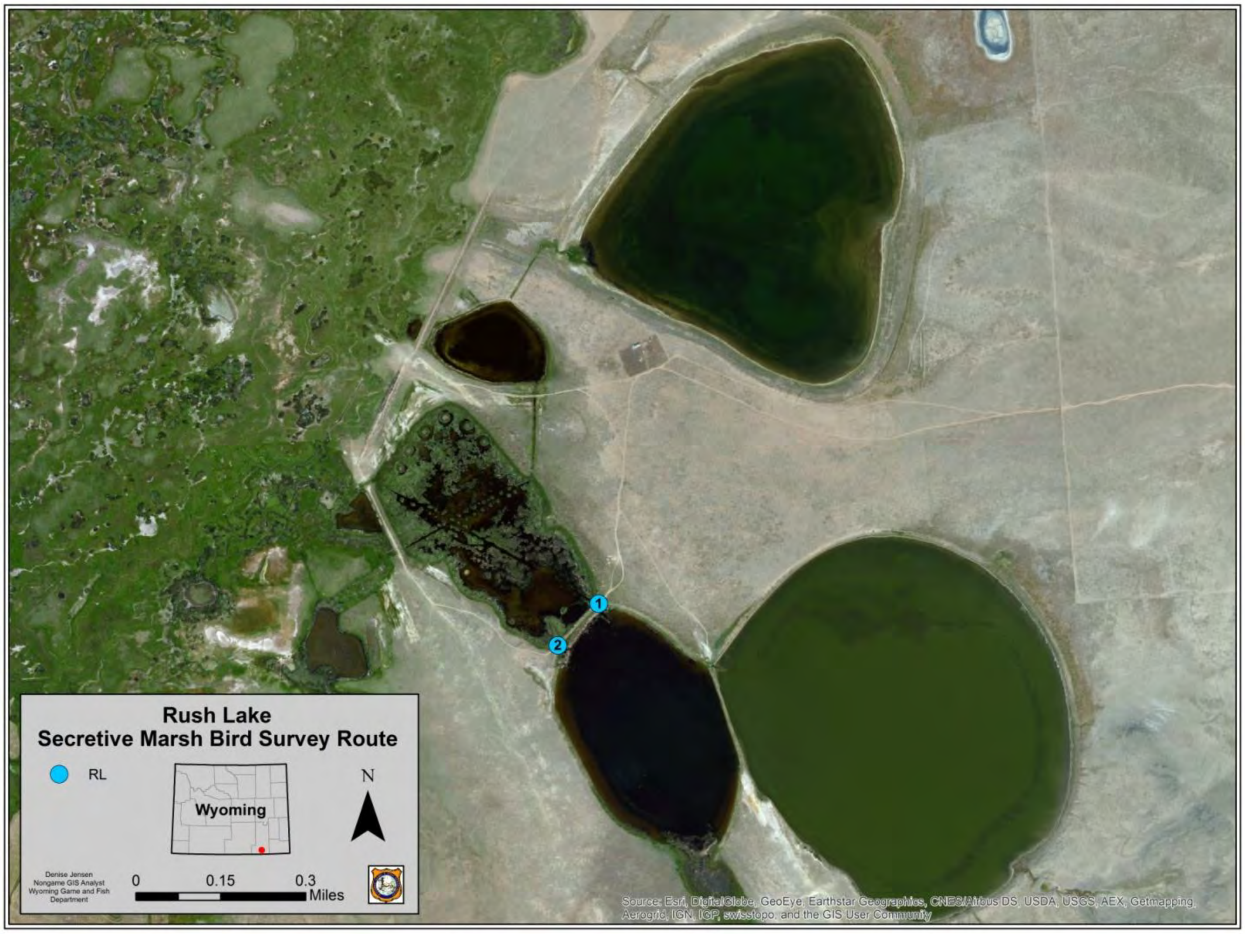

Figure 9. Location of the Rush Lake secretive marsh bird survey route we established on the Hutton Lake National Wildlife Refuge, Wyoming.

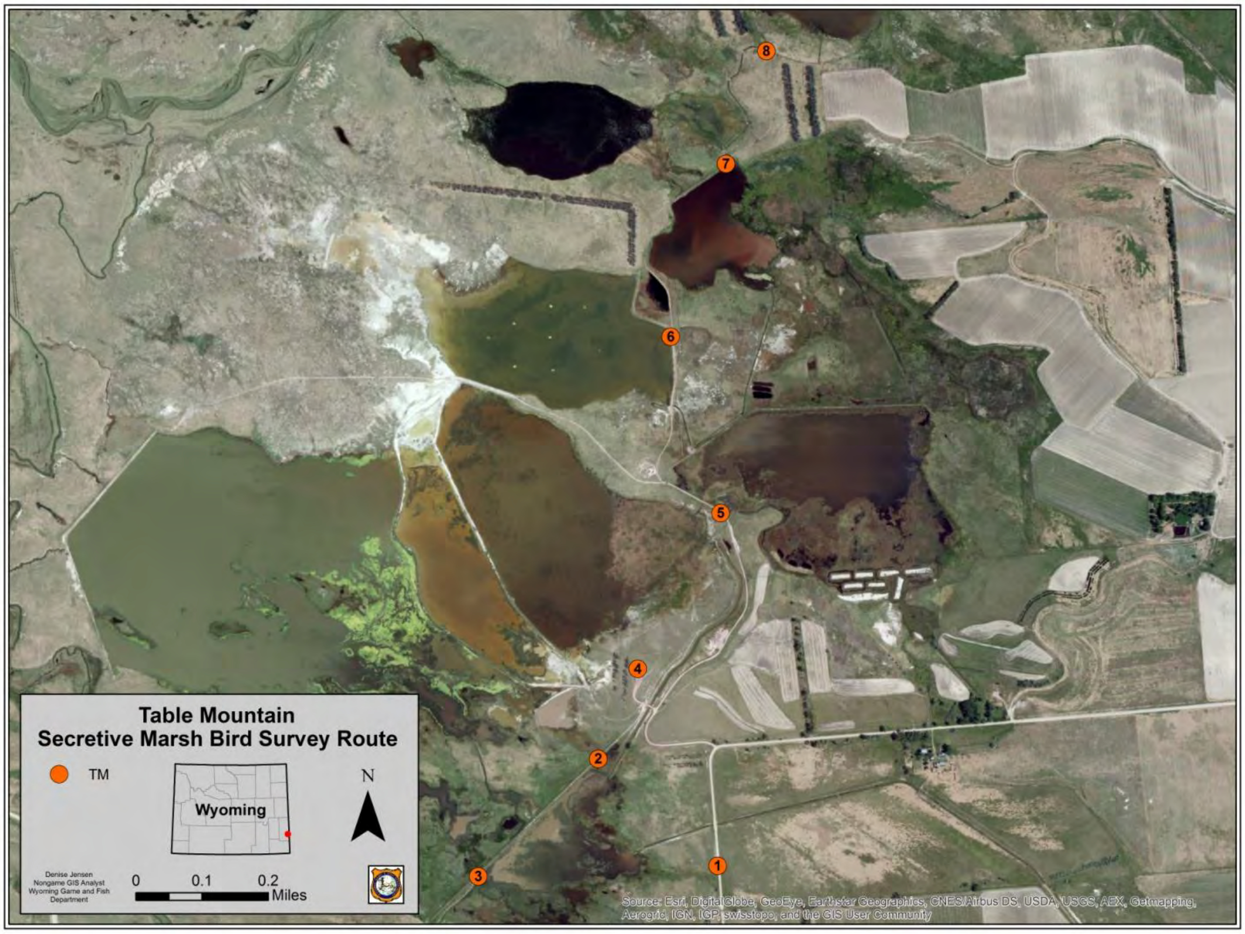

Figure 10. Location of the Table Mountain secretive marsh bird survey route we established on the Table Mountain Wildlife Habitat Management Area, Wyoming.

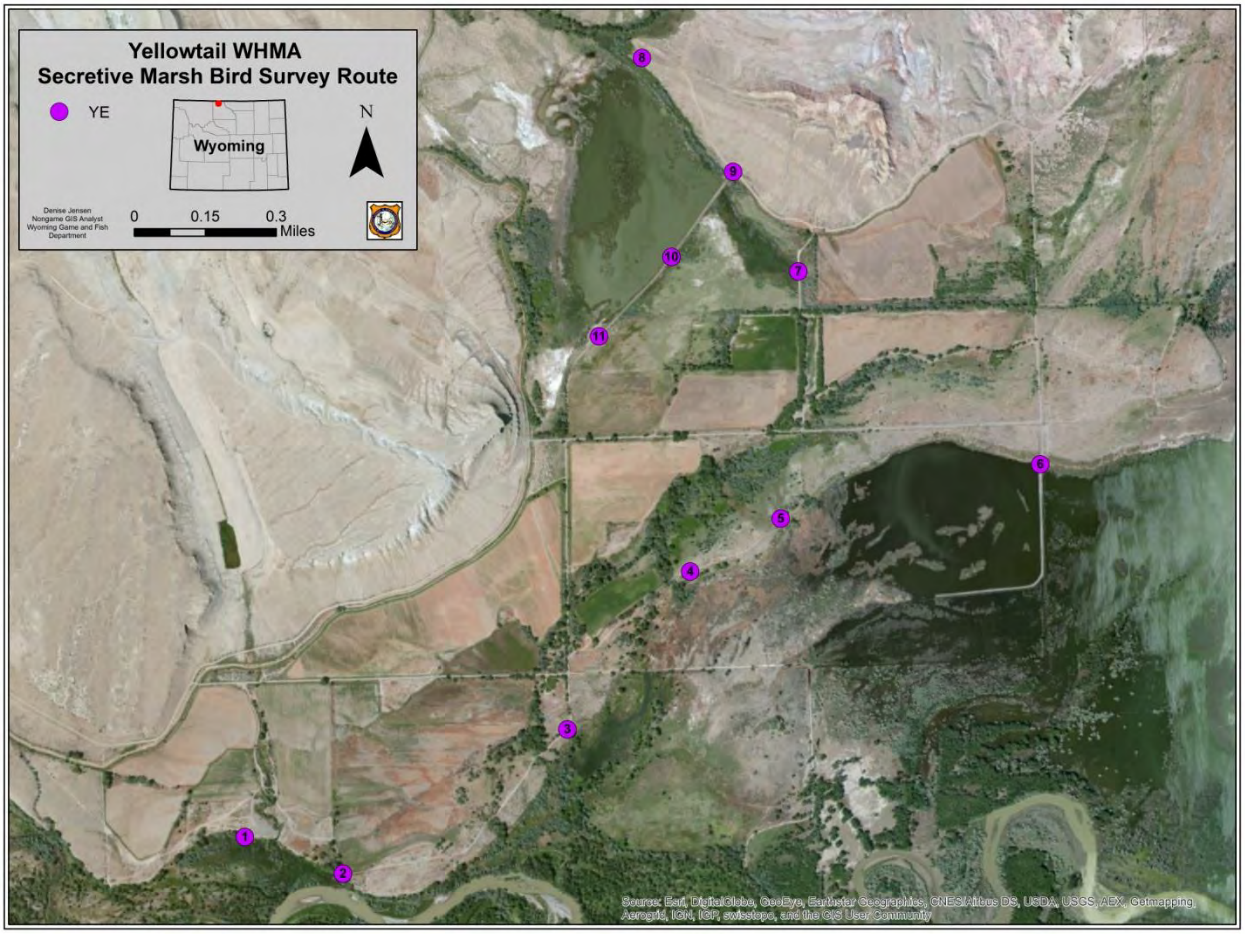

Figure 11. Location of the Yellowtail East secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

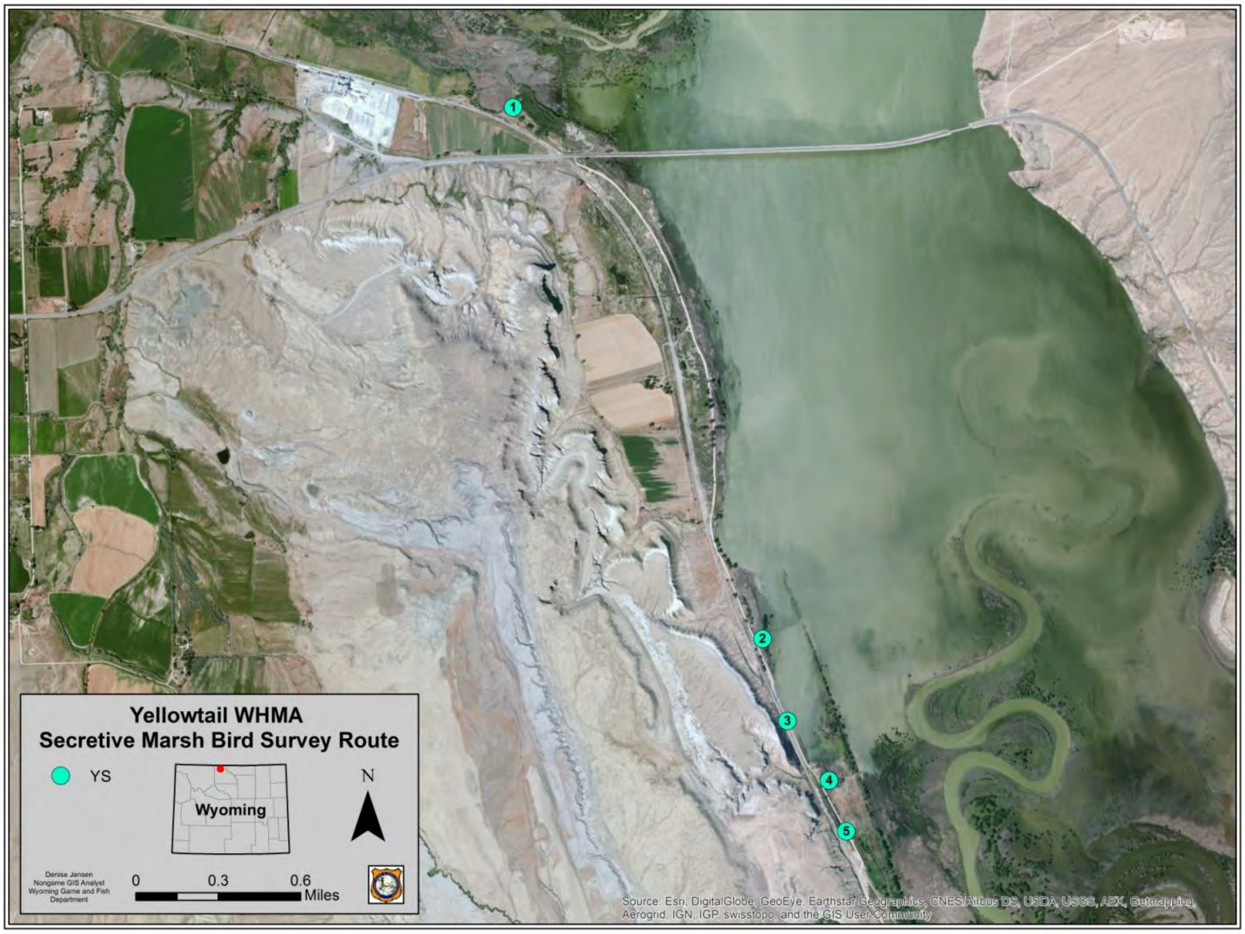

Figure 12. Location of the Yellowtail South secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

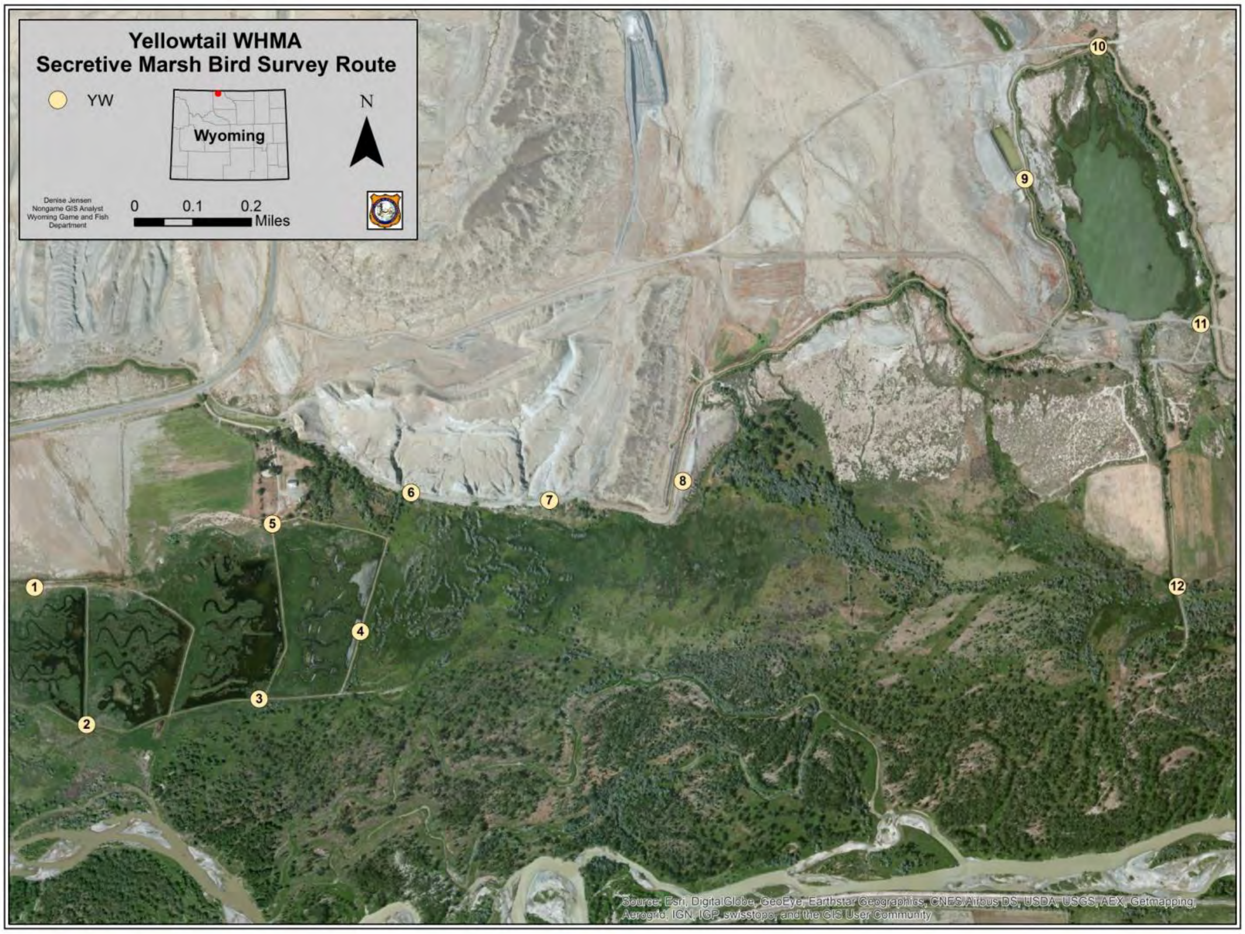

Figure 13. Location of the Yellowtail West secretive marsh bird survey route we established on the Yellowtail Wildlife Habitat Management Area, Wyoming.

LONG-TERM MONITORING OF AVIAN GRASSLAND SPECIES OF GREATEST CONSERVATION NEED IN WYOMING: SUMMARY OF YEAR 4 RESULTS

STATE OF WYOMING

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

FUNDING SOURCE: Wyoming Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 1 April 2018 – 31 August 2019

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Courtney Rudd, Nongame Biologist

SUMMARY

Grasslands are known to be among 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, shrubsteppe, and wetlands (Mengel 1970; Table 1; Figure 1). All 9 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 (*Buteo regalis*), Prairie Falcon (*Falco mexicanus*), and Burrowing Owl (*Athene cunicularia*) 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 1 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 2017). Two grassland endemics—Mountain Plover (*Charadrius montanus*) and Long-billed Curlew (*Numenius americanus*)—and 2 secondary grassland associates—Upland Sandpiper (*Bartramia longicauda*) and Burrowing Owl—are classified as SGCN in the SWAP (WGFD 2017; 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 4 avian SGCN, 3 of which are classified as Native Species Status Unknown (NSSU; WGFD 2017) 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 4 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. 2016) with a NSSU, Tier I classification in the SWAP (WGFD 2017). 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 2 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. 2016) with a NSSU, Tier II classification in the SWAP (WGFD 2017). 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. 2016) with a NSS3, Tier II classification in the SWAP (WGFD 2017). 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 1 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. 2016) with a NSSU, Tier I classification in the SWAP (WGFD 2017). 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.

Wyoming Governor's Endangered Species Account 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 (Figures 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 (2017). Moreover, avian grassland species are equally dependent on quality habitat in their breeding, migration, and winter ranges (Knopf 1996). 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.

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The Wyoming Game and Fish Department Commission provided funding for this project, for which we are extremely grateful. We also thank Governor Mead for providing funding assistance in 2013 and 2014 through the Wyoming Governor's Endangered Species Account, which enabled us to establish over 90 new survey routes for Species of Greatest Conservation Need. Thanks to Department GIS Analysts, Denise Jensen and Nyssa Whitford, for producing all survey maps. We extend special thanks to the numerous Department personnel for their valuable monitoring assistance; individuals are identified in each of the SGCN tables.

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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 2017). 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**	**NSS4, II**
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**	**NSSU, II**
Sprague's Pipit	*Anthus spragueii*	Migrant	
Chestnut-collared	***Calcarius ornatus***	**Summer**	**NSS4, II**
McCown's Longspur	***Rhynchophanes mccownii***	**Summer**	**NSS4, II**
Cassin's Sparrow	*Peucaea cassinii*	Accidental	
Lark Bunting	***Calamospiza melanocorys***	**Summer**	
Baird's Sparrow	***Ammodramus bairdii***	**Summer**	**NSS4, II**
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**	**NSSU, II**
Eastern Meadowlark	*Sturnella magna*	Accidental	
Western Meadowlark	***Sturnella neglecta***	**Summer**	

Table 2. Results from the 4th year of surveys for Mountain Plover (*Charadrius montanus*) in Wyoming. We planned to survey Mountains Plovers (MOPL) from the last 10 days of June through the 1st week of July in 2018, during the pre-fledging and brood-rearing phase. We attempted to conduct 1 Mountain Plover survey per route.

MOPL route	Assigned observer	Survey date	Total MOPL
Arminto	Heather O'Brien	2 July	0
Bucknum Road	Adam Parks	8 July	0
Bush Rim	Andrea Orabona	3 July	6
Fetterman Road	Flor Calderon	28 June	0
Great Divide Basin	Greg Hiatt	29 June	0
Laramie Basin	Lee Knox	22 June	0
Lysite	Greg Anderson	26 June	0
Marshall Road	Flor Calderon	26 June	0
Mexican Flats	Tony Mong	--	--
North Cody	Jerry Altermatt	6 July	--
Polecat Bench	Tim Woolley	--	--
Red Desert	Stan Harter	6 July	5
Shirley Basin	Will Schultz	25 and 27 June	0
Thunder Basin Central	Joe Sandrini	28 June	0
Thunder Basin North	Joe Sandrini	23 June	0
Thunder Basin South	Willow Bish	3 July	0
Total routes = 16		*Total Adult MOPL = 11*	

Table 3. Results from the 4th year of surveys for Upland Sandpiper (*Bartramia longicauda*) in Wyoming. We planned to survey Upland Sandpipers (UPSA) from early June to mid-July 2018, when they are on their breeding grounds in Wyoming. We attempted to conduct 2 surveys along each route using the same observer per route, with surveys separated by a minimum of 10 and maximum of 14 days to incorporate the range of the breeding season and facilitate detection.

UPSA route	Assigned observer	1st replicate	Total UPSA	2nd replicate	Total UPSA
Bariod Road	Flor Calderon	21 June	6	7 July	3
Douglas	Flor Calderon	26 June	5	10 July	0
East Sheridan	Dustin Shorma	10 July	3	none	--
East Yoder	Grant Frost	15 June	0	26 June	0
Glendo	Martin Hicks	5 July	2	none	--
Goldie Divide	Flor Calderon	6 June	0	22 June	12
Hulett West	Erika Peckham	30 June	1	14 July	0
Jireh Road	Willow Bish	13 June	0	23 June	3
Lusk North	Brady Vandeberg	9 June	0	19 June	0
Lusk South	Brady Vandeberg	13 June	0	23 June	0
Moorcroft	John Davis	14 June	8	29 June	8
Pleasantdale	Dustin Kirsch	14 June	2	none	--
Rockpile	Todd Caltrider	21 June	3	15 July	4
Rocky Point	Todd Caltrider	6 June	5	23 June	9
Seely	Chris Teter	5 July	4	16 July	0
West Sheridan	Bruce Scigliano	15 June	0	6 July	0
Total routes = 16		*Total UPSA = 39*		*Total UPSA = 39*	

Table 4. Results from the 4th year of surveys for Long-billed Curlew (*Numenius americanus*) in Wyoming. We planned to survey Long-billed Curlews (LBCU) during the pre-incubation and courtship stages, between 21 April and 15 May 2018, when birds are easier to detect. We attempted to conduct 2 surveys along each route using the same observer per route, with surveys separated by a minimum of 7 and maximum of 14 days.

LBCU route	Assigned observer	1st replicate	Total LBCU	2nd replicate	Total LBCU
Arvada	Stephanie Rhine	28 April	0	16 May	0
Beckton	Stephanie Rhine	29 April	0	14 May	0
Buffalo South	Cheyenne Stewart	8 May	0	16 May	0
Carpenter West	Flor Calderon	4 May	0	17 May	0
Chapman Bench	Tony Mong	26 April	2	15 May	4
Cheyenne River	Flor Calderon	25 April	0	8 May	0
Chugwater Flats	Ian Tator	none	--	none	--
Dull Center	Willow Bish	1 May	0	11 May	0
East Bill	Rod Lebert	10 May	0	16 May	0
Elk Refuge	Susan Patla	3 May	14	15 May	11
Glenrock East	Cody Bish	23 April	0	12 May	0
Goshen Hole	Ryan Amundson	none	--	none	--
Grand Teton	Aly Courtemanch	7 May	1	16 May	13
Harmony Heights	Stephanie Rhine	24 April	0	4 May	0
Hawk Springs	Stephanie Rhine	25 April	0	5 May	0
Heward Ranch	Flor Calderon	5 May	0	14 May	0
Horse Creek	Jill Randall	5 May	56	13 May	73
Huntley	Stephanie Rhine	26 April	0	6 May	0
Jay Em	Stephanie Rhine	23 April	0	3 May	0
Kaan Road	Brady Vandeberg	23 April	10	1 May	12
Lance Creek	Willow Bish	7 May	0	14 May	0
Little Medicine	Will Schultz	8 May	0	14 May	0
Meadowdale West	Martin Hicks	24 May	0	none	--
Meriden	Bob Lanka	29 April	0	15 May	0
Morrissey Road	Joe Sandrini	26 April	0	2 May	0
New Fork	Dean Clause	27 April	19	7 May	22
Node	Brady Vandeberg	25 April	0	4 May	0
Osage	Troy Achterhof	27 April	0	10 May	0
Veteran	Ryan Amundson	none	--	none	--
Weston	Erika Peckham	20 April	0	1 May	0
Wildcat South	Erika Peckham	23 April	0	16 May	0
Wyarno	Tim Thomas	21 April	0	4 May	0
Total routes = 32		*Total LBCU = 102*		*Total LBCU = 135*	

Table 5. Results from the 4th year of surveys for Burrowing Owl (*Athene cunicularia*) in Wyoming. We planned to survey for Burrowing Owls (BUOW) from 15 April to 7 August 2018 to encompass each of the 3 nesting stages (pre-incubation, incubation/hatching, and nestling). We attempted to conduct 3 surveys of each route, with each survey occurring during a 30-day survey window and separated from the previous survey by at least 10 days. Ad = adult BUOW, Juv = juvenile BUOW.

BUOW route	Assigned observer	1st replicate	Total BUOW	2nd replicate	Total BUOW	3rd replicate	Total BUOW
Agate Flat	Stephanie Rhine	20 April	0	4 June	0	17 July	0
Bar X	Patrick Burke	--	--	--	--	--	--
Fontenelle	Tom Christiansen	16 May	1 Ad	15 June	0	21 July	0
Greybull North	Leslie Schreiber	27 April	0	25 June	0	30 July	0
Hiattville West	Leslie Schreiber	3 May	3 Ad 1 nest	25 June	4 Ad 1 nest	31 July	7 Ad 3 nests
Jonah	Jordan Kraft	not run	--	not run	--	not run	--
North Dunes	Stephanie Rhine	7 May	2 Ad	4 June	2 Ad	10 July	--
North Huntley	Grant Frost	3 May	24 Ad 7 nests	2 June	11 Ad 1 nest	19 July	9 Ad 6 Juv 5 nests
Pinedale Mesa	Andrea Orabona	22 May	0	14 July	0	2 August	1 Ad 1 Juv 1 nest
South Wamsutter	Flor Calderon	24 April	0	29 June	0	25 July	0
Tipperary Road	Stephanie Rhine	14 May	2 Ad 1 nest	19 June	1 Ad 1 nest	weather ed out	--
Upton South	Joe Sandrini	16 May	0	25 June	0	25 July	1 Ad

Table 5. Continued.

BUOW route	Assigned observer	1st replicate	Total BUOW	2nd replicate	Total BUOW	3rd replicate	Total BUOW
Wamsutter	Flor Calderon	25 April	0	19 June	2 Ad	26 July	0
Wamsutter Highway	Flor Calderon	24 April	0	28 June	0	24 July	1 Ad
West Gillette	Erika Peckham	4 May	0	10 June	0	6 August	0
Wildcat Butte	Jeff Short	12 May	0	18 June	0	7 August	0
Total routes = 16		*Total BUOW = 32 adults 0 juveniles 9 nests*		*Total BUOW = 20 adults 0 juveniles 3 nests*		*Total BUOW = 19 adults 7 juveniles 9 nests*	

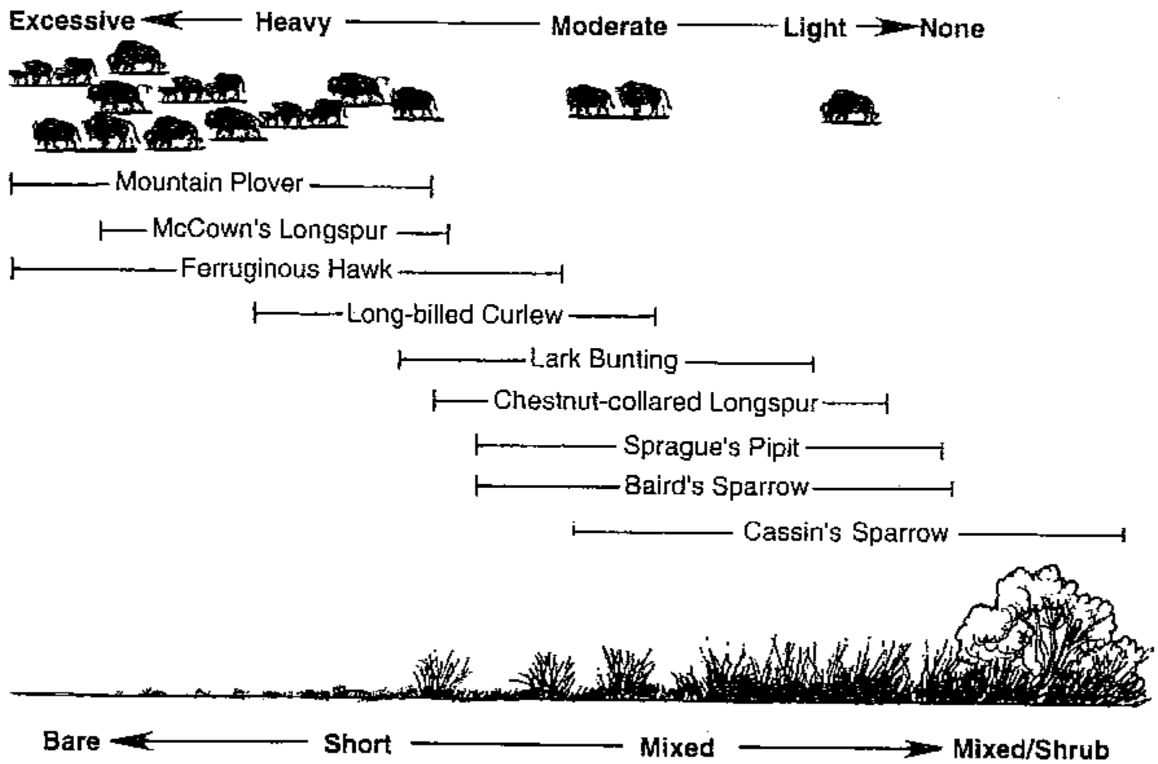

Figure 1. Distributions of avian species endemic to the Great Plains in relation to grassland type and historical grazing pressure (Knopf 1996).

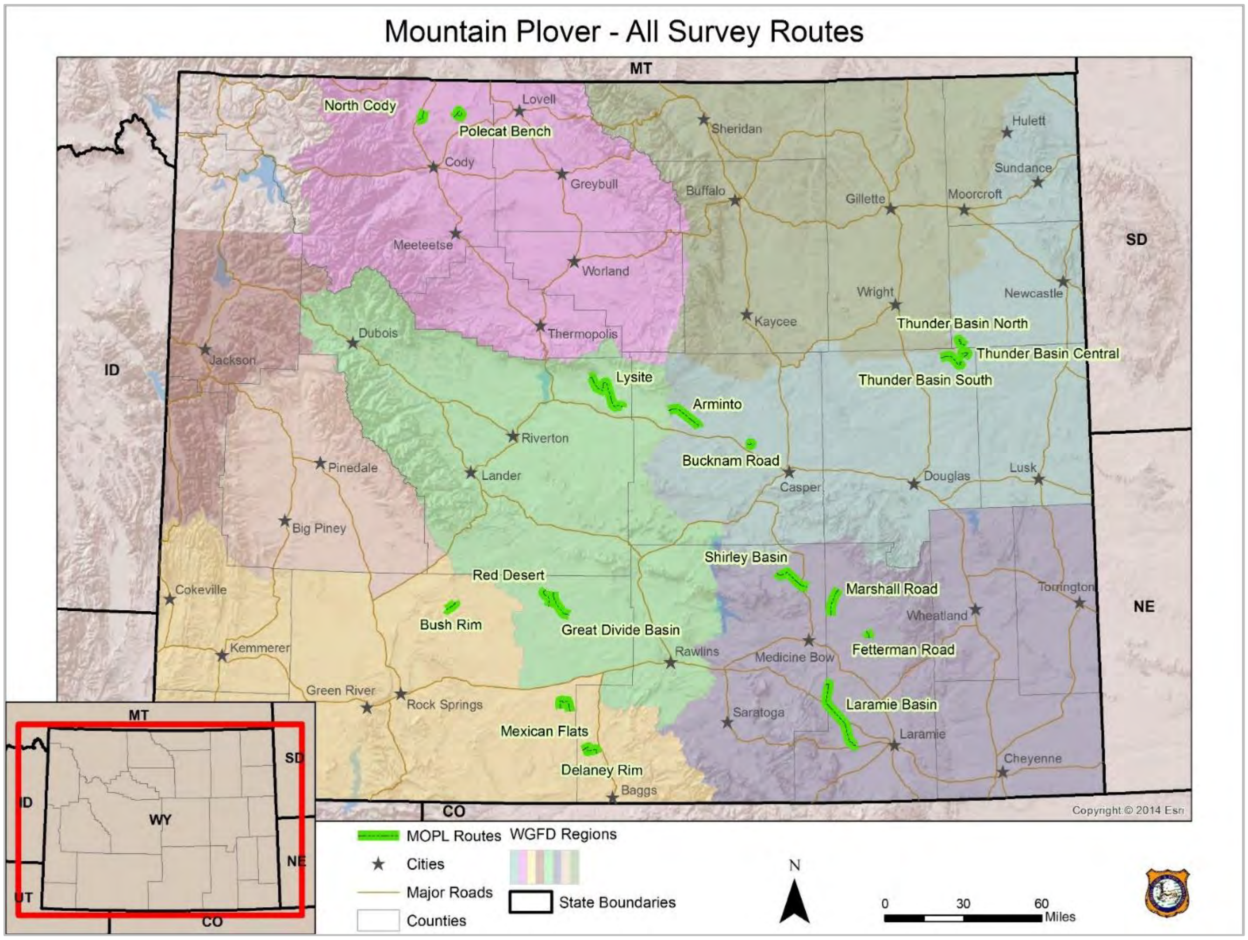

Figure 2. Survey routes we established for monitoring Mountain Plovers (*Charadrius montanus*) in Wyoming.

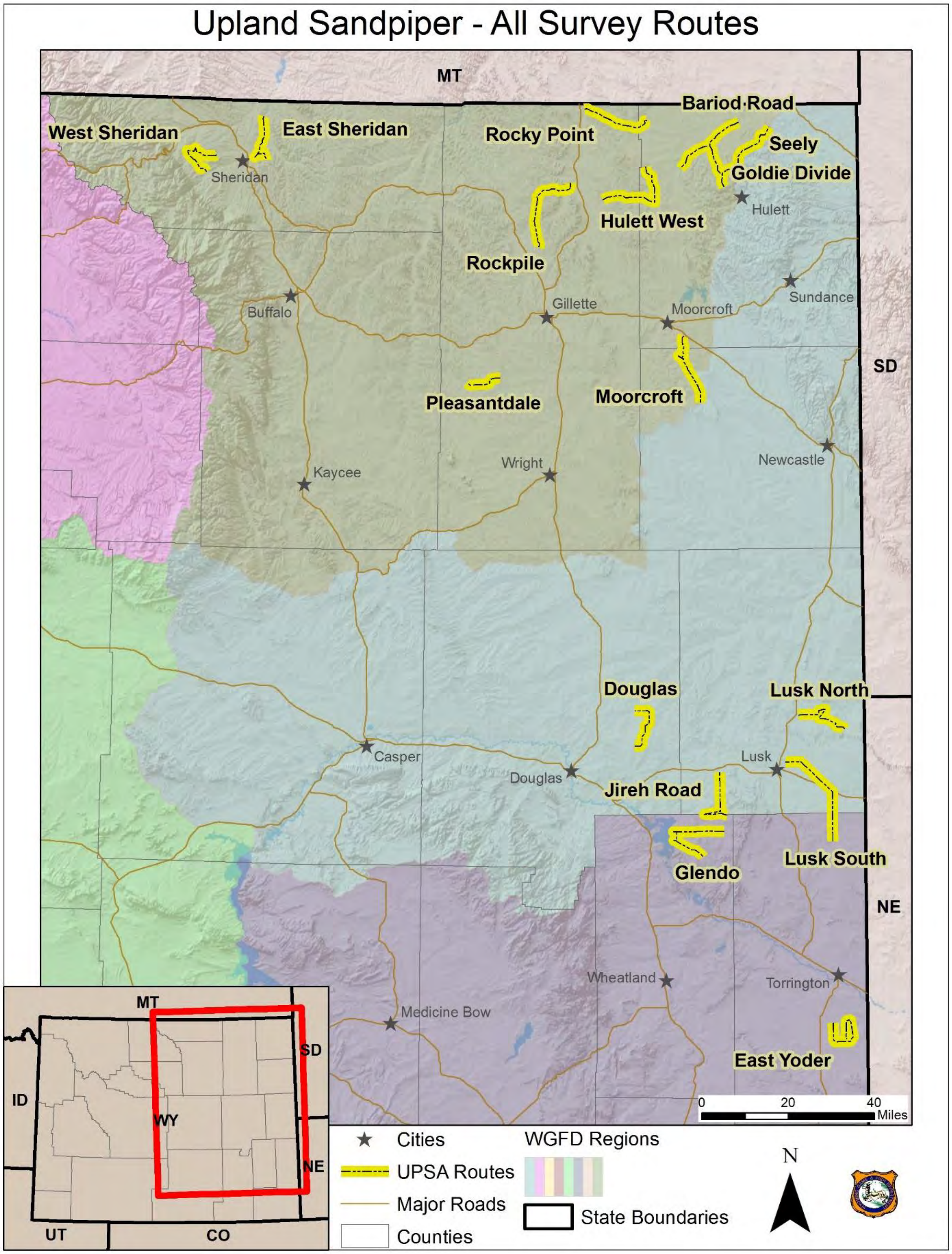

Figure 3. Survey routes we established for monitoring Upland Sandpipers (*Bartramia longicauda*) in Wyoming.

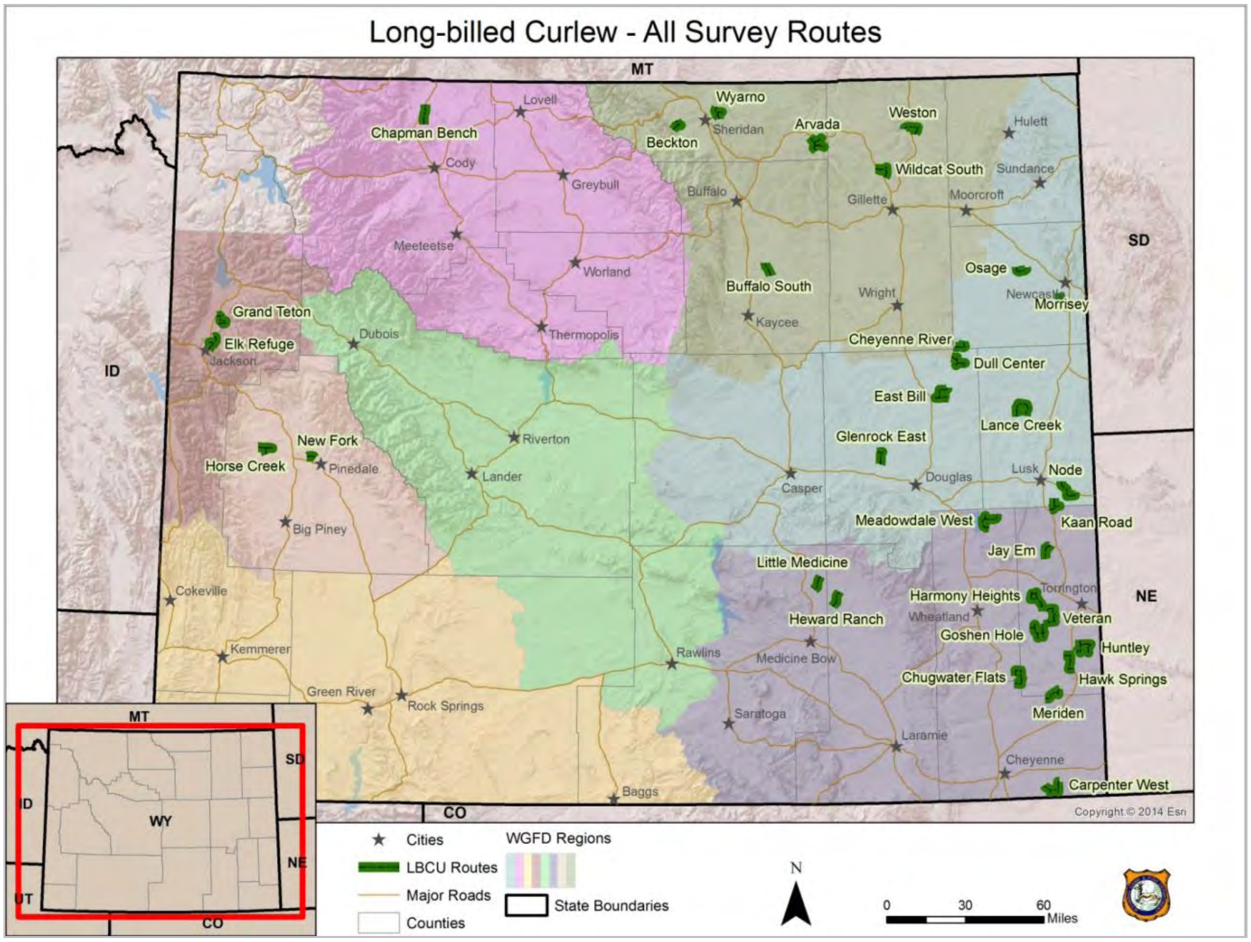

Figure 4. Survey routes we established for monitoring Long-billed Curlews (*Numenius americanus*) in Wyoming.

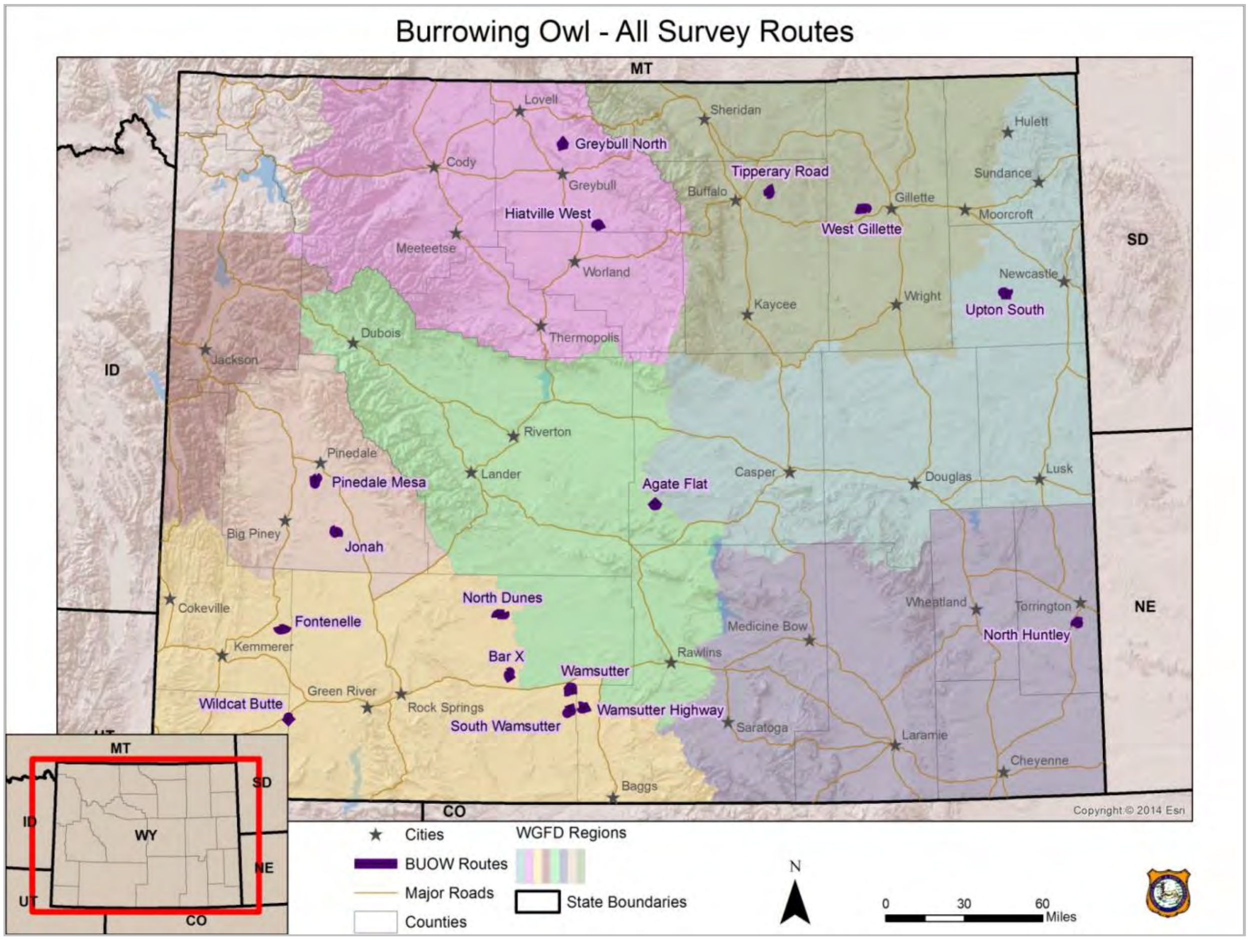

Figure 5. Survey routes we established for monitoring Burrowing Owls (*Athene cunicularia*) in Wyoming.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) MONITORING IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

FUNDING SOURCE: United States Army Corps of Engineers
Wyoming Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 3 April 2018 – 1 March 2019

PREPARED BY: Stephanie Rhine, Nongame Biologist
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 the Migratory Bird Treaty Act, and is classified as a Species of Greatest Conservation Need with a Native Species Status of 3 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 2018, we obtained occupancy data for 92 territories and productivity data for 79 nest sites, which produced a total of 88 young. Compared to 2017 results, the percentage of territories occupied and the number of successful territories were slightly lower. However, Bald Eagles still occupied a high proportion (i.e., 77%) of nesting territories we monitored, and had slightly lower productivity compared to the previous year, with an average of 1.52 young produced per successful nest, compared to 1.67 in 2017. The Bald Eagle nesting population in western Wyoming appears to be stable. Occupancy rate and productivity remain high. Some site-specific risks remain due to increasing energy development, rural development, recreational activities, and environmental contaminants. The Department continues 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.

The US Fish and Wildlife Service (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 (BGEPA) and the Migratory Bird Act Treaty. The USFWS released national management guidelines to advise landowners and land managers under what circumstances the protective provisions of BGEPA may apply to activities where eagles occur (USFWS 2007). They have also released guidelines to assist developers of land-based wind energy projects in identifying risks to wildlife species, including Bald Eagles (USFWS 2012). In addition, they have finalized permit regulations that allow for limited take of Bald and Golden Eagles where the take is associated with otherwise lawful activities (USFWS 2016a). A population status report was also completed (USFWS 2016b).

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 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 Migratory Bird Technical Committee.

METHODS

We conducted aerial surveys to monitor occupancy and productivity at a majority of known Bald Eagle nest sites in western Wyoming. We conducted fixed-wing aircraft surveys 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, and species of nest tree, and photographed new sites. We also recorded locations of other Species of Greatest Conservation Need (WGFD 2017).

In 2018, we used a single observer and fixed-wing Scout airplane (Sky Aviation) that flew approximately 100-200 m above ground and at speeds of 120-160 kph to conduct aerial nest occupancy surveys on 3 and 13 April, and a productivity survey on 2 and 3 June. 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, New Fork River, and the Green River from Green River Lakes to south of Seedskadee NWR.

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. 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 hours depending on visibility, behavior of adult birds, and status of the nest. Some wildlife consultant companies provided nest observation data, as well.

RESULTS

In 2018, we evaluated occupancy status of 92 nest sites (Table 1). Overall, 8 nests detected were either new or had shifted locations, 4 in the Snake River drainage and 4 in the Green River drainage. Data collected from nest sites in Yellowstone National Park by private consultant groups and Department biologists in other parts of Wyoming are not summarized here. 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 77% of sites surveyed. Table 1 presents productivity data for nest sites in western Wyoming that we monitored with repeated aerial or ground surveys. We found the majority of occupied nests along the main stem of the Snake River (including Jackson Lake) and the Green River drainage (Table 1). Overall, 73% of the territories we checked for productivity in western Wyoming produced mature young. The number of mature young produced per successful nest was 1.52, or 1.24 per occupied nest. Overall, 16 nest sites failed in the Snake River drainage.

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. A few new nest territories continue to be found in the Green River drainage. Comparing productivity data for the Greater Yellowstone population collected from 1982-1995 to the current year indicates that current productivity, or the number of young produced per occupied site, for 2018 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. Aging stands of cottonwood trees that are failing to regenerate may also reduce nesting habitat in some areas in future years.

ACKNOWLEDGEMENTS

We would like to thank the many volunteers and biologists for providing the invaluable data on nesting Bald Eagles in 2018. We greatly appreciate funding for aerial surveys provided by the Army Corp of Engineers (Walla Walla office) and the Wyoming Game and Fish Department Commission.

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Table 1. Summary of Bald Eagle (*Haliaeetus leucocephalus*) nesting data collected by the Wyoming Game and Fish Department Nongame Program in 2018. We present data by major drainages and geographic boundaries in Wyoming. [a] Greater Yellowstone Area (GYA) does not include data from Yellowstone National Park. [b] Aerial surveys from Green River Lakes to Manns Flat south of Seedskadee National Wildlife Refuge. [c] Percentage of occupied territories checked for productivity that produced mature young. [d] Mature young is the number of fully feathered nestlings counted prior to fledging in June and July.

Nesting data collected	Wyoming portion of GYA [a]	Green River [b]	Combined survey results
2018 Territories checked for occupancy (*n*)	57	35	92
2018 Territories occupied (*n*)	44	27	70
2018 Percent of territories occupied	77%	77%	77%
2018 Territories surveyed for productivity (*n*)	45	34	79
2018 Territories that produced young (*n*)	27	31	58
2018 Percent of successful nests [c]	60%	91%	73%
2018 Mature young produced [d] (*n*)	36	52	88

2018 RAPTOR NEST AERIAL SURVEY ON THE UNITED STATES FOREST SERVICE THUNDER BASIN NATIONAL GRASSLANDS

NONGAME BIRDS: Species of Greatest Conservation Need – Golden Eagle, Ferruginous Hawk; raptors

FUNDING SOURCE: United States Forest Service
Wyoming Game and Fish Department

PROJECT DURATION: 25 August 2016 – 30 September 2021

PERIOD COVERED: 1 May 2018 – 31 May 2018

PREPARED BY: Andrea Orabona, Nongame Bird Biologist

ABSTRACT

In 2018, we conducted aerial surveys using a fixed-wing aircraft to provide inventory or monitoring data on nesting raptors associated with lands administered by the United States Forest Service Thunder Basin National Grasslands. We followed similar study parameters detailed in previous years' raptor nest survey reports. In 2013, we modified the transect interval from 800 m to 600 m for compatibility with other Wyoming raptor surveys, and we used a standardized raptor survey data sheet and survey codes that were developed with input from various stakeholders and field tested by the author during the 2018 raptor nest surveys. Surveys coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles. All nests we located were georeferenced using Universal Transverse Mercator (UTM) coordinates, NAD 83 datum. We recorded nest status, nest status level, nest outcome, physical condition of the nest, nest substrate, nest type, and primary habitat in which each nest occurred. We expended 26.8 hours of flight time to survey the remainder of Priority Area 2 and all of Priority Areas 3 and 4.

We located a total of 77 diurnal raptor nests representing 5 species: Ferruginous Hawk (*Buteo regalis;* total *n* = 6, occupied *n* = 0, unoccupied *n* = 6), Golden Eagle (*Aquila chrysaetos;* total *n* = 31, occupied *n* = 0, unoccupied *n* = 31), Bald Eagle (*Haliaeetus leucocephalus*; total *n* = 1, occupied *n* = 1, unoccupied *n* = 0), Swainson's Hawk (*Buteo swainsoni;* total *n* = 1, occupied *n* = 1, unoccupied *n* = 0), and Red-tailed Hawk (*Buteo jamaicensis;* total *n* = 38, occupied *n* = 30, unoccupied *n* = 8). We also detected Northern Harrier (*Circus cyaneus*) and Turkey Vulture (*Cathartes aura*), but did not observe nesting activity. In addition, we found 1 unoccupied Common Raven (*Corvus corax*) nest, 1 occupied Canada Goose (*Branta canadensis*) nest, and 1 remnant unoccupied nest that we could not identify to species. The prolonged wet spring weather in 2018 and considerable die-off of black-tailed prairie dogs (*Cynomys ludovicianus*) due to plague likely contributed to the limited raptor nesting activity we observed

overall. Thus, the absence of records for raptor species known to occupy habitats in eastern Wyoming should not be considered documentation that they do not occur in the areas surveyed.

INTRODUCTION

The purpose of this study was to inventory known and document new raptor nest locations on the United States Forest Service Thunder Basin National Grasslands (USFS TBNG) in northeastern Wyoming.

A cost-share agreement to survey for nesting raptors was initiated in 1996 between TBNG and Wyoming Game and Fish Department (Department), and has continued periodically since (1996-1999, 2001, 2004-2006, 2008, and 2017-2018). During all survey years, priority survey areas included specific portions of the TBNG as designated by USFS personnel. Surveys in 2018 focused on Priority Areas 2, 3, and 4 within the TBNG (Figure 1).

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

METHODS

In 2018, we followed similar study parameters detailed in previous years' raptor nest survey reports. In 2013, we modified the transect interval from 800 m to 600 m for compatibility with other raptor surveys that have been conducted in Wyoming, and we performed the 2nd year of field-testing a standardized raptor survey data sheet and survey codes that were developed by a diversity of state, federal, and private stakeholders in Wyoming. We conducted surveys during a timeframe that coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles.

Transects were flown in a fixed-wing aircraft on 9, 10, 15, 16, 17, and 18 May 2018 (Aviat Husky N37NH; Flightline Laird Flying Service; Bob Laird, pilot). The Department's Nongame Bird Biologist, Andrea Orabona, conducted all aerial surveys. We planned to survey for 10-14 days in May; however, inclement weather hindered our ability to conduct surveys during some scheduled days. No ground surveys or follow-up aerial surveys were conducted in 2018.

We used a handheld Global Positioning System (GPS) unit (Garmin GPS map 76S) to georeference nest locations during survey flights using Universal Transverse Mercator (UTM) coordinates, NAD 83 datum. We used an on-board GPS unit to maintain accurate flight patterns on survey transects and as a backup, if needed. We checked each located nest for evidence of nesting activity and the presence of adult birds, young birds, or eggs. We recorded the nest status, nest status level, nest outcome, physical condition of each observed nest, nest substrate, nest type, and the primary habitat type in which each nest occurred. We recorded all raptor nests encountered, regardless of activity status or condition. We recorded observations at each nest using standardized raptor survey codes.

RESULTS AND DISCUSSION

We expended 26.8 hours of flight time to search for, locate, and observe raptor nests during the 2018 survey. During the limited survey time available, we were able to complete the remainder of Priority Area 2 and all of Priority Areas 3 and 4.

Results of nesting surveys are summarized in Table 1. Standardized avian species alpha codes, nest codes, nest condition codes, nest type codes, nest substrate codes, and age class codes we used during all surveys are presented in Tables 2-7, respectively. Specific nest locations and other information recorded during aerial surveys are presented in Appendix I.

We detected a total of 77 diurnal raptor nests within the Thunder Basin National Grasslands Priority Areas surveyed in 2018 (Table 1; Figure 2). We located 10 occupied diurnal raptor nests (Figure 3)—Bald Eagle (n = 1), Swainson's Hawk (n = 1), and Red-tailed Hawk (n = 8). We also recorded 67 unoccupied diurnal raptor nests (Figure 3)—Ferruginous Hawk (n = 6), Golden Eagle (n = 31), and Red-tailed Hawk (n = 30). Additional raptor species we observed include Northern Harrier and Turkey Vulture, although we did not locate any nests of these species.

The 1996, 1997, and 1998 surveys were conducted to coincide with the timing of the incubation, hatching, and pre-fledging stages for Ferruginous Hawks and the nestling stage (post-hatching and pre-fledging) for Golden Eagles. The surveys in 1999-2008 (excluding 2003 and 2007 when surveys were not conducted) were initiated 2 to 3 weeks earlier than previous years due to slightly different project objectives in 1999 and to avoid the observation problems with early leaf-out that occurred in 1998. Therefore, the 1999-2005 surveys coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles. We planned the 2006 and 2008 surveys for the same timeframe as 1999-2005. However, delays in obtaining the necessary pre-survey paperwork precluded initiating the 2006 inventory until late April, and a prolonged, cool, wet spring in 2008 appears to have affected the initiation of nesting for some raptors, particularly Ferruginous and Swainson's Hawks. Thus, the timing of the start of the survey in early April may not have been conducive to the timing of nest initiation and detectability of occupied nests for these species. Again, the 2018 survey coincided with the timing of the incubation and hatching stages for Ferruginous Hawks and the incubation, hatching, and nestling stages for Golden Eagles.

A few biases have been noted during past surveys that should receive consideration during future efforts or evaluations of results. Swainson's Hawk nests often deteriorate during the winter, and their delayed spring arrival compared to other raptors means that this species may be missed during surveys in late April or early May. This was particularly evident in 2018, based on the paucity of Swainson's Hawk detections. In addition, falcons cannot be effectively detected using fixed wing aircraft surveys. These species require adequate ground or helicopter surveys instead, neither of which were conducted in 2018. Thus, the absence of records for raptor species known to occupy habitats in eastern Wyoming should not be considered documentation that they do not occur in the areas surveyed. Lastly, the prey base (i.e., black-tailed prairie dogs; *Cynomys ludovicianus*) for all expected raptor species in the area was substantially affected by a plague outbreak, which can be expected to have deleterious effects on raptor nest occupancy and productivity during the 2018 breeding season.

Table 1. A summary of the 2018 raptor nest survey we conducted for the Thunder Basin National Grasslands Priority Areas. See Table 3 for nest code definitions.

Species	OCCU	UNOC	Total nests
Ferruginous Hawk	0	6	6
Golden Eagle	0	31	31
Bald Eagle	1	0	1
Swainson's Hawk	1	0	1
Red-tailed Hawk	8	30	38
Total Nests	*10*	*67*	*77*

Table 2. Standardized avian species alpha codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Species alpha code	Definition
AMCR	American Crow
AMKE	American Kestrel
BAEA	Bald Eagle
BNOW	Barn Owl
BBMA	Black-billed Magpie
BUOW	Burrowing Owl
CAGO	Canada Goose
COHA	Cooper’s Hawk
CORA	Common Raven
FEHA	Ferruginous Hawk
GHOW	Great Horned Owl
GOEA	Golden Eagle
GTBH	Great Blue Heron
LEOW	Long-eared Owl
MERL	Merlin
NOGO	Northern Goshawk
NOHA	Northern Harrier
OSPR	Osprey
PEFA	Peregrine Falcon
PRFA	Prairie Falcon
RTHA	Red-tailed Hawk
SEOW	Short-eared Owl
SSHA	Sharp-shinned Hawk
SWHA	Swainson’s Hawk
TUVU	Turkey Vulture
othr	Other raptor species
unkn	Unknown raptor species

Table 3. Nest codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Nest status, status level, and outcome codes	Meaning	Definition
OCCU	Occupied	An occupied nest with one or two adults present at or near the nest and/or fresh lining material in the nest.
UNOC	Unoccupied	An unoccupied nest with no apparent recent use or adult presence at the time of the observation.
NOCH	Not checked	A nest that was not checked during the appropriate survey period.
OCAC	Occupied Active	An occupied nest in which a breeding attempt was made, indicated by one or two adults at or near the nest and/or fresh lining material in the nest, along with one or more of the following: a recent and well-used perch near the nest; prey remains and/or fresh mutes on or near the nest edge; an incubating or brooding adult, eggs, or young in the nest; or fledged young near the nest.
OCAL	Occupied Alternate	An occupied nest within a territory with fresh lining material in the nest (i.e., tended) but no additional evidence of nesting (e.g., no adults, eggs, prey remains, mutes).
UNAL	Unoccupied Alternate	An unoccupied nest within a territory that contains an occupied nest.
RELO	Relocated	A nest that was relocated for mitigation purposes.
UNKN	Unknown	A nest whose status was undetermined during subsequent surveys in the same nesting season.
OCFL	Occupied Fledged	An occupied nest that fledged young.
OCFA	Occupied Failed	An occupied active nest that failed to fledge any young.
Young	Number of Young	The number of young detected in or near the nest. Age class/percent feathered is recorded in the comments section.
Eggs	Number of Eggs	The number of eggs detected in the nest.

Table 4. Nest condition codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Nest condition	Definition
Good	Nest cup is present.
Fair	Vertical nest structure is evident.
Poor	A dilapidated nest in a state of ruin (e.g., no vertical structure) due to weather, natural aging, and/or neglect. Nest material is sloughing but an identifiable circular nest shape still exists.
Remnant	Only remnant physical evidence is present. Nest is in a state of disrepair and has degraded to the point that it is no longer useable without major reconstruction. However, nest material is is still present and the nest can be rebuilt.
Destroyed	A nest that was located during a previous study but has completely disappeared and is not present during the current study. Although there is no physical evidence that the nest exists, historical data on the nest are present in files.

Table 5. Nest type codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Nest type code	Nest type	Definition
BUR	Burrow	A burrow created by a fossorial mammal (describe in comments if known)
CAV	Cavity	A natural or excavated hollow space suitable for nesting
DOS	Domed Stick	A nest made of sticks that has a dome-shaped cover over the nest cup area
LED	Ledge	Nest is on or in an opening on a ledge with no real nest material present
NBO	Nest Box	A manmade, fully or partially enclosed nest box above or below ground
OPS	Open Stick	A nest made of sticks where the nest cup area is exposed and visible
OTH	Other	A nest other than those described above

Table 6. Nest substrate codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Nest substrate code	Definition
ANS	Artificial Nest Structure
ASD or L	Aspen Dead or Live
CKB	Creek Bank
CLF	Cliff
CTD or L	Cottonwood Dead or Live
ERR	Erosional Pillar
GHS	Ground/Hillside
HFR	H Frame Power Pole
JUN	Juniper
LPD or L	Lodgepole Pine Dead or Live
MMS	Manmade Structure
OTH	Other
POL	Power Pole
PPD or L	Ponderosa Pine Dead or Live
ROC	Rock Outcrop
RUD or L	Russian Olive Dead or Live
SFD or L	Spruce/Fir Dead or Live
UNG	Underground
WID or L	Willow Dead or Live

Table 7. Age class codes we used during the 2018 raptor nest survey on Thunder Basin National Grasslands.

Class	Definition	Percent feathered
I	All downy, no feathers	1-25%
II	Feathers visible, downy patches on body or head	26-50%
III	Completely feathered	51-75%
IV	Fledged	76-100%

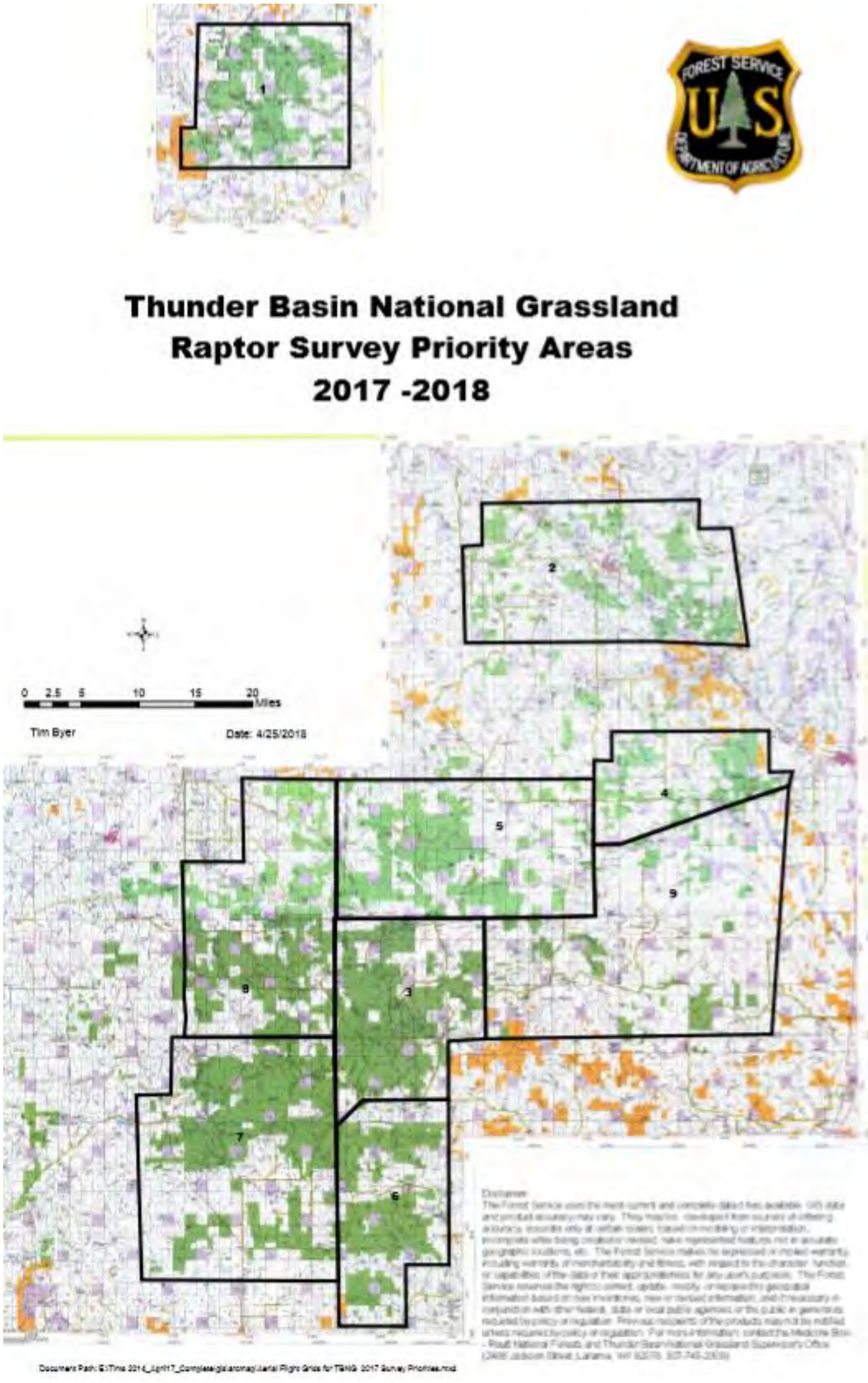

Figure 1. Raptor nest survey Priority Areas on the Thunder Basin National Grasslands. In 2018, we completed surveys in the remainder of Priority Area 2 and all of Priority Areas 3 and 4.

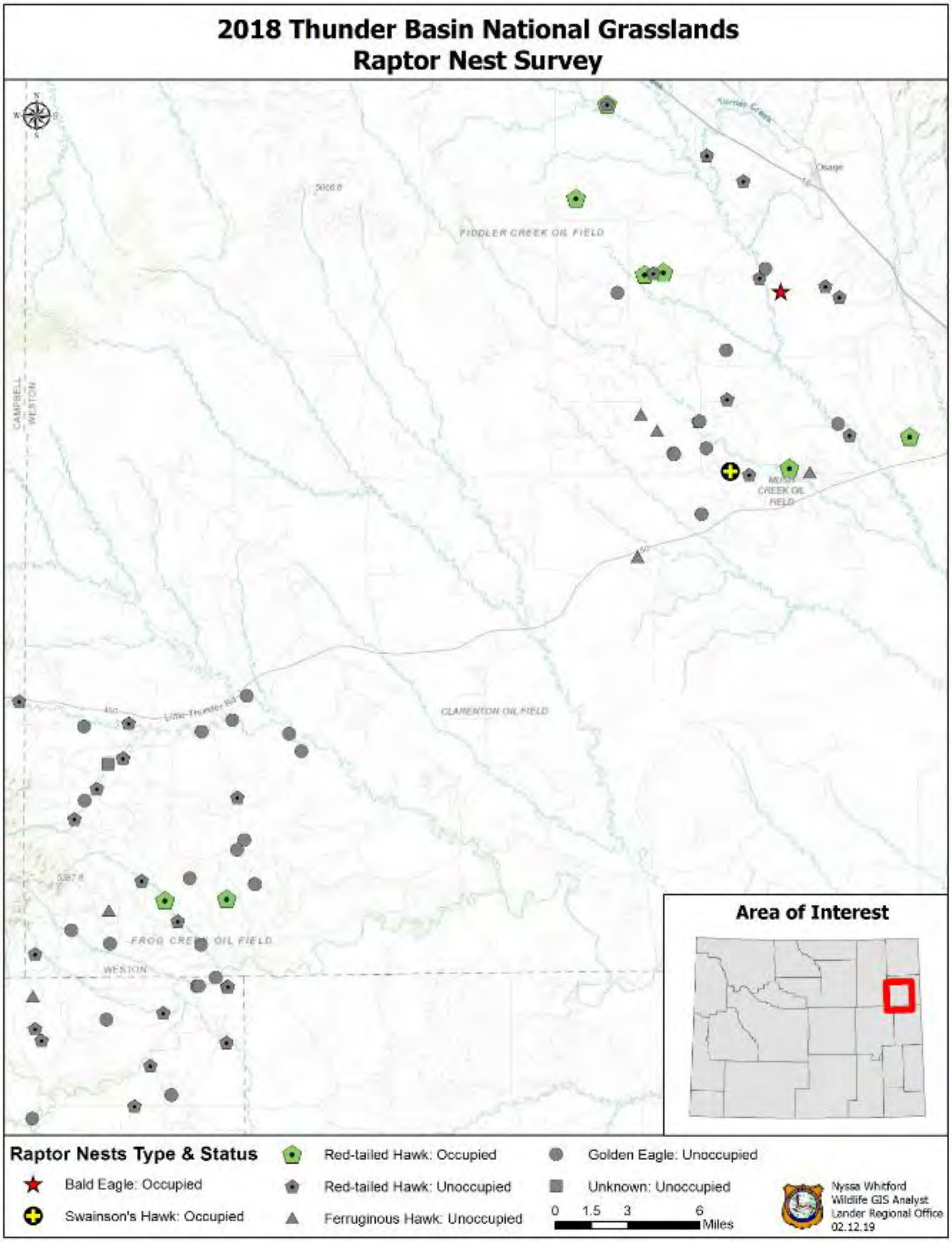

Figure 2. Locations of raptor nests we detected during the 2018 aerial survey in the US Forest Service Thunder Basin National Grasslands Priority Areas 2, 3, and 4. Note the different colored symbols denoting occupied and unoccupied nests.

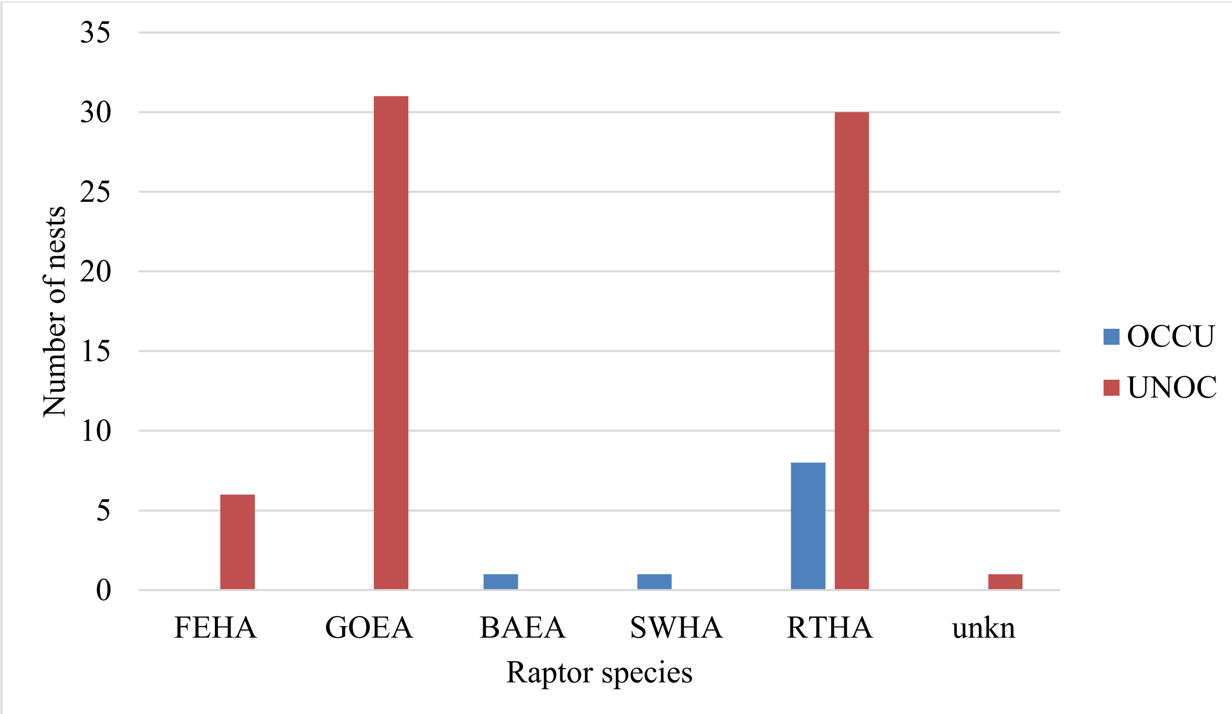

Figure 3. Number of occupied (OCCU) and unoccupied (UNOC) nests detected during the 2018 aerial surveys for nesting raptors on Thunder Basin National Grasslands Priority Areas 2, 3, and 4. FEHA = Ferruginous Hawk, GOEA = Golden Eagle, BAEA = Bald Eagle, SWHA = Swainson's Hawk, RTHA = Red-tailed Hawk, and unkn = unknown raptor species.

SUMMARY OF PEREGRINE FALCON (*FALCO PEREGRINES*) MONITORING IN WYOMING, 2018

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Peregrine Falcon

FUNDING SOURCE: Wyoming Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Bob Oakleaf, Wyoming Game and Fish Department (retired)
Susan Patla, Nongame Biologist, Wyoming Game and Fish Department (retired)
Andrea Orabona, Nongame Bird Biologist, Wyoming Game and Fish Department

SUMMARY

Nesting Peregrine Falcons (*Falco peregrines*; peregrines) were mostly extirpated from Wyoming, and national population trends warranted the US Fish and Wildlife Service (USFWS) to de-list the species in 1999 (USDI 1999). Cade et al. (2003) detailed factors contributing to the national endangered species status and recovery of the species prior to the 1970s (Oakleaf and Craig 2003). We did not locate any nesting pairs during surveys from 1978-1983. We documented the first nesting pair in1984, and at least 121 nesting territories in Wyoming by 2015. Recovery of peregrines in Wyoming resulted from nationwide restrictions on the use of the insecticide dichlorodiphenyltrichloroethane (DDT), and reintroduction of 325 captive produced young in Wyoming, 1980-1995 (Oakleaf and Craig 2003, Enderson et al. 2012, Baril et al. 2015). We have not released peregrines since 1995 because we attained project 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.

The Wyoming Game and Fish Department and Yellowstone and Grand Teton National Parks continued monitoring nesting success of peregrines until 2015. We documented the production of over 1,057 nesting attempts of peregrines in Wyoming (Figure 1). Portions of monitoring included cooperative efforts with the USFWS post de-listing protocol (USDI 2003). We followed standard raptor monitoring protocol and terminology (Steenhoff and Newton 2007). Continued monitoring of nesting success beyond 2015 is warranted due to the large investment for recovery, continued high public interest, and the concept that peregrines have proven valuable as an environmental indicator. Although DDT has been banned, other potentially

detrimental compounds are likely to be developed that may become concentrated in the food chain and affect top level predators. For example, Baril et al. (2015) reviewed the literature relating to potential risks of compounds within the family of brominated flame retardants. DeWeese et al. (1986) provided additional information on organochlorine contaminants in peregrine prey. In addition, the potential risks to avifauna from some diseases such as West Nile Virus are not well known.

The monitoring database for Wyoming peregrines was extremely costly to collect. Such expenditures and effort will likely never be repeated. Yet, if we take advantage of the opportunity to use the database as a foundation for continued monitoring, expenditures could be minimal and a fraction of what it would take to recreate such a foundation, if ignored for years. Some of our preliminary findings could guide future monitoring efforts.

The amount of effort required to annually monitor a nesting site can vary from a few hours to several days depending on the location, characteristics of the site, and other factors influencing logistics. We compared sites that were easy to monitor to more difficult sites. The criteria for a site to be classified as easy included sites that are within 2 hours from the nearest town with public access, have a good view conducive to a complete young count, have a history of few alternate sites, and have recent years of occupancy. Sites with less than 3 years of monitoring were not included in the analysis. We found that easy sites averaged as many or higher young per occupied site than more difficult sites. We believe that complete counts of mature young are more likely to occur at easy sites, and factors such as nearby roads do not negatively impact production. Monitoring of these sites could also be completed with less experienced personnel or trained volunteers.

Evaluations of Wyoming data indicate that we can focus on indices requiring less effort. Past monitoring protocol required occupancy surveys during early phases of the nesting season. Once established, we found that nearly all known nest sites were reoccupied in following years. The few sites (<3%) recorded as not occupied were mostly associated with incomplete understanding of alternate nesting sites or, in a few cases, the establishment of nesting at extremely marginal sites. All of the sites recommended for long term monitoring do not have any years when they were recorded as not occupied; all (100%) were occupied during years surveyed. Therefore, we recommend a monitoring scheme that assumes all sites are occupied and primarily focuses on documenting the number of mature young during the fledging period.

In addition to monitoring the number of young at these historic sites, we still need data at many locations in Wyoming before they can be classified as established peregrine nesting sites. For example, in 2016 we documented peregrine young at 7 sites where only adults had been recorded previously. The database includes 21 probable nesting sites that should be surveyed until young have been documented. In addition, there are reports of nesting peregrines at 3 sites that need further documentation while the information is current.

We recommend selecting 5 of the easy nest sites for each survey area. Ideally, sites with the most years of data would be selected. In addition, Grand Teton National Park may continue to monitor nest sites (n = 5) within the Park, and results could be additive or evaluated separately. Approximate survey dates can be identified from previous fledging data. Trained volunteers or agency personnel should plan at least 1 day in July to record success and number of young of selected sites according to protocol. We also recommend that experienced personnel continue follow-up on reports or survey sites needing better documentation.

A summary of 2018 survey results is presented below. This was a difficult year, as 2 of the selected monitoring sites failed (Selected Site 1 and Selected Site 2) and there were apparently 2 renesting attempts, both of which requires extra surveys and effort. In addition, 3 potential areas were checked without success.

Selected Monitoring Sites

Selected Site 1: Both adults were present; incubation was documented; nest failed in May; adults were gone by early June.
Selected Site 2: Both adults were present on 13 April and 22 May; nest failed and adults were gone on 6 July.
Selected Site 3: Both adults were present; incubating or small young on 22 May; 3 young (1l fledged and 2 in the eyrie) on 7 July.
Selected Site 4: Both adults were present on 23 May and 7 July on the same ledge; 1 young fledged on 15 July, a week earlier than most years.
Selected Site 5: Young were still in the eyrie on 16 July; 2 young fledged on 29 July; must be a renest.
Selected Site 6: Both adults were present and 1 fledged young was flying well and only briefly observed on 2 August; fledging in previous years occurred near mid-July.

Additional Sites

Additional Site 1: Both adults were present on 22 May; still feeding young on 16 July; 2 young were almost fledged on 29 July; must be a renest.
Additional Site 2: Both adults were present and either incubating or had a small young on 24 May; checked to make sure a new eyrie nearby did not come from here; did not recheck for production.
Additional Site 3: Both adults were present on 23 May; 2 young fledged on 6 July.
Additional Site 4: Both adults were present on 23 May; no young or adults on 7 July or 15 July.

New Sites

New Site 1: First time of ever working this cliff on 22 May; both adults were feeding young; 3 young fledged on 6 July; may be a result of nearby sites becoming vacant.
New Site 2: Both adults were present on 23 May; 4 young fledged about 7 July; not sure how long this site has been active, as adults were seen perched nearby but they were assumed to be from other known sites.
New Site 3: 1 adult and 3 fledged young on 16 July; a subadult female was set up on this cliff in 2013, so this would be briefly checked coming and going to nearby sites.

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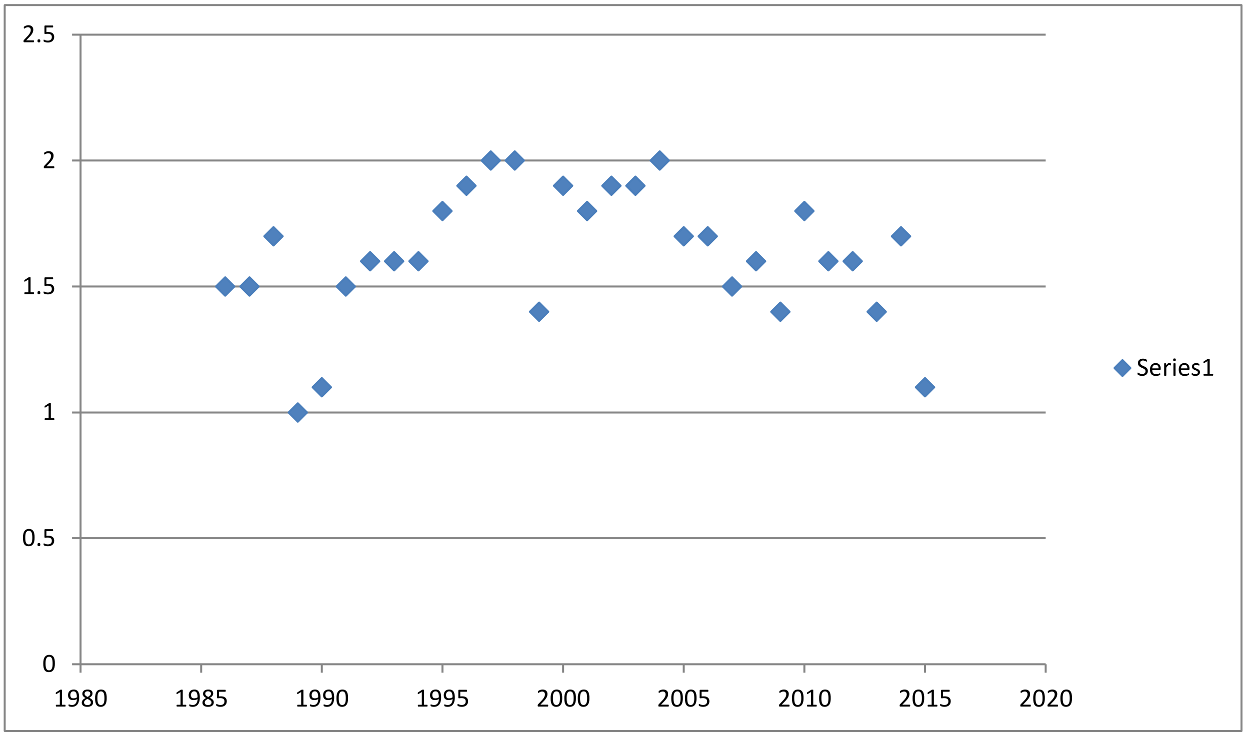

Figure 1. Average young per occupied Peregrine Falcon (*Falco peregrines*) nest site in Wyoming, 1986-2015. Data for 1984-1985 are not included, as there was only 1 site.

WYOMING PARTNERS IN FLIGHT AND INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need

FUNDING SOURCE: Bureau of Land Management Cooperative Agreement
National Park Service Cooperative Agreement
United States Fish and Wildlife Service State Wildlife Grant
United States Forest Service Cooperative Agreement
Wyoming Game and Fish Department Commission Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2017 – 1 June 2018

PREPARED BY: Nancy Drilling, Bird Conservancy of the Rockies
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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 2017). 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 Bird Conservancy of the Rockies (formerly 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). The IMBCR partnership currently includes 32 entities in the western US. In 2018, the IMBCR program covered all or parts of 15 states, 4 US Forest Service Regions, and 9 Bird Conservation Regions. Between 22 April and 19 July 2018, partners completed 18,124 point counts within the 1,628 sampling units surveyed, and detected 237,046 individual birds representing 336 species. The area of inference was approximately 2 million km^2. In Wyoming, partners completed 2,561 point counts in 2018 on 200 of the 201 planned survey grids (99.5%) within the 37 strata in the 5 Bird Conservation Regions in Wyoming, covering a total of 253,487 km^2. They detected 191 avian species, including 46 SGCN. Biometricians estimated occupancy for 212 species detected in any given year of the program, including 59 SGCN (27.8%). Data provided robust occupancy estimates (CV <50%) for 128 of the 212 species, (60.4%), including 27 SGCN (21.1%). Biometricians estimated density and population size for 206 species detected in any given year of the program, including 56 SGCN (27.2%). Data provided robust density estimates (CV <50%) for 101 of the 206 species (49.0%), including 27 SGCN (26.7%). 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 2016).

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), Bird Conservancy of the Rockies (Bird Conservancy; formerly Rocky Mountain Bird Observatory), Bureau of Land Management (BLM), US Forest Service (USFS), US Fish and Wildlife Service, Bureau of Reclamation, National Park Service (NPS), 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 2017).

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 18th consecutive year, biologists from the Department, Bird Conservancy, BLM, USFS, NPS, WYNDD, and Audubon Rockies have collaborated to execute a state-of-the-art avian monitoring program across Wyoming. Numerous federal agency cooperative agreements, including a multi-year BLM grant, State Wildlife Grants dollars, and the Wyoming Game and Fish Department provide funding and other resources. 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 2017). Funding is also provided to develop educational materials and improve outreach opportunities that focus on birds in Wyoming. The Bird Conservancy is responsible for implementing the monitoring program, which originally focused on 6 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. 2018). 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 (WOS2) database. With funding and guidance from the IMBCR partnership, Bird Conservancy 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 (Drilling et al. 2019) 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 (Figure 1). In 2018, the IMBCR program covered all or parts of 15 states, 4 USFS Regions, and 9 Bird Conservation Regions. The area of inference was approximately 2 million km^2 (Figure 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). Bird Conservancy biometricians overlaid BCRs with 1 km^2 sample grids, randomly selected sample grids, and used a 4 x 4 point count array with 16 survey points spaced 250 m apart within each sample grid (Figure 3; Hanni et al. 2018). To estimate the variances of population parameters, a minimum of 2 sampling units within each stratum are required (Drilling et al. 2019).

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 sampling methods established by IMBCR partners (Hanni et al. 2018) to conduct point counts during the field season. They surveyed grids in the morning from 0.5 hour before sunrise to no later than 5 hours after sunrise, and surveyed each count point for 6 minutes to facilitate estimation of site occupancy. For each bird detected, technicians recorded species, sex, horizontal distance from the observer, minute of detection, type of detection (e.g., song, call, visual), if the bird was a migrant, and if they could detect the bird visually. Other data were also noted, such as the presence of flyovers and clusters, as well as the presence of American pika (*Ochotona princeps*), Abert's squirrels (*Sciurus aberti*), and American red squirrels (*Tamiasciurus hudsonicus*). 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 the Bird Conservancy used Distance 6.0 to estimate detection probabilities (Buckland et al. 2001, Thomas et al. 2010). They used the RIMBCR package in Program R (R Core Team 2019) to estimate density, population size, and occupancy for species detected in individual strata or combinations of strata at various biologically meaningful spatial scales (Drilling et al. 2019). Lastly, they used a removal design to estimate detection probability for each species (MacKenzie et al. 2006).

RESULTS

The IMBCR partnership currently includes 32 entities in the western US, and the area of inference is approximately 2 million km^2 (Figure 2). In 2018, the IMBCR program included all of Colorado, Montana, Utah, and Wyoming; parts of 11 other states (Arizona, California, Idaho, Kansas, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, and Texas); 3 entire USFS Regions (Regions 1, 2, and 4) and portions of 1 additional USFS Region (Region 3); all of BCR 17 (Badlands and Prairies) and BCR 18 (Shortgrass Prairie); and portions of BCRs 9 (Great Basin), 10 (Northern Rockies), 11 (Prairie Potholes), 15 (Sierra Nevada), 16 (Southern Rockies/Colorado Plateau), 19 (Central Mixed-grass Prairie), and 33 (Sonoran and Mojave Deserts; Drilling et al. 2019; Figure 2). Between 22 April and 19 July 2018, partners completed 18,124 point counts within the 1,628 sampling units surveyed (99.6%), and detected 237,046 individual birds representing 336 species (Drilling et al. 2019).

Between 21 May and 19 July 2018, field technicians and biologists with Bird Conservancy and WYNDD completed 2,561 point counts on 200 of the 201 planned survey grids (99.5%) within 37 of the 38 strata (97.4%) in the 5 BCRs in Wyoming, covering a total of 253,487 km^2 (Drilling et al. 2019; Table 1; Figures 1 and 4). Field personnel detected a total of 191 species, including 46 SGCN (24.1%; Table 2; Drilling et al. 2019). Statewide results were obtained by compiling and jointly analyzing data from survey locations within the 37 different strata.

Bird Conservancy biometricians were able to estimate occupancy, or the proportion of 1 km^2 grid cells occupied (Psi; ψ), for 212 species that have been detected in any given year of the monitoring program, including 59 SGCN (27.8%; Table 3; Drilling et al. 2019). Data provided robust occupancy estimates (CV <50%) for 128 of the 212 species detected (60.4%), including 27 SGCN (21.1%; Table 3; Drilling et al. 2019).

Bird Conservancy biometricians were able to estimate density (D) and population size (N) for 206 species that have been detected in any given year of the monitoring program, including 56 SGCN (27.2%; Table 4; Drilling et al. 2019). Data provided robust density estimates (CV <50%) for 101 of the 206 species (49.0%), including 27 SGCN (26.7%; Table 4; Drilling et al. 2019).

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 (Bird Conservancy 2019). 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#N4IgzgrgDgpgTmALnAhoiBbEAuABCAdQE0QBfIAA, click "OK" on the disclaimer box, and click the "Run Query" button highlighted in red near the top of the page. To view just the 2018 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 2018, click "Add Filter", and then click "Run Query" (Drilling et al. 2019).

DISCUSSION

The methods employed by Bird Conservancy of the Rockies and project partners to monitor avian populations using the IMBCR design enable us to estimate occupancy, density, abundance, and populations trends at various spatial scales for species with large enough sample sizes. These robust data also provide information on species distribution and habitat associations, estimates across space, and evaluation of land management activities (Drilling et al. 2019). The IMBCR program provides occupancy and density 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, Bird Conservancy of the Rockies 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 2018 IMBCR design provided robust occupancy and density estimates for many 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 numerous SGCN.

Four species, Brewer's Sparrow (*Spizella breweri*), Sagebrush Sparrow (*Artemesiospiza nevadensis*), Sage Thrasher (*Oreoscoptes montanus*), and Greater Sage-Grouse (*Centrocercus urophasianus*), are considered sagebrush obligates, and the Grasshopper Sparrow (*Ammodramus savannarum*) and McCown's Longspur (*Rhynchophanes mccownii*) 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 2017).

The Common Nighthawk (*Chordeiles minor*) is well-distributed across Wyoming in open and semi-open habitats below 2,590 m in elevation, and feeds in the air over most habitats, especially aquatic and agricultural areas (Orabona et al. 2016). Population trends for this species suggest declines, and insecticide use may be problematic (Sauer et al. 1996, WGFD 2017).

The MacGillivray's Warbler (*Geothlypis tolmiei*) is another well-distributed species in Wyoming, found at elevations below 2,743 m in aspen, cottonwood-riparian, and riparian shrubland habitats (Orabona et al. 2016). Monitoring of this species is important to determine the effects of habitat loss, degradation, and fragmentation; incompatible livestock grazing; and inappropriate land use practices on populations statewide (WGFD 2017).

Although the Loggerhead Shrike (*Lanius ludovicianus*) is found across Wyoming in pine-juniper, woodland-chaparral, basin-prairie shrubland, and mountain-foothills shrubland habitats, the species is found in low numbers and the reasons for state and regional population declines are currently unknown (WGFD 2017).

Clark's Nutcracker (*Aechmophorus clarkia*) and Red Crossbill (*Loxia curvirostra*) are also widespread in the state, occurring in mature coniferous forests (Orabona et al. 2016). However, monitoring data suggest that populations of both species are declining, and incompatible forest management practices and climate change are limiting factors (WGFD 2017).

While the American Pipit (*Anthus rubescens*) can be found across Wyoming during migration, its subalpine and alpine breeding habitats are limited in distribution (Orabona et al. 2016). Robust population trends were not available until 2018 due to low detection rates during monitoring surveys. In addition, its breeding habitats are susceptible to alteration, unfavorable weather conditions, and climate change (WGFD 2017).

The uncommon Black Rosy-Finch (*Leucosticte atrata*) also breeds in high elevation alpine habitats in the state (Orabona et al. 2016). Although population trends are currently not robust, Wyoming supports a large portion of the global breeding population based on available habitat (Johnson 2002).

The Common Yellowthroat (*Geothlypis trichas*) is classified as common in Wyoming below 2,438 m in dense willow and other shrubby habitats along the edges of riparian areas and in bulrush and cattail marshes (Orabona et al. 2016, WGFD 2017). However, loss and degradation of riparian and wetland habitats can negatively affect local populations, no quantitative studies have been conducted to provide additional detail or specific habitat associations across the species' range, and anthropogenic habitat alterations could present additional risks (WGFD 2017). Common Yellowthroats would benefit from continued monitoring, and management practices that maintain shrubs and diverse vegetation heights in wetland and riparian habitats, employ rotational livestock grazing during the nesting season, and minimize insecticide use in wetland and riparian habitats (WGFD 2017).

The Blue-gray Gnatcatcher (*Polioptila caerulea*) is an uncommon summer resident in the state that inhabits pine-juniper, cottonwood-riparian, juniper, and mountain-foothills shrublands habitats (Orabona et al. 2016). A robust population estimate for this species in Wyoming was not available until 2018 due to limited distribution and low detection rates during monitoring surveys (WGFD 2017).

The American Kestrel (*Falco sparverius*) is widespread in most habitats in Wyoming, especially below 2,590 m where trees, cliffs, and man-made structures for nesting are present (Faulkner 2010). Robust population trends for the have been available most years of the IMBCR program. However, a limited availability of large diameter trees and snags; loss of mature coniferous forest habitat from beetle kill, disease, and logging; and the effects of climate change can reduce nesting habitat (WGFD 2017). This species is also susceptible to secondary poisoning by pesticides during foraging, and competition with non-native species for existing cavities can be problematic (Smallwood and Bird 2002).

Golden Eagles (*Aquila chrysaetos*) occur in most habitats in Wyoming with open areas for foraging, and have been documented breeding in all 28 latitude/longitude blocks in the state (Orabona et al. 2016). While the breeding population in Wyoming appears to be stable, the effects of increased energy development, including wind energy, are uncertain (Noguera et al. 2010, Tack and Fedy 2015). This species would benefit from long-term monitoring, as well as monitoring and research on key prey species, to better understand year-to-year population fluctuations and long-term trends (Oakleaf et al. 2014).

The Merlin (*Falco columbarius*) is an uncommon species in Wyoming, occurring in most habitats below 2,590 m and typically nesting in abandoned Black-billed Magpie (*Pica hudsonia*) nests (Orabona et al. 2016). Populations appear to have experienced historic declines, but insufficient data are available to understand the causes (WGFD 2017). This species would benefit from a re-evaluation of historic nesting sites and additional surveys at new potential sites.

Robust population trends for the Swainson's Hawk (*Buteo swainsoni*) in Wyoming were not available until 2018 due to low detection rates during monitoring surveys. Although common where open areas for foraging and trees for nesting occur, this species can be negatively impacted, both directly and indirectly, by the use of pesticides to control insect or rodent populations through toxicity and reduced prey availability (Orabona et al. 2016, WGFD 2017).

The uncommon Williamson's Sapsucker is most abundant in the western mountains of Wyoming, and relatively rare in the Big Horn, Laramie, and Sierra Madre ranges (WGFD 2017). Similar to other woodpecker species, more general monitoring programs, such as the Breeding Bird Survey, do not adequately track this and other species of woodpecker. By continuing to monitor Wyoming's breeding birds via the IMBCR program, results can provide an indication of trends for many SGCN, as well as a host of more common species in the state.

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 (Drilling et al. 2019).

There are 5 major categories for management applications from IMBCR data (Drilling et al. 2019):

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, Drilling et al. 2019). 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 (Drilling et al. 2019). Furthermore, this design allows pooled use of monitoring resources from separate management entities in a spatially balanced, probabilistic framework, which promotes resource efficiency and permits reference to a larger area of interest (Pavlacky et al., 2017). 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 (Drilling et al. 2019). Moreover, the IMBCR design allows us to monitor trends of avian SGCN that may be omitted or inadequately represented by other survey techniques, permits slight modifications to the design in order to investigate other priority species as needs arise, and reduces monitoring costs through coordination and collaboration with monitoring partners.

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Table 1. Planned and completed surveys, by stratum, conducted in Wyoming between 21 May and 19 July 2018 using the Integrated Monitoring in Bird Conservation Regions design (Drilling et al. 2019). [a] Not completed because accessibility was determined too late to conduct the survey.

BCR name (number)	Number of strata	Strata area (km^2)	Number of surveys planned	Number of surveys done	Percent surveys done (%)
Great Basin (9)	1	119	2	2	100
Northern Rockies (10)	23	165,332	125	124 [a]	99.2
Southern Rockies/Colorado Plateau (16)	4	11,594	24	24	100
Badlands and Prairies (17)	6	64,164	34	34	100
Shortgrass Prairie (18)	3	12,258	16	16	100
Statewide totals	37	253,487	201	200	99.8

Table 2. Avian species detected in Wyoming during the 2018 Integrated Monitoring in Bird Conservation Regions surveys. X = species detected in large enough numbers to provide robust estimates of occupancy and density.

Common name	Scientific name	SGCN tier	Occupancy estimate	Density estimate
American Avocet	*Recurvirostra americana*		X	X
American Bittern	*Botaurus lentiginosus*	TII	X	X
American Kestrel	*Falco sparverius*	TIII	X	X
American Pipit	*Anthus rubescens*	TIII	X	X
American Three-toed Woodpecker	*Picoides dorsalis*		X	X
American White Pelican	*Pelecanus erythrorhynchos*	TII	X	X
Ash-throated Flycatcher	*Myiarchus cinerascens*	TII	X	X
Baird's Sparrow	*Centronyx bairdii*	TII	X	X
Bald Eagle	*Haliaeetus leucocephalus*	TII	X	X
Barn Owl	*Tyto alba*			
Bewick's Wren	*Thryomanes bewickii*	TIII	X	X
Black Rosy-Finch	*Leucosticte atrata*	TII	X	X
Black Swift	*Cypseloides niger*			
Black Tern	*Chlidonias niger*	TII	X	
Black-backed Woodpecker	*Picoides arcticus*	TII	X	X
Black-billed Cuckoo	*Coccyzus erythropthalmus*	TII	X	X
Black-chinned Hummingbird	*Archilochus alexandri*	TII	X	X
Black-throated Gray Warbler	*Setophaga nigrescens*	TII	X	X
Blue Grosbeak	*Passerina caerulea*	TIII	X	X
Blue-gray Gnatcatcher	*Polioptila caerulea*	TIII	X	X
Bobolink	*Dolichonyx oryzivorus*	TII	X	X
Boreal Owl	*Aegolius funereus*	TII		
Brewer's Sparrow	*Spizella breweri*	TII	X	X

Table 2. Continued.

Common name	Scientific name	SGCN tier	Occupancy estimate	Density estimate
Brown-capped Rosy-Finch	*Leucosticte australis*	TII	X	X
Bullock's Oriole	*Icterus bullockii*		X	X
Burrowing Owl	*Athene cunicularia*	TI	X	X
Canvasback	*Aythya valisineria*			
Canyon Wren	*Thryothorus ludovicianus*	TIII	X	X
Cassin's Sparrow	*Peucaea cassinii*		X	X
Chestnut-collared Longspur	*Calcarius ornatus*	TII	X	X
Clark's Nutcracker	*Nucifraga columbiana*	TII	X	X
Common Nighthawk	*Chordeiles minor*	TIII	X	X
Common Yellowthroat	*Geothlypis trichas*	TIII	X	X
Dickcissel	*Spiza americana*	TII	X	X
Eastern Meadowlark	*Sturnella magna*		X	X
Ferruginous Hawk	*Buteo regalis*	TII	X	X
Field Sparrow	*Spizella pusilla*		X	X
Forster's Tern	*Sterna forsteri*	TII		
Franklin's Gull	*Leucophaeus pipixcan*	TII	X	X
Golden Eagle	*Aquila chrysaetos*	TII	X	X
Grasshopper Sparrow	*Ammodramus savannarum*	TII	X	X
Gray Vireo	*Vireo vicinior*	TII	X	X
Great Blue Heron	*Ardea herodias*	TII	X	X
Great Gray Owl	*Strix nebulosa*	TII		
Greater Prairie-Chicken	*Tympanuchus cupido*		X	X
Greater Sage-Grouse	*Centrocercus urophasianus*	TII	X	X

Table 2. Continued.

Common name	Scientific name	SGCN tier	Occupancy estimate	Density estimate
Green Heron	*Butorides virescens*		X	
Harris's Hawk	*Parabuteo unicinctus*			
Harris's Sparrow	*Zonotrichia querula*			
Juniper Titmouse	*Baeolophus ridgwayi*	TII	X	X
Kentucky Warbler	*Geothlypis formosa*			
Lark Bunting	*Calamospiza melanocorys*		X	X
Lark Sparrow	*Chondestes grammacus*		X	X
Least Tern	*Sternula antillarum*		X	
Lesser Scaup	*Aythya affinis*		X	X
Lewis's Woodpecker	*Melanerpes lewis*	TII	X	X
Loggerhead Shrike	*Lanius ludovicianus*	TII	X	X
Long-billed Curlew	*Numenius americanus*	TII	X	X
MacGillivray's Warbler	*Geothlypis tolmiei*	TII	X	X
Marbled Godwit	*Limosa fedoa*		X	X
McCown's Longspur	*Rhynchophanes mccownii*	TII	X	X
Merlin	*Falco columbarius*	TIII	X	
Mississippi Kite	*Ictinia mississippiensis*		X	X
Mountain Plover	*Charadrius montanus*	TI	X	X
Nelson's Sparrow	*Ammospiza nelsoni*			
Northern Bobwhite	*Colinus virginianus*		X	X
Northern Goshawk	*Accipiter gentilis*	TI	X	X
Northern Harrier	*Circus hudsonius*		X	X
Northern Pintail	*Anas acuta*		X	X

Table 2. Continued.

Common name	Scientific name	SGCN tier	Occupancy estimate	Density estimate
Olive-sided Flycatcher	*Contopus cooperi*		X	X
Orchard Oriole	*Icterus spurius*		X	X
Painted Bunting	*Passerina ciris*		X	X
Peregrine Falcon	*Falco peregrinus*	TII	X	X
Pileated Woodpecker	*Dryocopus pileatus*		X	X
Pinyon Jay	*Gymnorhinus cyanocephalus*		X	X
Piping Plover	*Charadrius melodus*			
Prairie Falcon	*Falco mexicanus*		X	X
Purple Martin	*Progne subis*	TIII	X	X
Pygmy Nuthatch	*Sitta pygmaea*	TII	X	X
Red Crossbill	*Loxia curvirostra*	TII	X	X
Red-eyed Vireo	*Vireo olivaceus*	TII	X	X
Red-headed Woodpecker	*Melanerpes erythrocephalus*	TII	X	X
Red-shouldered Hawk	*Buteo lineatus*			
Rufous Hummingbird	*Selasphorus rufus*	TII	X	X
Sage Thrasher	*Oreoscoptes montanus*	TII	X	X
Sagebrush Sparrow	*Artemisiospiza nevadensis*	TII	X	X
Scissor-tailed Flycatcher	*Tyrannus forficatus*		X	X
Scott's Oriole	*Icterus parisorum*	TII	X	X
Sedge Wren	*Cistothorus platensis*		X	X
Sharp-tailed Grouse	*Tympanuchus phasianellus*	TII	X	X
Short-eared Owl	*Asio flammeus*	TII	X	X
Snowy Egret	*Egretta thula*	TII		

Table 2. Continued.

Common name	Scientific name	SGCN tier	Occupancy estimate	Density estimate
Solitary Sandpiper	*Tringa solitaria*			
Sprague's Pipit	*Anthus spragueii*		X	X
Summer Tanager	*Piranga rubra*		X	X
Swainson's Hawk	*Buteo swainsoni*	TII	X	X
Upland Sandpiper	*Bartramia longicauda*	TII	X	X
Virginia Rail	*Rallus limicola*	TIII	X	
Virginia's Warbler	*Oreothlypis virginiae*	TII	X	X
Western Bluebird	*Sialia mexicana*		X	X
Western Meadowlark	*Sturnella neglecta*		X	X
White-faced Ibis	*Plegadis chihi*	TII	X	X
Wild Turkey	*Meleagris gallopavo*		X	X
Willet	*Tringa semipalmata*		X	X
Williamson's Sapsucker	*Sphyrapicus thyroideus*	TII	X	X
Willow Flycatcher	*Empidonax traillii*	TIII	X	X
Wilson's Phalarope	*Phalaropus tricolor*		X	X
Wood Thrush	*Hylocichla mustelina*		X	X
Woodhouse's Scrub-Jay	*Aphelocoma woodhouseii*	TII	X	X
Yellow-billed Cuckoo	*Coccyzus americanus*	TII	X	X

Table 3. Estimated proportion of sample units occupied (ψ), standard error (SE), percent coefficient of variation (% CV), and number of grids with ≥1 detections (n) of 52 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2010-2018. Occupancy estimates are considered robust if percent CV <50%, and are noted in bold (27 species). Scientific names are presented below the table.

Species common name	Year	Psi ψ	SE	% CV	n
American Kestrel	**2010**	**0.483**	**0.121**	**25**	**12**
American Kestrel	2011	0.169	0.100	59	7
American Kestrel	**2012**	**0.073**	**0.018**	**25**	**12**
American Kestrel	**2013**	**0.174**	**0.077**	**44**	**8**
American Kestrel	**2014**	**0.191**	**0.093**	**49**	**8**
American Kestrel	**2015**	**0.208**	**0.082**	**40**	**14**
American Kestrel	**2016**	**0.052**	**0.021**	**40**	**10**
American Kestrel	**2017**	**0.102**	**0.047**	**46**	**12**
American Kestrel	**2018**	**0.393**	**0.053**	**14**	**20**
American Pipit	2010	0.011	0.006	59	4
American Pipit	2011	0.034	0.018	52	5
American Pipit	2012	0.029	0.015	54	4
American Pipit	**2013**	**0.040**	**0.014**	**35**	**6**
American Pipit	**2014**	**0.040**	**0.014**	**35**	**6**
American Pipit	**2015**	**0.065**	**0.017**	**27**	**10**
American Pipit	**2016**	**0.039**	**0.014**	**36**	**4**
American Pipit	**2017**	**0.036**	**0.013**	**37**	**3**
American Pipit	**2018**	**0.054**	**0.012**	**23**	**4**
Ash-throated Flycatcher	2010	0.000	0.000	71	1
Ash-throated Flycatcher	2015	0.022	0.021	96	1
Baird’s Sparrow	2017	0.027	0.026	97	1
Baird’s Sparrow	2018	0.011	0.009	82	2
Bald Eagle	2017	0.001	0.001	100	1
Bald Eagle	2018	0.031	0.019	61	2
Bewick’s Wren	2010	0.023	0.022	95	1
Bewick’s Wren	2014	0.020	0.013	65	2
Bewick’s Wren	2015	0.018	0.017	96	1
Bewick’s Wren	2016	0.035	0.020	56	3
Bewick’s Wren	**2017**	**0.049**	**0.022**	**46**	**5**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	% CV	*n*
Bewick's Wren	2018	0.029	0.014	50	3
Black Rosy-Finch	2010	0.016	0.008	51	5
Black Rosy-Finch	2011	0.033	0.018	54	3
Black Rosy-Finch	2012	0.028	0.015	55	3
Black Rosy-Finch	2013	0.036	0.020	57	5
Black Rosy-Finch	2017	0.017	0.012	73	2
Black Rosy-Finch	**2018**	**0.020**	**0.008**	**39**	**2**
Black-backed Woodpecker	2016	0.020	0.019	97	1
Black-throated Gray Warbler	2010	0.001	0.001	71	1
Black-throated Gray Warbler	2011	0.019	0.014	73	1
Black-throated Gray Warbler	2013	0.001	0.001	97	1
Black-throated Gray Warbler	2015	0.025	0.024	97	1
Black-throated Gray Warbler	2017	0.014	0.014	97	1
Black-throated Gray Warbler	2018	0.073	0.073	99	4
Blue Grosbeak	2010	0.000	0.000	97	1
Blue Grosbeak	2014	0.007	0.007	93	1
Blue Grosbeak	2015	0.007	0.007	95	1
Blue Grosbeak	2016	0.005	0.005	95	1
Blue Grosbeak	2017	0.008	0.007	92	1
Blue-gray Gnatcatcher	2010	0.057	0.045	79	4
Blue-gray Gnatcatcher	**2011**	**0.035**	**0.017**	**47**	**5**
Blue-gray Gnatcatcher	2012	0.030	0.016	55	4
Blue-gray Gnatcatcher	2013	0.044	0.022	50	6
Blue-gray Gnatcatcher	**2014**	**0.039**	**0.016**	**41**	**6**
Blue-gray Gnatcatcher	**2015**	**0.054**	**0.024**	**45**	**6**
Blue-gray Gnatcatcher	**2016**	**0.065**	**0.032**	**49**	**7**
Blue-gray Gnatcatcher	**2017**	**0.040**	**0.018**	**46**	**6**
Blue-gray Gnatcatcher	**2018**	**0.055**	**0.017**	**31**	**10**
Bobolink	2017	0.013	0.013	97	1
Brewer's Sparrow	**2010**	**0.542**	**0.051**	**9**	**80**
Brewer's Sparrow	**2011**	**0.505**	**0.052**	**10**	**77**
Brewer's Sparrow	**2012**	**0.533**	**0.049**	**9**	**87**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	% CV	*n*
Brewer's Sparrow	**2013**	**0.602**	**0.048**	**8**	**97**
Brewer's Sparrow	**2014**	**0.554**	**0.056**	**10**	**83**
Brewer's Sparrow	**2015**	**0.586**	**0.039**	**7**	**121**
Brewer's Sparrow	**2016**	**0.622**	**0.044**	**7**	**101**
Brewer's Sparrow	**2017**	**0.620**	**0.041**	**7**	**95**
Brewer's Sparrow	**2018**	**0.582**	**0.026**	**5**	**91**
Burrowing Owl	2015	0.000	0.000	72	1
Burrowing Owl	**2017**	**0.000**	**0.000**	**34**	**1**
Burrowing Owl	2018	0.012	0.008	65	1
Bushtit	2016	0.048	0.052	109	1
Calliope Hummingbird	2010	0.002	0.002	108	1
Calliope Hummingbird	2012	0.028	0.025	89	2
Canyon Wren	2010	0.022	0.016	70	3
Canyon Wren	2015	0.008	0.007	93	1
Canyon Wren	2016	0.010	0.009	87	1
Canyon Wren	2018	0.012	0.007	61	2
Chestnut-collared Longspur	2010	0.033	0.021	65	3
Chestnut-collared Longspur	2012	0.023	0.020	88	2
Chestnut-collared Longspur	2013	0.025	0.020	82	3
Chestnut-collared Longspur	2014	0.000	0.000	71	1
Chestnut-collared Longspur	2015	0.014	0.010	70	2
Chestnut-collared Longspur	2017	0.004	0.004	95	2
Chestnut-collared Longspur	2018	0.013	0.011	83	1
Clark's Nutcracker	**2010**	**0.138**	**0.026**	**19**	**24**
Clark's Nutcracker	**2011**	**0.183**	**0.016**	**9**	**33**
Clark's Nutcracker	**2012**	**0.216**	**0.039**	**18**	**42**
Clark's Nutcracker	**2013**	**0.183**	**0.040**	**22**	**52**
Clark's Nutcracker	**2014**	**0.139**	**0.027**	**20**	**43**
Clark's Nutcracker	**2015**	**0.149**	**0.033**	**22**	**50**
Clark's Nutcracker	**2016**	**0.127**	**0.021**	**17**	**35**
Clark's Nutcracker	**2017**	**0.162**	**0.031**	**19**	**32**
Clark's Nutcracker	**2018**	**0.178**	**0.025**	**14**	**30**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	% CV	*n*
Common Nighthawk	2010	0.110	0.057	52	7
Common Nighthawk	**2011**	**0.199**	**0.077**	**39**	**21**
Common Nighthawk	**2012**	**0.175**	**0.034**	**20**	**18**
Common Nighthawk	**2013**	**0.341**	**0.074**	**22**	**41**
Common Nighthawk	**2014**	**0.155**	**0.071**	**46**	**11**
Common Nighthawk	**2015**	**0.212**	**0.052**	**24**	**33**
Common Nighthawk	**2016**	**0.235**	**0.093**	**40**	**15**
Common Nighthawk	**2017**	**0.135**	**0.037**	**27**	**22**
Common Nighthawk	**2018**	**0.347**	**0.058**	**17**	**27**
Common Yellowthroat	2010	0.080	0.050	63	7
Common Yellowthroat	**2011**	**0.007**	**0.002**	**34**	**7**
Common Yellowthroat	2012	0.059	0.038	63	7
Common Yellowthroat	2013	0.043	0.023	53	6
Common Yellowthroat	2014	0.002	0.001	74	2
Common Yellowthroat	**2015**	**0.038**	**0.016**	**42**	**6**
Common Yellowthroat	2016	0.059	0.035	59	5
Common Yellowthroat	2017	0.078	0.034	**43**	6
Common Yellowthroat	**2018**	**0.039**	**0.017**	**43**	**3**
Dickcissel	2014	0.006	0.006	94	1
Ferruginous Hawk	2017	0.030	0.026	89	2
Ferruginous Hawk	2018	0.048	0.027	56	2
Franklin's Gull	2017	0.021	0.021	99	1
Golden Eagle	**2018**	**0.592**	**0.084**	**14**	**12**
Grasshopper Sparrow	**2010**	**0.134**	**0.038**	**28**	**27**
Grasshopper Sparrow	**2011**	**0.103**	**0.028**	**27**	**26**
Grasshopper Sparrow	**2012**	**0.107**	**0.030**	**28**	**16**
Grasshopper Sparrow	**2013**	**0.062**	**0.029**	**47**	**13**
Grasshopper Sparrow	**2014**	**0.085**	**0.028**	**33**	**15**
Grasshopper Sparrow	**2015**	**0.151**	**0.024**	**16**	**33**
Grasshopper Sparrow	**2016**	**0.092**	**0.027**	**29**	**15**
Grasshopper Sparrow	**2017**	**0.144**	**0.031**	**22**	**28**
Grasshopper Sparrow	**2018**	**0.150**	**0.025**	**17**	**33**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	CV	*n*
Great Blue Heron	2012	0.002	0.002	108	1
Great Blue Heron	2013	0.001	0.001	101	1
Great Blue Heron	2014	0.001	0.001	107	1
Great Blue Heron	2015	0.004	0.005	116	1
Great Blue Heron	2016	0.073	0.058	80	2
Great Blue Heron	2017	0.009	0.009	99	1
Great Blue Heron	**2018**	**0.252**	**0.051**	**20**	**7**
Greater Sage-Grouse	**2014**	**0.033**	**0.000**	**0**	**1**
Greater Sage-Grouse	2016	0.017	0.011	67	2
Greater Sage-Grouse	2017	0.061	0.073	119	2
Greater Sage-Grouse	**2018**	**0.083**	**0.029**	**35**	**2**
Juniper Titmouse	2016	0.018	0.017	97	1
Lewis's Woodpecker	2011	0.003	0.003	90	1
Lewis's Woodpecker	2014	0.002	0.002	105	1
Lewis's Woodpecker	2015	0.003	0.003	91	1
Loggerhead Shrike	**2010**	**0.047**	**0.012**	**24**	**6**
Loggerhead Shrike	**2011**	**0.182**	**0.070**	**39**	**13**
Loggerhead Shrike	2012	0.092	0.071	77	6
Loggerhead Shrike	2013	0.117	0.061	52	6
Loggerhead Shrike	**2014**	**0.115**	**0.053**	**46**	**6**
Loggerhead Shrike	**2015**	**0.327**	**0.088**	**27**	**25**
Loggerhead Shrike	**2016**	**0.200**	**0.060**	**30**	**13**
Loggerhead Shrike	**2017**	**0.152**	**0.050**	**33**	**11**
Loggerhead Shrike	**2018**	**0.254**	**0.060**	**24**	**9**
Long-billed Curlew	2015	0.010	0.009	98	1
Long-billed Curlew	2016	0.029	0.026	88	2
Long-billed Curlew	2017	0.019	0.019	98	1
MacGillivray's Warbler	**2010**	**0.053**	**0.021**	**40**	**19**
MacGillivray's Warbler	**2011**	**0.067**	**0.028**	**43**	**15**
MacGillivray's Warbler	**2012**	**0.034**	**0.014**	**42**	**17**
MacGillivray's Warbler	**2013**	**0.050**	**0.017**	**34**	**27**
MacGillivray's Warbler	**2014**	**0.052**	**0.016**	**31**	**29**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	CV	n
MacGillivray's Warbler	**2015**	**0.102**	**0.018**	**17**	**45**
MacGillivray's Warbler	**2016**	**0.107**	**0.023**	**21**	**33**
MacGillivray's Warbler	**2017**	**0.069**	**0.018**	**26**	**33**
MacGillivray's Warbler	**2018**	**0.074**	**0.012**	**16**	**24**
McCown's Longspur	2010	0.045	0.023	50	5
McCown's Longspur	**2011**	**0.022**	**0.010**	**47**	**4**
McCown's Longspur	2012	0.045	0.023	50	6
McCown's Longspur	**2013**	**0.024**	**0.010**	**43**	**4**
McCown's Longspur	2014	0.019	0.010	54	3
McCown's Longspur	**2015**	**0.033**	**0.014**	**43**	**9**
McCown's Longspur	2016	0.018	0.009	52	4
McCown's Longspur	2017	0.036	0.019	54	5
McCown's Longspur	**2018**	**0.036**	**0.012**	**32**	**4**
Merlin	**2018**	**0.159**	**0.067**	**42**	**1**
Mountain Plover	2010	0.000	0.000	71	1
Mountain Plover	2011	0.020	0.017	85	2
Mountain Plover	2013	0.003	0.002	62	2
Mountain Plover	2015	0.001	0.001	66	2
Mountain Plover	2016	0.013	0.008	64	3
Mountain Plover	2018	0.024	0.014	58	3
Northern Goshawk	2012	0.031	0.027	87	3
Northern Goshawk	**2018**	**0.113**	**0.025**	**22**	**3**
Northern Pygmy-Owl	2013	0.001	0.001	110	1
Peregrine Falcon	2018	0.025	0.018	71	1
Purple Martin	2014	0.001	0.001	82	1
Pygmy Nuthatch	2010	0.002	0.002	64	2
Pygmy Nuthatch	2011	0.007	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**
Pygmy Nuthatch	2015	0.018	0.017	95	2
Pygmy Nuthatch	2016	0.001	0.001	97	1

Table 3. Continued.

Species common name	Year	Psi ψ	SE	CV	*n*
Pygmy Nuthatch	2017	0.001	0.001	97	1
Pygmy Nuthatch	2018	0.035	0.021	62	1
Red Crossbill	**2010**	**0.082**	**0.010**	**12**	**29**
Red Crossbill	**2011**	**0.126**	**0.015**	**12**	**23**
Red Crossbill	**2012**	**0.162**	**0.038**	**23**	**40**
Red Crossbill	**2013**	**0.096**	**0.023**	**24**	**50**
Red Crossbill	**2014**	**0.108**	**0.024**	**22**	**50**
Red Crossbill	**2015**	**0.084**	**0.012**	**14**	**44**
Red Crossbill	**2016**	**0.092**	**0.018**	**20**	**42**
Red Crossbill	**2017**	**0.088**	**0.014**	**16**	**43**
Red Crossbill	**2018**	**0.155**	**0.025**	**16**	**54**
Red-eyed Vireo	2012	0.003	0.002	72	1
Red-eyed Vireo	**2013**	**0.002**	**0.001**	**41**	**4**
Red-eyed Vireo	2014	0.002	0.001	82	1
Red-eyed Vireo	2015	0.002	0.001	82	1
Red-eyed Vireo	2017	0.002	0.001	58	2
Red-eyed Vireo	2018	0.009	0.011	122	1
Red-headed Woodpecker	2011	0.003	0.002	85	1
Red-headed Woodpecker	2013	0.001	0.001	98	1
Red-headed Woodpecker	2014	0.002	0.002	82	1
Red-headed Woodpecker	2015	0.012	0.006	50	5
Red-headed Woodpecker	2016	0.000	0.000	71	1
Red-headed Woodpecker	2017	0.007	0.005	70	2
Red-headed Woodpecker	2018	0.003	0.002	53	2
Rufous Hummingbird	2012	0.016	0.013	79	2
Rufous Hummingbird	2014	0.024	0.022	94	2
Rufous Hummingbird	2015	0.009	0.007	75	3
Rufous Hummingbird	2017	0.012	0.008	66	4
Sage Thrasher	**2010**	**0.262**	**0.051**	**20**	**34**
Sage Thrasher	**2011**	**0.241**	**0.040**	**17**	**33**
Sage Thrasher	**2012**	**0.353**	**0.080**	**23**	**38**
Sage Thrasher	**2013**	**0.182**	**0.039**	**21**	**26**

Table 3. Continued.

Species common name	Year	Psi ψ	SE	CV	*n*
Sage Thrasher	**2014**	**0.223**	**0.048**	**21**	**22**
Sage Thrasher	**2015**	**0.292**	**0.041**	**14**	**46**
Sage Thrasher	**2016**	**0.337**	**0.040**	**12**	**46**
Sage Thrasher	**2017**	**0.371**	**0.039**	**10**	**51**
Sage Thrasher	**2018**	**0.332**	**0.033**	**10**	**42**
Sagebrush Sparrow	**2010**	**0.190**	**0.037**	**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**
Sagebrush Sparrow	**2015**	**0.144**	**0.026**	**18**	**23**
Sagebrush Sparrow	**2016**	**0.194**	**0.028**	**14**	**31**
Sagebrush Sparrow	**2017**	**0.243**	**0.030**	**12**	**37**
Sagebrush Sparrow	**2018**	**0.198**	**0.021**	**11**	**29**
Sharp-tailed Grouse	2016	0.004	0.004	96	1
Sharp-tailed Grouse	2017	0.008	0.008	100	1
Short-eared Owl	2015	0.026	0.017	65	5
Short-eared Owl	2016	0.015	0.012	81	2
Swainson’s Hawk	2010	0.016	0.015	95	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
Swainson’s Hawk	2015	0.109	0.076	70	3
Swainson’s Hawk	**2016**	**0.197**	**0.060**	**30**	**5**
Swainson’s Hawk	**2018**	**0.146**	**0.053**	**36**	**4**
Upland Sandpiper	2010	0.039	0.030	77	5
Upland Sandpiper	2011	0.025	0.021	83	6
Upland Sandpiper	2012	0.014	0.008	62	2
Upland Sandpiper	2014	0.076	0.044	58	4
Upland Sandpiper	**2015**	**0.049**	**0.020**	**41**	**8**
Upland Sandpiper	2016	0.026	0.020	80	3
Upland Sandpiper	2017	0.010	0.006	59	3

Table 3. Continued.

Species common name	Year	Psi ψ	SE	CV	*n*
Upland Sandpiper	2018	0.041	0.027	67	4
Virginia's Warbler	2014	0.001	0.001	82	1
Virginia's Warbler	2015	0.001	0.001	71	1
Virginia's Warbler	2017	0.017	0.015	89	2
Williamson's Sapsucker	2010	0.003	0.002	72	2
Williamson's Sapsucker	**2011**	**0.011**	**0.005**	**47**	**3**
Williamson's Sapsucker	2012	0.024	0.016	69	4
Williamson's Sapsucker	**2013**	**0.005**	**0.002**	**41**	**5**
Williamson's Sapsucker	**2014**	**0.007**	**0.003**	**40**	**6**
Williamson's Sapsucker	**2015**	**0.007**	**0.003**	**48**	**6**
Williamson's Sapsucker	2016	0.015	0.010	68	3
Williamson's Sapsucker	2017	0.006	0.003	58	2
Williamson's Sapsucker	**2018**	**0.019**	**0.009**	**46**	**4**
Willow Flycatcher	2010	0.059	0.040	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
Willow Flycatcher	2015	0.024	0.021	88	3
Willow Flycatcher	2016	0.029	0.019	65	4
Willow Flycatcher	2017	0.027	0.028	105	1
Willow Flycatcher	2018	0.031	0.017	55	2
Woodhouse's Scrub-Jay	2015	0.009	0.009	98	1

Index of Scientific Names:

American Kestrel	*Falco sparverius*
American Pipit	*Anthus rubescens*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Baird's Sparrow	*Ammodramus bairdii*
Bald Eagle	*Haliaeetus leucocephalus*
Bewick's Wren	*Thryomanes bewickii*
Black Rosy-Finch	*Leucosticte atrata*
Black-backed Woodpecker	*Picoides arcticus*
Black-throated Gray Warbler	*Setophaga virens*
Blue Grosbeak	*Passerina caerulea*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Bobolink	*Dolichonyx oryzivorus*

Brewer's Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Bushtit	*Psaltriparus minimus*
Calliope Hummingbird	*Selasphorus calliope*
Canyon Wren	*Catherpes mexicanus*
Chestnut-collared Longspur	*Calcarius ornatus*
Clark's Nutcracker	*Nucifraga columbiana*
Common Nighthawk	*Chordeiles minor*
Common Yellowthroat	*Geothlypis trichas*
Dickcissel	*Spiza americana*
Ferruginous Hawk	*Buteo regalis*
Franklin's Gull	*Leucophaeus pipixcan*
Golden Eagle	*Aquila chrysaetos*
Grasshopper Sparrow	*Ammodramus savannarum*
Great Blue Heron	*Ardea herodias*
Greater Sage-Grouse	*Centrocercus urophasianus*
Juniper Titmouse	*Baeolophus ridgwayi*
Lewis's Woodpecker	*Melanerpes lewis*
Loggerhead Shrike	*Lanius ludovicianus*
Long-billed Curlew	*Numenius americanus*
MacGillivray's Warbler	*Geothlypis tolmiei*
McCown's Longspur	*Rhynchophanes mccownii*
Merlin	*Falco columbarius*
Mountain Plover	*Charadrius montanus*
Northern Goshawk	*Accipiter gentilis*
Northern Pygmy-Owl	*Glaucidium gnoma*
Purple Martin	*Progne subis*
Pygmy Nuthatch	*Sitta pygmaea*
Red Crossbill	*Loxia curvirostra*
Red-eyed Vireo	*Vireo olivaceus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Rufous Hummingbird	*Selasphorus rufus*
Sage Thrasher	*Oreoscoptes montanus*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Short-eared Owl	*Asio flammeus*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Virginia's Warbler	*Oreothlypis virginiae*
Williamson's Sapsucker	*Sphyrapicus thyroideus*
Willow Flycatcher	*Empidonax traillii*
Woodhouse's Scrub-Jay	*Aphelocoma woodhouseii*

Table 4. Estimated density (D; individuals per km^2), population size (N), percent coefficient of variation (% CV), and number of independent detections (n) of 47 avian Species of Greatest Conservation Need on Integrated Monitoring in Bird Conservation Regions survey grids throughout Wyoming from 2009-2018. Density estimates are considered robust if percent CV <50%, and are denoted in bold (27 species). Scientific names are presented below the table.

Species common name	Year	D	N	% CV	*n*
American Kestrel	**2009**	**0.400**	**74,454**	**30**	**29**
American Kestrel	**2010**	**0.490**	**122,183**	**27**	**15**
American Kestrel	**2011**	**0.140**	**36,494**	**46**	**11**
American Kestrel	**2012**	**0.060**	**15,643**	**26**	**22**
American Kestrel	2013	0.130	32,799	79	6
American Kestrel	2014	0.140	35,683	55	16
American Kestrel	**2015**	**0.140**	**35,447**	**36**	**40**
American Kestrel	**2016**	**0.130**	**32,951**	**37**	**19**
American Kestrel	**2017**	**0.180**	**44,536**	**37**	**30**
American Kestrel	**2018**	**0.160**	**41,045**	**35**	**24**
American Pipit	2009	0.180	33,292	61	41
American Pipit	2010	0.380	95,953	63	51
American Pipit	2011	0.530	132,753	60	40
American Pipit	2012	2.730	686,292	76	29
American Pipit	2013	1.160	293,037	74	48
American Pipit	2014	1.090	275,038	71	48
American Pipit	2015	1.810	458,381	57	102
American Pipit	2016	0.950	239,567	58	31
American Pipit	2017	1.950	493,344	66	25
American Pipit	**2018**	**1.790**	**452,352**	**30**	**39**
American White Pelican	2014	0.010	1,643	101	3
American White Pelican	2017	0.000	237	121	3
American White Pelican	2018	0.000	567	175	1
Ash-throated Flycatcher	2015	0.040	10,838	97	2
Ash-throated Flycatcher	**2018**	**0.070**	**16,555**	**40**	**3**
Baird's Sparrow	2017	0.050	13,209	100	1
Baird's Sparrow	2018	0.020	4,712	93	2
Bald Eagle	2017	0.020	3,958	95	3
Bald Eagle	2018	0.000	926	64	3
Bewick's Wren	2010	0.770	192,544	85	1

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Bewick's Wren	2014	0.100	25,016	69	2
Bewick's Wren	2015	1.150	291,612	104	22
Bewick's Wren	2016	0.450	113,787	67	9
Bewick's Wren	**2017**	**0.460**	**116,837**	**50**	**13**
Bewick's Wren	**2018**	**0.870**	**221,244**	**19**	**22**
Black Rosy-Finch	2017	0.730	186,059	114	10
Black Rosy-Finch	2018	0.280	69,640	92	5
Black-backed Woodpecker	2018	0.000	--	373	0
Black-throated Gray Warbler	2010	0.010	1,797	100	1
Black-throated Gray Warbler	2013	0.000	1,102	101	1
Black-throated Gray Warbler	2015	0.130	32,158	104	1
Black-throated Gray Warbler	2017	0.130	32,694	100	2
Black-throated Gray Warbler	**2018**	**0.430**	**108,235**	**36**	**6**
Blue Grosbeak	2009	0.000	216	100	1
Blue Grosbeak	2010	0.000	296	82	1
Blue Grosbeak	2014	0.010	3,440	97	1
Blue Grosbeak	2015	0.010	2,133	101	1
Blue Grosbeak	2016	0.020	5,925	100	2
Blue Grosbeak	2017	0.030	6,648	70	4
Blue Grosbeak	2018	0.020	3,691	56	2
Blue-gray Gnatcatcher	2009	1.430	269,874	76	6
Blue-gray Gnatcatcher	2010	1.270	318,756	53	12
Blue-gray Gnatcatcher	2011	0.430	108,050	57	5
Blue-gray Gnatcatcher	2012	0.970	243,383	62	13
Blue-gray Gnatcatcher	2013	0.630	158,532	60	4
Blue-gray Gnatcatcher	2014	0.700	178,240	71	10
Blue-gray Gnatcatcher	2015	0.440	110,559	56	6
Blue-gray Gnatcatcher	2016	1.110	280,556	63	15
Blue-gray Gnatcatcher	2017	1.160	293,740	58	14
Blue-gray Gnatcatcher	**2018**	**1.240**	**314,488**	**30**	**17**
Bobolink	2018	0.000	--	882	0
Brewer's Sparrow	**2009**	**44.260**	**8,328,561**	**24**	**828**

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Brewer's Sparrow	**2010**	**29.750**	**7,481,986**	**13**	**804**
Brewer's Sparrow	**2011**	**30.690**	**7,707,408**	**15**	**824**
Brewer's Sparrow	**2012**	**22.570**	**5,670,208**	**15**	**873**
Brewer's Sparrow	**2013**	**24.200**	**6,134,460**	**16**	**1235**
Brewer's Sparrow	**2014**	**31.760**	**8,048,826**	**19**	**907**
Brewer's Sparrow	**2015**	**44.270**	**11,220,044**	**12**	**1875**
Brewer's Sparrow	**2016**	**40.320**	**10,219,451**	**11**	**1563**
Brewer's Sparrow	**2017**	**41.110**	**10,420,914**	**10**	**1578**
Brewer's Sparrow	**2018**	**39.960**	**10,127,880**	**10**	**1603**
Burrowing Owl	2014	0.000	240	99	1
Burrowing Owl	2015	0.000	64	89	2
Burrowing Owl	2017	0.000	609	98	4
Burrowing Owl	2018	0.000	214	89	1
Bushtit	2016	0.210	52,852	101	1
Calliope Hummingbird	2018	0.000	--	360	0
Canyon Wren	2009	0.000	408	70	2
Canyon Wren	2010	0.070	17,526	99	7
Canyon Wren	2012	0.000	35	100	1
Canyon Wren	2013	0.000	79	100	1
Canyon Wren	2015	0.000	1,125	98	1
Canyon Wren	2016	0.040	9,241	93	10
Canyon Wren	2017	0.030	7,179	98	3
Canyon Wren	**2018**	**0.020**	**4,566**	**37**	**6**
Chestnut-collared Longspur	2010	0.440	109,983	54	6
Chestnut-collared Longspur	2012	1.200	302,303	106	9
Chestnut-collared Longspur	2013	0.140	35,401	102	4
Chestnut-collared Longspur	2014	0.000	380	137	8
Chestnut-collared Longspur	2015	1.100	278,706	97	29
Chestnut-collared Longspur	2017	0.030	7,779	100	4
Chestnut-collared Longspur	**2018**	**0.280**	**70,749**	**34**	**24**
Clark's Nutcracker	**2009**	**1.250**	**234,659**	**44**	**88**
Clark's Nutcracker	**2010**	**2.180**	**549,376**	**38**	**96**

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Clark's Nutcracker	**2011**	**1.660**	**417,934**	**33**	**170**
Clark's Nutcracker	**2012**	**1.380**	**346,559**	**27**	**226**
Clark's Nutcracker	**2013**	**1.600**	**404,832**	**34**	**187**
Clark's Nutcracker	**2014**	**1.070**	**271,885**	**24**	**358**
Clark's Nutcracker	**2015**	**0.760**	**192,744**	**25**	**261**
Clark's Nutcracker	**2016**	**0.970**	**244,981**	**34**	**222**
Clark's Nutcracker	**2017**	**1.080**	**274,719**	**27**	**173**
Clark's Nutcracker	2018	1.100	278,720	67	239
Common Nighthawk	2009	0.140	26,178	60	11
Common Nighthawk	2010	0.360	90,051	56	13
Common Nighthawk	**2011**	**0.980**	**246,880**	**38**	**45**
Common Nighthawk	**2012**	**0.520**	**130,127**	**31**	**51**
Common Nighthawk	**2013**	**0.590**	**149,366**	**33**	**68**
Common Nighthawk	**2014**	**0.120**	**29,903**	**39**	**35**
Common Nighthawk	**2015**	**0.470**	**120,131**	**28**	**87**
Common Nighthawk	**2016**	**0.230**	**59,010**	**37**	**52**
Common Nighthawk	**2017**	**0.420**	**107,287**	**26**	**70**
Common Nighthawk	**2018**	**0.540**	**137,191**	**26**	**103**
Common Yellowthroat	2009	0.440	82,067	58	57
Common Yellowthroat	2010	0.740	186,002	53	17
Common Yellowthroat	**2011**	**0.060**	**15,226**	**23**	**22**
Common Yellowthroat	2012	0.360	91,027	71	16
Common Yellowthroat	2013	0.060	15,387	78	7
Common Yellowthroat	2014	0.090	23,075	72	6
Common Yellowthroat	**2015**	**0.130**	**33,977**	**43**	**10**
Common Yellowthroat	2016	0.150	37,189	59	9
Common Yellowthroat	2017	0.560	140,930	56	17
Common Yellowthroat	**2018**	**0.170**	**42,633**	**30**	**8**
Dickcissel	2014	0.010	3,420	107	1
Dickcissel	2018	0.000	--	564	0
Ferruginous Hawk	2018	0.000	525	77	2
Franklin's Gull	2018	0.000	--	490	0

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Golden Eagle	2014	0.000	465	101	1
Golden Eagle	2015	0.010	2,793	73	6
Golden Eagle	2016	0.010	3,159	113	1
Golden Eagle	2017	0.050	12,271	69	6
Golden Eagle	**2018**	**0.030**	**6,730**	**39**	**23**
Grasshopper Sparrow	**2009**	**2.000**	**376,107**	**37**	**45**
Grasshopper Sparrow	**2010**	**3.350**	**843,508**	**31**	**98**
Grasshopper Sparrow	**2011**	**3.960**	**994,665**	**24**	**185**
Grasshopper Sparrow	**2012**	**2.820**	**708,620**	**32**	**103**
Grasshopper Sparrow	2013	1.010	256,991	51	52
Grasshopper Sparrow	**2014**	**1.650**	**418,926**	**42**	**66**
Grasshopper Sparrow	**2015**	**5.320**	**1,348,656**	**26**	**178**
Grasshopper Sparrow	**2016**	**2.580**	**654,819**	**26**	**110**
Grasshopper Sparrow	**2017**	**4.420**	**1,119,222**	**23**	**179**
Grasshopper Sparrow	**2018**	**5.440**	**1,377,817**	**13**	**303**
Great Blue Heron	2012	0.040	8,854	86	3
Great Blue Heron	2013	0.000	206	104	1
Great Blue Heron	2014	0.000	123	103	1
Great Blue Heron	2015	0.000	894	78	4
Great Blue Heron	2016	0.010	3,422	78	2
Great Blue Heron	2017	0.010	3,321	97	3
Great Blue Heron	2018	0.020	3,828	90	4
Greater Sage-Grouse	2016	0.080	19,414	73	7
Greater Sage-Grouse	2017	0.020	5,927	59	4
Greater Sage-Grouse	2018	0.040	11,162	163	3
Juniper Titmouse	2016	0.240	61,905	101	2
Juniper Titmouse	2018	0.000	--	648	0
Lewis's Woodpecker	2014	0.000	473	101	1
Lewis's Woodpecker	2018	0.000	--	209	0
Loggerhead Shrike	**2009**	**0.240**	**44,929**	**38**	**12**
Loggerhead Shrike	**2010**	**0.100**	**23,917**	**47**	**8**
Loggerhead Shrike	**2011**	**0.240**	**59,225**	**39**	**14**

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Loggerhead Shrike	2012	0.110	28,062	54	8
Loggerhead Shrike	2013	0.160	39,347	50	8
Loggerhead Shrike	2014	0.130	31,918	55	7
Loggerhead Shrike	**2015**	**0.400**	**102,032**	**30**	**42**
Loggerhead Shrike	**2016**	**0.600**	**151,109**	**38**	**32**
Loggerhead Shrike	**2017**	**0.220**	**55,776**	**30**	**22**
Loggerhead Shrike	**2018**	**0.190**	**48,663**	**35**	**11**
Long-billed Curlew	2011	0.160	41,209	86	3
Long-billed Curlew	2012	0.140	34,494	108	3
Long-billed Curlew	2015	0.240	61,444	81	7
Long-billed Curlew	2016	0.100	26,033	98	6
Long-billed Curlew	2017	0.010	1,292	100	1
Long-billed Curlew	2018	0.010	1,567	91	1
MacGillivray's Warbler	2009	3.440	646,770	59	48
MacGillivray's Warbler	2010	1.360	341,027	81	29
MacGillivray's Warbler	2011	0.720	179,700	55	21
MacGillivray's Warbler	2012	0.470	118,881	77	28
MacGillivray's Warbler	**2013**	**0.960**	**243,351**	**40**	**62**
MacGillivray's Warbler	**2014**	**0.500**	**125,930**	**29**	**67**
MacGillivray's Warbler	**2015**	**2.010**	**509,810**	**38**	**106**
MacGillivray's Warbler	**2016**	**0.580**	**147,723**	**25**	**70**
MacGillivray's Warbler	**2017**	**0.580**	**147,571**	**24**	**79**
MacGillivray's Warbler	**2018**	**0.940**	**238,836**	**16**	**69**
McCown's Longspur	2009	2.690	505,993	60	26
McCown's Longspur	2010	1.700	427,797	50	34
McCown's Longspur	2011	1.650	414,502	68	50
McCown's Longspur	2012	2.410	604,745	60	117
McCown's Longspur	2013	2.200	558,239	65	105
McCown's Longspur	2014	0.400	100,987	101	16
McCown's Longspur	2015	4.060	1,028,926	54	112
McCown's Longspur	2016	1.240	314,551	70	68
McCown's Longspur	2017	0.540	137,910	54	34

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
McCown's Longspur	**2018**	**1.230**	**310,641**	**34**	**60**
Mountain Plover	2013	0.000	863	80	3
Mountain Plover	2014	0.140	34,447	89	17
Mountain Plover	2015	0.000	381	102	3
Mountain Plover	2016	0.180	45,424	72	29
Mountain Plover	2017	0.030	7,878	103	4
Mountain Plover	**2018**	**0.090**	**21,515**	**36**	**8**
Northern Goshawk	2018	0.010	1,700	56	3
Northern Pygmy-Owl	2018	0.000	--	247	0
Peregrine Falcon	2018	0.000	874	80	1
Purple Martin	2014	0.000	787	103	1
Purple Martin	2018	0.000	--	702	0
Pygmy Nuthatch	2009	0.060	11,493	61	4
Pygmy Nuthatch	2010	0.030	6,868	81	2
Pygmy Nuthatch	2011	0.080	19,321	77	2
Pygmy Nuthatch	2012	0.080	18,969	81	8
Pygmy Nuthatch	2013	0.010	1,980	72	2
Pygmy Nuthatch	2014	0.040	9,243	61	5
Pygmy Nuthatch	2015	0.060	14,766	72	5
Pygmy Nuthatch	2017	0.010	2,939	101	2
Pygmy Nuthatch	2018	0.230	58,134	70	2
Red Crossbill	2009	0.820	153,889	50	55
Red Crossbill	**2010**	**0.710**	**178,661**	**42**	**44**
Red Crossbill	**2011**	**1.310**	**329,432**	**25**	**51**
Red Crossbill	**2012**	**5.850**	**1,469,709**	**49**	**83**
Red Crossbill	**2013**	**1.590**	**403,246**	**30**	**121**
Red Crossbill	**2014**	**1.420**	**359,045**	**24**	**114**
Red Crossbill	**2015**	**0.590**	**149,998**	**22**	**116**
Red Crossbill	**2016**	**1.650**	**417,140**	**29**	**116**
Red Crossbill	**2017**	**1.630**	**413,133**	**27**	**163**
Red Crossbill	2018	1.720	435,570	139	143
Red-eyed Vireo	2012	0.050	12,694	103	4

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Red-eyed Vireo	2013	0.020	4,466	57	10
Red-eyed Vireo	2014	0.010	3,477	96	4
Red-eyed Vireo	2015	0.090	21,815	99	12
Red-eyed Vireo	2017	0.010	2,432	63	4
Red-eyed Vireo	**2018**	**0.010**	**2,273**	**37**	**3**
Red-headed Woodpecker	2013	0.010	2,746	91	2
Red-headed Woodpecker	2014	0.010	3,358	101	6
Red-headed Woodpecker	**2015**	**0.040**	**9,708**	**44**	**12**
Red-headed Woodpecker	2016	0.000	14	65	1
Red-headed Woodpecker	2017	0.010	2,048	72	4
Red-headed Woodpecker	**2018**	**0.020**	**4,150**	**45**	**10**
Rufous Hummingbird	2014	0.230	58,264	118	1
Rufous Hummingbird	2015	0.380	97,314	136	1
Rufous Hummingbird	2018	0.890	226,653	95	0
Sage Thrasher	**2009**	**2.780**	**522,260**	**16**	**231**
Sage Thrasher	**2010**	**2.630**	**661,911**	**18**	**284**
Sage Thrasher	**2011**	**2.310**	**581,212**	**13**	**405**
Sage Thrasher	**2012**	**2.370**	**594,478**	**17**	**252**
Sage Thrasher	**2013**	**1.220**	**310,125**	**23**	**411**
Sage Thrasher	**2014**	**1.760**	**444,993**	**14**	**278**
Sage Thrasher	**2015**	**3.070**	**778,800**	**18**	**485**
Sage Thrasher	**2016**	**2.930**	**741,614**	**14**	**715**
Sage Thrasher	**2017**	**3.170**	**802,604**	**9**	**853**
Sage Thrasher	**2018**	**3.420**	**867,818**	**5**	**656**
Sagebrush Sparrow	**2009**	**5.570**	**1,047,864**	**18**	**281**
Sagebrush Sparrow	**2010**	**5.010**	**1,260,838**	**23**	**252**
Sagebrush Sparrow	**2011**	**5.790**	**1,453,124**	**21**	**271**
Sagebrush Sparrow	**2012**	**4.250**	**1,067,892**	**30**	**254**
Sagebrush Sparrow	**2013**	**2.490**	**631,410**	**27**	**320**
Sagebrush Sparrow	**2014**	**3.020**	**764,327**	**25**	**234**
Sagebrush Sparrow	**2015**	**6.080**	**1,541,390**	**32**	**507**
Sagebrush Sparrow	**2016**	**8.520**	**2,159,500**	**18**	**665**

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Sagebrush Sparrow	**2017**	**8.440**	**2,140,250**	**18**	**704**
Sagebrush Sparrow	**2018**	**7.670**	**1,943,059**	**9**	**622**
Sharp-tailed Grouse	2013	0.000	485	101	2
Sharp-tailed Grouse	2015	0.010	2,385	98	1
Sharp-tailed Grouse	2016	0.060	16,313	102	6
Sharp-tailed Grouse	2017	0.030	6,491	63	4
Sharp-tailed Grouse	2018	0.010	1,861	152	0
Short-eared Owl	2017	0.000	427	103	1
Short-eared Owl	2018	0.000	794	104	1
Swainson's Hawk	2009	0.090	16,237	57	9
Swainson's Hawk	2010	0.010	3,587	77	4
Swainson's Hawk	2011	0.020	4,496	71	3
Swainson's Hawk	2012	0.000	794	80	3
Swainson's Hawk	2013	0.030	8,687	70	3
Swainson's Hawk	2014	0.050	12,241	91	4
Swainson's Hawk	2015	0.070	17,890	77	6
Swainson's Hawk	2016	0.070	17,841	57	13
Swainson's Hawk	2017	0.010	2,055	80	5
Swainson's Hawk	**2018**	**0.020**	**5,812**	**49**	**4**
Upland Sandpiper	2010	0.150	38,587	71	12
Upland Sandpiper	2011	0.120	30,357	54	22
Upland Sandpiper	2012	0.020	4,554	70	3
Upland Sandpiper	2013	0.060	14,010	87	8
Upland Sandpiper	2014	0.150	37,022	68	19
Upland Sandpiper	**2015**	**0.160**	**40,730**	**42**	**36**
Upland Sandpiper	**2016**	**0.140**	**36,718**	**39**	**23**
Upland Sandpiper	2017	0.150	37,601	69	17
Upland Sandpiper	**2018**	**0.060**	**15,102**	**34**	**15**
Virginia's Warbler	2014	0.010	1,267	103	1
Virginia's Warbler	2015	0.010	2,184	88	1
Virginia's Warbler	2017	0.080	19,705	100	1
Virginia's Warbler	2018	0.000	--	510	0

Table 4. Continued.

Species common name	Year	D	N	% CV	*n*
Western Grebe	2018	0.000	--	276	0
White-faced Ibis	2018	0.010	2,406	318	0
Williamson's Sapsucker	2012	0.090	23,458	73	7
Williamson's Sapsucker	2013	0.010	3,461	61	4
Williamson's Sapsucker	2014	0.050	12,272	51	11
Williamson's Sapsucker	2015	0.030	7,745	81	4
Williamson's Sapsucker	2016	0.280	70,741	70	7
Williamson's Sapsucker	2017	0.090	23,467	86	5
Williamson's Sapsucker	**2018**	**0.060**	**14,284**	**47**	**4**
Willow Flycatcher	2013	0.010	2,429	107	1
Willow Flycatcher	2014	0.210	52,528	95	3
Willow Flycatcher	2015	0.440	111,217	96	6
Willow Flycatcher	2016	0.280	71,228	78	7
Willow Flycatcher	2017	0.350	88,508	99	4
Willow Flycatcher	**2018**	**0.370**	**93,405**	**30**	**8**
Woodhouse's Scrub-Jay	2015	0.020	4,988	101	1

Index of Scientific Names:

American Kestrel	*Falco sparverius*
American Pipit	*Anthus rubescens*
American White Pelican	*Pelecanus erythrorhynchos*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Baird's Sparrow	*Ammodramus bairdii*
Bald Eagle	*Haliaeetus leucocephalus*
Bewick's Wren	*Thryomanes bewickii*
Black Rosy-Finch	*Leucosticte atrata*
Black-backed Woodpecker	*Picoides arcticus*
Black-throated Gray Warbler	*Setophaga virens*
Blue Grosbeak	*Passerina caerulea*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Bobolink	*Dolichonyx oryzivorus*
Brewer's Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Bushtit	*Psaltriparus minimus*
Calliope Hummingbird	*Selasphorus calliope*
Canyon Wren	*Catherpes mexicanus*
Chestnut-collared Longspur	*Calcarius ornatus*

Clark's Nutcracker	*Nucifraga columbiana*
Common Nighthawk	*Chordeiles minor*
Common Yellowthroat	*Geothlypis trichas*
Dickcissel	*Spiza americana*
Ferruginous Hawk	*Buteo regalis*
Franklin's Gull	*Larus pipixcan*
Golden Eagle	*Aquila chrysaetos*
Grasshopper Sparrow	*Ammodramus savannarum*
Great Blue Heron	*Ardea herodias*
Greater Sage-Grouse	*Centrocercus urophasianus*
Juniper Titmouse	*Baeolophus ridgwayi*
Lewis's Woodpecker	*Melanerpes lewis*
Loggerhead Shrike	*Lanius ludovicianus*
Long-billed Curlew	*Numenius americanus*
MacGillivray's Warbler	*Geothlypis tolmiei*
McCown's Longspur	*Rhynchophanes mccownii*
Mountain Plover	*Charadrius montanus*
Northern Goshawk	*Accipiter gentilis*
Northern Pygmy-Owl	*Glaucidium gnoma*
Peregrine Falcon	*Falco peregrinus*
Purple Martin	*Progne subis*
Pygmy Nuthatch	*Sitta pygmaea*
Red Crossbill	*Loxia curvirostra*
Red-eyed Vireo	*Vireo olivaceus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Rufous Hummingbird	*Selasphorus rufus*
Sage Thrasher	*Oreoscoptes montanus*
Sagebrush Sparrow	*Artemesiospiza nevadensis*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Short-eared Owl	*Asio flammeus*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Virginia's Warbler	*Oreothlypis virginiae*
Western Grebe	*Aechmophorus occidentalis*
White-faced Ibis	*Plegadis chihi*
Williamson's Sapsucker	*Sphyrapicus thyroideus*
Willow Flycatcher	*Empidonax traillii*
Woodhouse's Scrub-Jay	*Aphelocoma woodhouseii*

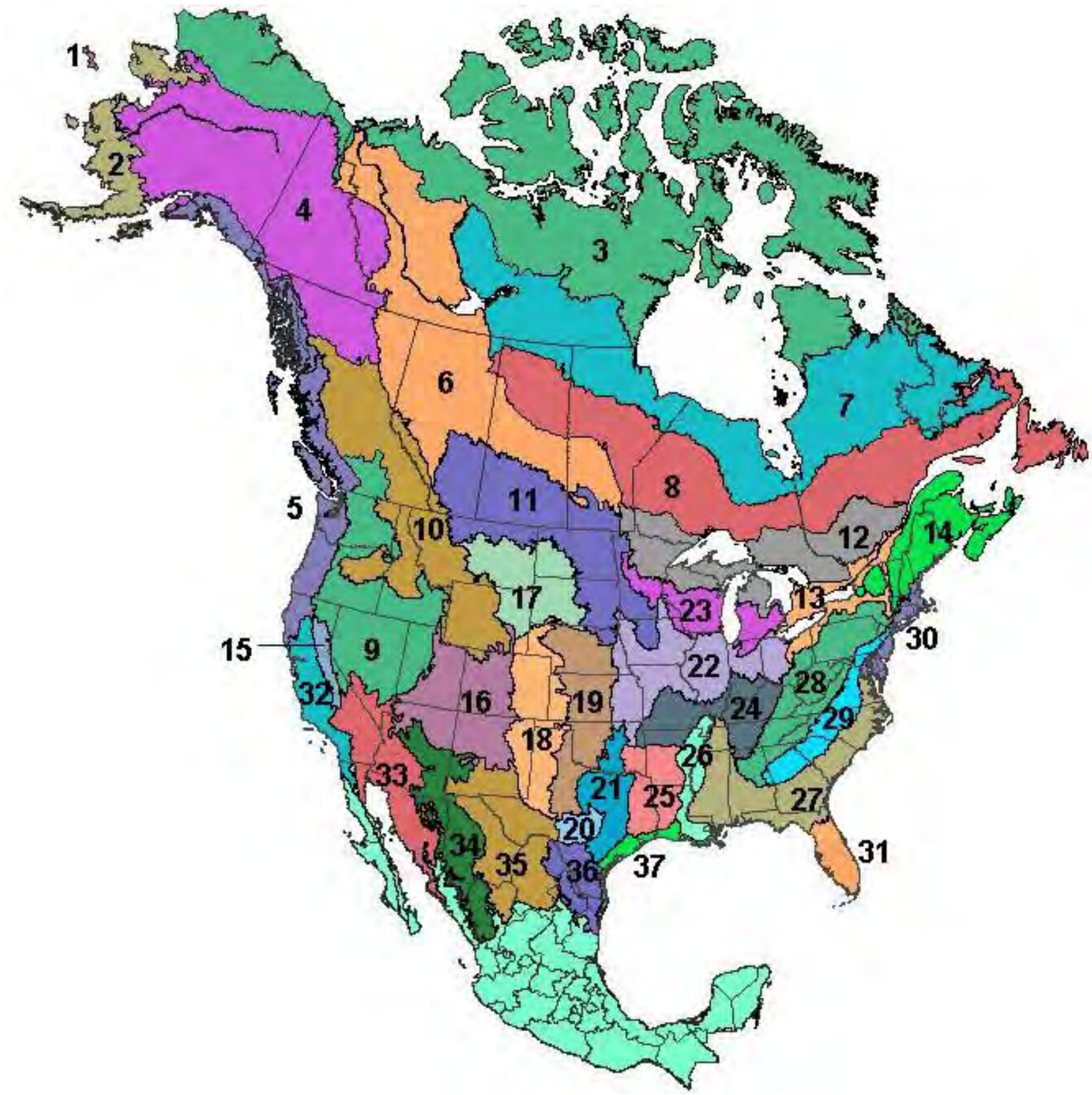

Figure 1. The North American Bird Conservation Region (BCR) map, excluding Hawaii and Mexico (Bird Studies Canada and NABCI 2014). Portions of BCRs that occur in Wyoming are: 9 – Great Basin, 10 – Northern Rockies, 16 – Southern Rockies/Colorado Plateau, 17 – Badlands and Prairies, and 18 – Shortgrass Prairie. Surveys were conducted in all BCRs in Wyoming in 2018.

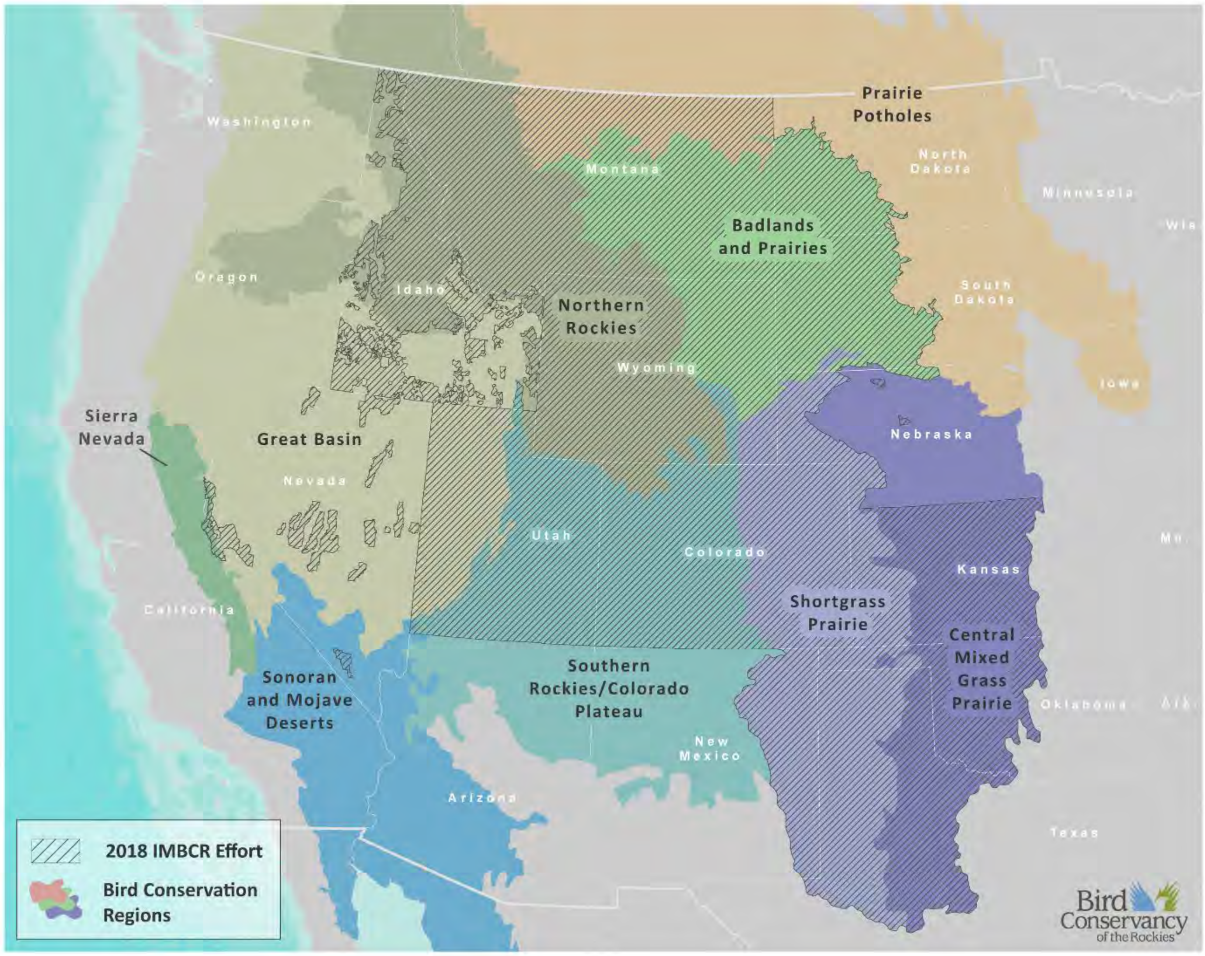

Figure 2. Spatial extent (hashed areas) of the IMBCR program in 2018 (Drilling et al. 2019). The IMBCR program covered all or parts of 15 states, 4 USFS Regions, and 9 Bird Conservation Regions, and the area of inference was approximately 2 million km^2.

Figure 3. Example of the 1 km^2 sampling unit using the IMBCR design (Drilling et al. 2019).

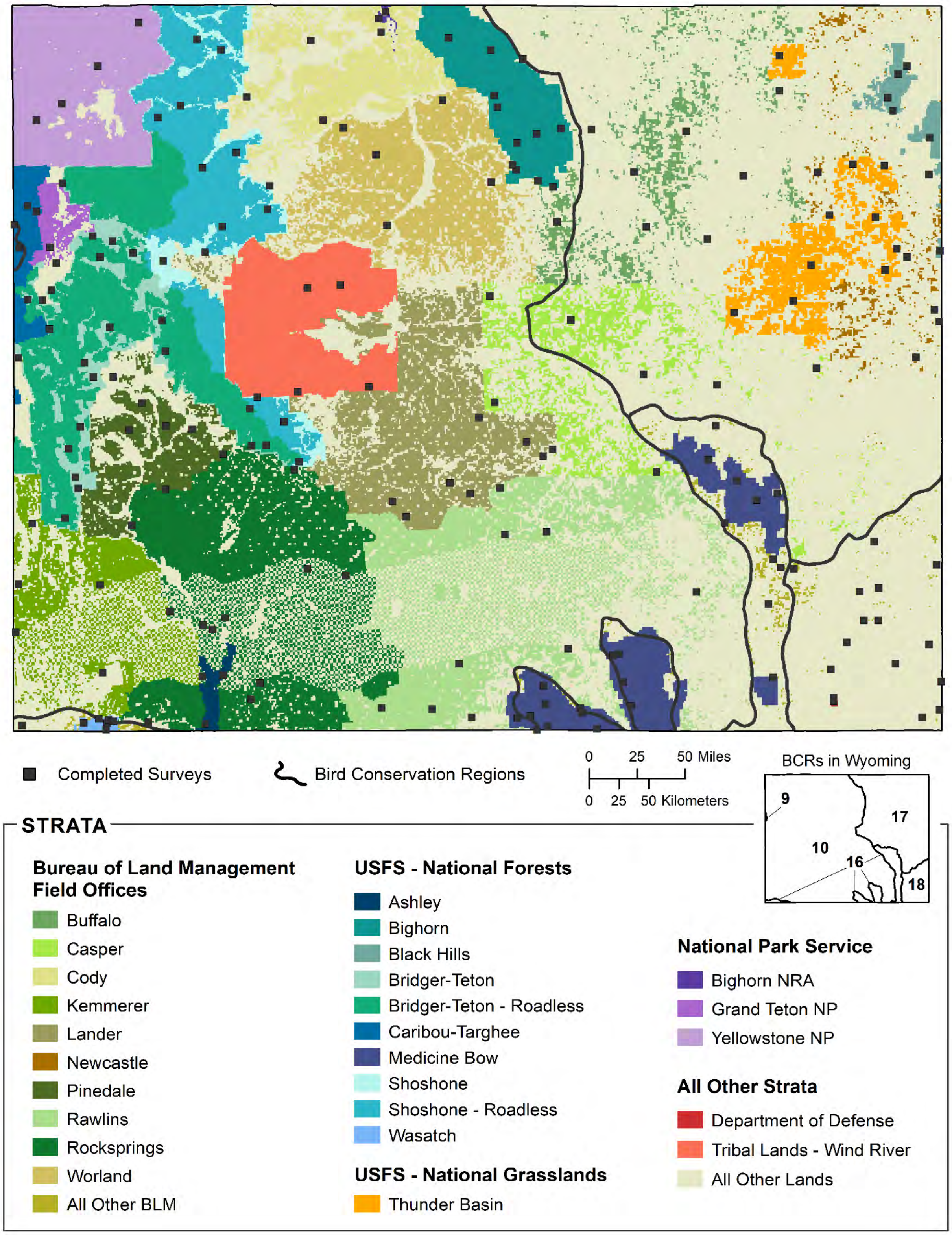

Figure 4. Integrated Monitoring in Bird Conservation Regions strata and survey grid locations in Wyoming, 2018 (Drilling et al. 2019).

SPECIES OF GREATEST CONSERVATION NEED – MAMMALS

IMPLEMENTATION OF THE STATIONARY ACOUSTIC PORTION OF THE NORTH AMERICAN BAT MONITORING PROGRAM IN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grant
United States Fish and Wildlife Service WNS Grants to States
Wyoming Game and Fish Commission Funds

PROJECT DURATION: Annual

PERIOD COVERED: 1 April 2018 – 30 August 2018

PREPARED BY: Laura Beard, Nongame Biologist
Nichole Bjornlie, Nongame Mammal Biologist

ABSTRACT

In 2018, the Wyoming Game and Fish Department (Department) implemented statewide acoustic bat monitoring using the North American Bat Monitoring Program (NABat). Stationary sites were established at 111 locations in 38 cells across the state. Local personnel from state and federal agencies assisted Department nongame personnel to establish sites and, in most locations, will deploy at these sites yearly. The Nongame Program will coordinate the effort, analyze the acoustic data, and fill in during deployment where needed. Further work is needed to ensure that all possibilities for access on cells located on private land has been exhausted and to establish driving routes in cells where this is feasible in order to monitor trends in species abundance. Data collected by this project will be contributed to the NABat database and used in multi-annual reports on "The State of North America's Bats".

INTRODUCTION

Bat distribution in Wyoming has been studied throughout the 20th century, increasing significantly during the early 1990s. In 2000, Cryan and Bogan used samples obtained from the Wyoming State Vet Lab and several museum collections to greatly refine the known distribution of 17 of Wyoming's 18 identified bat species. The Wyoming Game and Fish Department (Department) conducted extensive surveys of subterranean structures in the 1990s (Priday and Luce 1996). Several of these surveys led to the discovery of significant hibernacula, the monitoring of which represents the only quasi-systematic population monitoring conducted on a statewide scale in Wyoming. From 2008-2017, the Department conducted habitat-based capture and acoustic surveys to establish baseline distribution data for bats in the state (Filipi et al. 2009; Johnson and Grenier 2010a,b; Cudworth et al. 2011; Abel and Grenier 2012a,b; Yandow and Grenier 2013, 2014; Yandow and Beard 2015; Beard 2016). These data have contributed to the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2016), further refining our understanding of bat distribution in the state. Working under a BLM contract, the Wyoming Natural Diversity Database (WYNDD) has also conducted wide-scale capture and acoustic surveys (e.g., Abernethy et al. 2012, 2015b). These widely distributed survey efforts, combined with datasets contributed to the Wildlife Observation System database from other localized capture efforts were used to produce models of bat distribution in the state (Abernethy et al. 2015a). These distributional studies provide a firm basis for monitoring bat populations acoustically, as initial in-hand identification of most species is necessary to ensure that acoustic classifications are correct.

Until now, systematic monitoring of Wyoming's bat distribution and population trends has been limited to periodic surveys of known hibernacula by the Department and monitoring in select locations by WYNDD (Abernethy 2017a, b). The North American Bat Monitoring Program (NABat) was developed by the US Department of Agriculture to provide a continent-wide, scalable program to monitor bats that will provide reliable data to enable conservation decision making and promote the long-term viability of bat populations across the continent (Loeb et al. 2015). This international, multiagency program uses 4 monitoring approaches to gather data to assess changes in bat distributions and abundances: winter hibernaculum counts, maternity colony counts, mobile acoustic surveys, and acoustic surveys at stationary points. During the summer of 2018, the Department implemented the stationary acoustic survey portion of the NABat monitoring program on a statewide basis. With the statewide implementation of the NABat monitoring protocol, we hope to provide a baseline index of bat activity using acoustic techniques. Yearly monitoring at these locations will allow the Department, in partnership with the NABat program, to document changes in bat activity and species occupancy though time.

METHODS

We used the spatially balanced master sample grid found in the sampling design of NABat 3.3 (Loeb et al. 2015) to choose 100 km^2 sampling cells. The top 50 cells were selected from the NABat master sample (Figure 1). We eliminated any cell in which we were unable to gain legal or physical access to sites in ≥2 of the 4 quadrants. We also eliminated cells with <50% of the surface area in Wyoming, any cell that was already monitored by another agency, and any cell for which another agency had plans to start monitoring during the season. We added cells on 4 national forests to establish monitoring for interested forests.

We coordinated with local Department, BLM, USFS, and USFWS personnel to identify likely survey locations and gain access from private landowners when necessary. For each cell, we used satellite imagery to identify likely survey sites. If a cell was inaccessible due to inability to contact the landowner or if the landowner declined access to survey, the cell was not surveyed. We worked with local personnel to locate and access sites and to determine the best deployment locations within each quadrant-based landscape features known to attract or concentrate bats, such as flyways or water sources; legal and physical access; and variety of habitat types available to be surveyed. We attempted to survey all available habitat types within the cell while locating sites in unique quadrants as often as possible.

During initial site establishment, we used the repetition of deployments at multiple sites to familiarize local personnel with the equipment and the setup protocol. We deployed Pettersson D500X acoustic detectors (Pettersson Elektronik, Uppsala, Sweden) near water and in potential flyways where we expected high bat activity. The microphone was positioned 3 m above the ground on an extendable aluminum pool cleaning pole secured with guy lines; the microphone capsule was secured to the top of the pole with plastic coated wire. We programmed detectors to start recording 15 minutes before sunset and stop recording 15 minutes after sunrise. Detectors were set to record using a high pass filter unless cliffs were present in the area, indicating possible spotted bat (*Euderma maculatum*) habitat. For locations within the known range of the northern long-eared bat (*Myotis septentrionalis*), as well as in the Bighorn and Laramie Mountains, the trigger level was set to 120, and a gain of 80 was used to detect lower volume bat calls. For all other locations, the trigger level was 160, and a gain of 45 was used. Acoustic and deployment data is currently awaiting upload into the NABat database.

RESULTS

In 2018, we established 38 cells containing 111 sites: 10 cells contained 4 sites, 15 cells contained 3 sites, and 13 cells contained 2 sites. The majority of sites established were on public land. Of the cells surveyed, 33 cells were in the top 50 selected by the generalized random tessellation stratified (GRTS) sample prioritization from the master sample. An additional 5 cells were added to ensure monitoring was established on select national forests in the state. These cells are 8130 and 14610 in western Wyoming, 14466 and 15490 in northcentral Wyoming, and 19778 in northeastern Wyoming (Figure 2). In most cases, the same local personnel have agreed to monitor the cells on a yearly basis. In several cases, local personnel have agreed to take over a grid established by Nongame personnel.

There were 17 cells in the sample of 50 that were not surveyed in 2018 (Figure 2). For 2 cells (893 and 1109), the majority of the cell was in another state. For 1 cell (509), more than half the land area is in Wyoming, but Colorado's Natural Heritage program has already established monitoring in the portions of the cell in Colorado (Jeremy Siemers, personal communication). For consistency, monitoring in this grid should be established in coordination with Colorado, so that monitoring on the 2 halves occur simultaneously. Several cells were excluded from sampling by the Department because other agencies had already established monitoring or were in the process of doing so. Yellowstone National Park has monitored 2 cells within the park (1554 and 1605) for several years and will continue to do so. The Bridger-Teton National Forest implemented monitoring in 2018 and will continue to monitor 2 cells in the top 50 sample (450 and 530); mutual data sharing should be available through the NABat platform for these cells. For cells in the sample of 50 priority cells monitored by other agencies, the Department may take over cells in the event that the monitoring agency is unable to continue their efforts. For 2 cells (2178 and 2322), difficult physical access prevented us from establishing monitoring. For cell 2178, the access problems are surmountable, and monitoring will be established in 2019. For 2322, access would necessitate the use of horses for multiple days. If 2322 is monitored in the future, the remote nature of the cell may indicate periodic rather than annual monitoring. Access for 8 cells in the northeast corner of the state (642, 834, 898, 1346, 1858, 1992, 2114, and 2370), was not obtained. In some cases, limited water restricted potential sites such that ≥2 sites within a cell could not be achieved on land where the Department could gain legal access. Cells may be added as issues of access are resolved; however, if legal access to sites representative of the cell's habitat cannot be achieved, monitoring will not be established. Further work will be conducted in 2019 to exhaust all possibilities of monitoring these cells.

DISCUSSION

The NABat program as established by Department in the state of Wyoming relies on the continued effort of regional agency personnel from state and federal natural resource management agencies. Partnering with the professionals at these agencies provides a number of benefits, including access to local knowledge of the area as well as fundamental knowledge of biology and biological systems. Because of agency priorities and the continuation of specific positions, working with both state and federal agency personnel provides increased certainty in the continuation of the program. While this use of regional personnel is an efficient way to carry out monitoring efforts in a large state such as Wyoming, several special considerations must be kept in mind in order for this program to function smoothly. Though the natural resources professionals deploying detectors are not volunteers or members of the lay public, few are specifically trained or experienced in bat behavior or acoustic survey techniques. In addition, bat detectors are not generally user friendly, especially for individuals who use them only occasionally. Thus, it is important that technical support be available to help maintain and troubleshoot equipment. Though we worked directly with regional personnel in the initial year to establish survey sites, additional training materials are necessary and will be developed. Dedicated personnel within the Nongame Program will remain vital to ensure cohesion of the monitoring effort and to coordinate survey efforts throughout the state.

Data from this project require considerable time to analyze and should be examined in reference to trends between years as well as species occurrence within cells. Per the NABat Monitoring Program, the participants are responsible for classifying calls that they collect. Call analysis will continue to necessitate dedicated personnel who have the necessary training and experience to accurately classify calls to species. Calls should be archived as well, pending future advancements in analysis software. The national database for NABat is currently in flux, but all data from this effort will eventually be available through that database, providing large-scale bat information to researchers across the nation. The NABat program will provide continent-wide trend analysis of all submitted data periodically through a report on "The State of North America's Bats". Statewide analysis using this dataset is possible as well and may be completed on a periodic (e.g., 5-year) basis by the Nongame Program.

Further implementation efforts should include reinvestigating access to cells on the top 50 priority GRTS sample and implementing driving routes where feasible. Cells that are difficult or time consuming to access may need to be surveyed on a rotating schedule to balance the needs of data collection with efficiency. Further development of these cells is necessary. Private landowner constraints in the northeastern corner of the state resulted in gaps in the distribution of survey locations. Subsequent survey efforts will include pursuing alternative options to ensure all access options have been exhausted.

NABat provides an important tool for managers wishing to improve bat conservation in Wyoming. It is important to recognize that additional effort and methods may be needed to monitor species not well suited to acoustic monitoring, such as Townsend's big-eared bat (*Corynorhinus townsendii*), and those lacking statewide distributions, such as the northern long-eared myotis, where the density of cells within available habitat will limit robust analyses at the state level. The stationary acoustic survey portion of the NABat program is 1 of 4 protocols used by the program to monitor bats: the 3 additional techniques are summer and winter colony counts and mobile acoustic surveys. All of these techniques can be used to examine population trends to some extent. Winter colony counts have been conducted by the Department since 1992, and that dataset is currently being transferred to the NABat database. The nongame program has recently requested additional information from the public and regional personnel to help identify maternity roosts for monitoring and is working to establish a monitoring scheme with the intention of contributing these data to the NABat database. In 2018, roads within cells were visually assessed for practicality of driving surveys, but this portion of the protocol requires further development.

The implementation of this project is especially timely, as the fungus that causes white-nose syndrome (WNS), *Pseudogymnoascus destructans*, was documented in the southeastern corner of the state in the spring of 2018. The NABat protocol may provide insight into the effect of the disease on bat populations and community assemblages (Ford et al. 2011). In Wyoming, most of the species currently or suspected to be affected by WNS echolocate in the high frequency category (>30kHz), while most of the species that echolocate in the low frequency category (<30kHz) have not been found to be affected by the disease. The only high-frequency bat found in Wyoming and thought to be unaffected by WNS is the eastern red bat (*Lasiurus borealis*), which is rare and not widely distributed in Wyoming. California myotis (*M. californicus*) has yet to encounter the fungus, but no North American myotis species thus far has failed to develop the disease once the fungus has been encountered. Conversely, there is only 1 species of myotis in Wyoming that ecolocates in the low frequency range, fringed myotis (*M. thysanodes*), which is also rare in Wyoming. The big brown bat (*Eptesicus fuscus*) is a low frequency bat that is affected by the disease; however, there is some evidence that mortality rates in this species may be lower than in other affected species (Ford et al. 2011, Frank et al. 2014). Consequently, this frequency division between WNS-affected and unaffected bat species provides a convenient, though imperfect, method for using NABat to monitor statewide effects of the disease. Though not all bat calls are of sufficient quality to be assigned to a species, even calls of poor quality can be confidently categorized as either high or low, allowing a relative activity index to be easily and reliably produced. Appreciable changes in this index could indicate a shift in species assemblages as the fungus progresses across Wyoming.

In addition to WNS, bats in North America face conservation challenges such as habitat loss, climate change, and wind energy development. The NABat monitoring program will enable detection of changes in species occupancy across the state that may result from these challenges. Monitoring continued occupancy in known ranges and potential expansion of populations will allow managers to monitor the effects of such challenges on this taxon.

ACKNOWLEDGEMENTS

We would like to thank the US Fish and Wildlife Service and the Wyoming Game and Fish Commission for providing financial support for this project. Thank you to the Bureau of Land Management, US Forest Service, US Fish and Wildlife Service, and Wyoming Game and Fish Department personnel who assisted with survey site selection and detector deployment.

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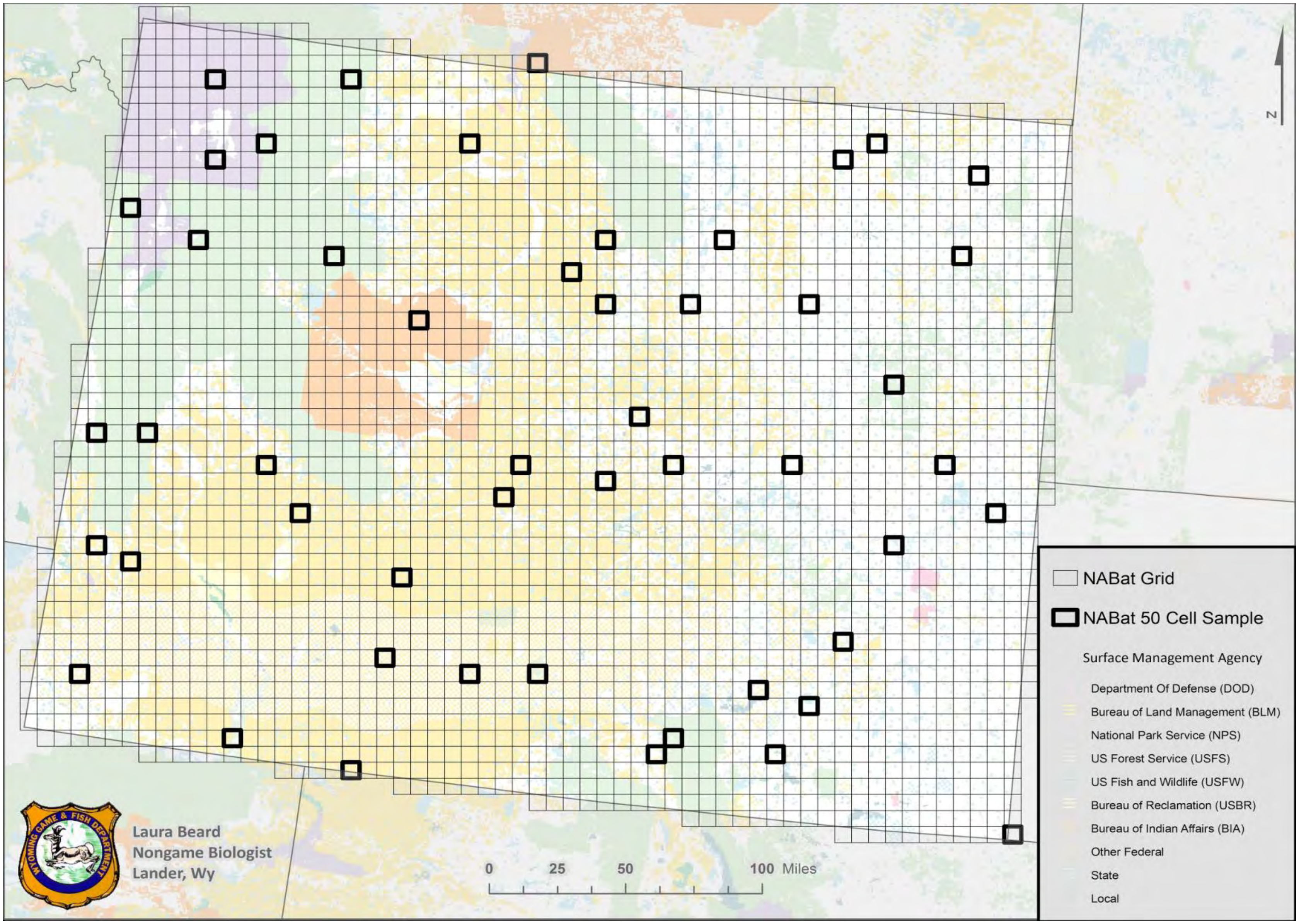

Figure 1. North American Bat Monitoring Program (NABat) sampling grid in Wyoming. Cells with a heavy black outline represent the master sample of the 50 cells in the state with the lowest GRTS number. Landownership is shown for reference.

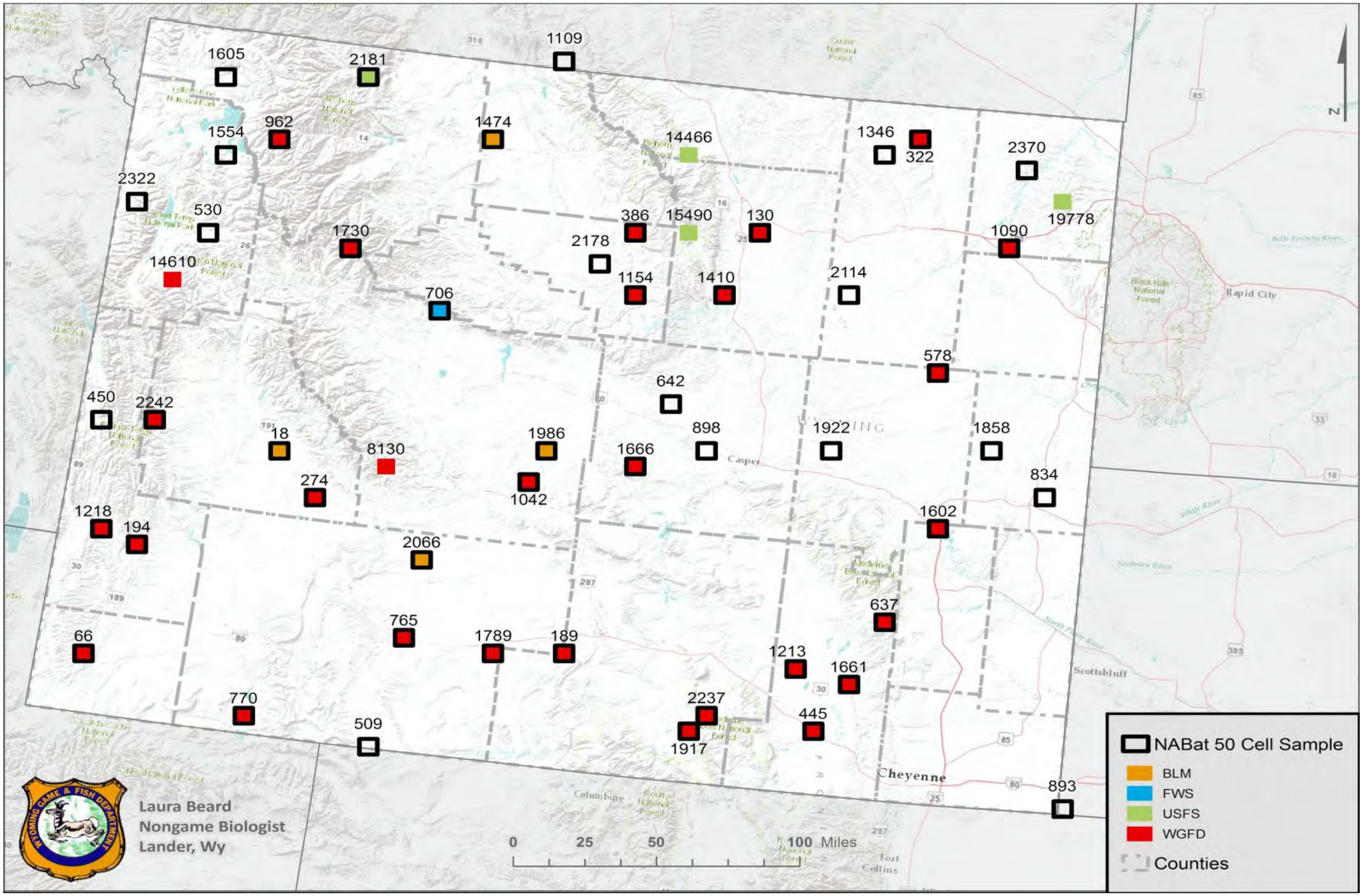

Figure 2. Top 50 cells and all cells acoustically surveyed for bats in Wyoming in 2018 as part of the North American Bat Monitoring Program (NABat). Fill color represents the agency responsible for deployment in the field in 2018, and the top 50 GRTS sample for Wyoming is outlined in black. All cells are labeled with their GRTS number from the USGS master sample.

SURVEILLANCE OF HIBERNATING BATS AND *PSEUDOGYMNOASCUS DESTRUCTANS* SCREENING 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 WNS Grants to States
Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: Annual

PERIOD COVERED: 1 November 2018 – 31 March 2019

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 as the causative fungus, *Pseudogymnoascus destructans*, continues to spread throughout the continent. Three species of bats found in Wyoming are known to be particularly vulnerable to white-nose syndrome in their eastern range: little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), and American perimyotis (*Perimyotis subflavus*). Populations of bats in caves and abandoned mines in 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 as the fungus progresses across the state. Since 1994, the Wyoming Game and Fish Department has worked to identify and monitoring bat hibernacula. During the winter of 2018-2019, we successfully surveyed 2 sites for hibernating bats, observing 43 bats representing ≥4 species. We documented 1 previously unknown hibernaculum. At the previously known hibernacula, we conducted *P. destructans* swabbing of bats and the environment. The results of this test were negative. Beginning in 2014, we have participated in a national effort to identify *P. destructans*-infected sites. Twelve sites in 7 counties have been sampled, several in multiple years. Thus far, no hibernacula in Wyoming have tested positive for the fungus; however, *P. destructans* was detected on bats near a maternity roost in Fort Laramie in 2018 as part of a National Park Service surveillance effort.

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 US and Canada. WNS is caused by the fungus *Pseudogymnoascus destructans,* which infects the skin of hibernating bats, resulting in a conspicuous white fungal growth on hairless membranes, such as the face and wings. Mortality due to WNS results from a cascade of physiological disturbances, beginning with increased energy use and changes in blood chemistry that lead to increased water, electrolyte, and fat reserve loss, ultimately resulting in death (Verant et al. 2014). The detection of *P. destructans* in a hibernaculum can precede mortality due to WNS by 1 or 2 hibernation seasons, because the time between infection and the end of hibernation increases as the fungus spreads throughout the hibernaculum. The impacts of WNS on bats compound throughout the hibernation season, so a bat that encounters the fungus close to the end of hibernation may have sufficient reserves to survive until prey is available in the spring. The infection is cleared by the bat's immune system soon after the end of hibernation. In May of 2018, *P. destructans* was detected on a bat at a summer roost in Fort Laramie (Abernethy 2018), representing the first detection of the fungus in Wyoming. WNS was confirmed in Jewel Cave, a cave in the Black Hills near the eastern boarder of Wyoming, during the same survey effort (Abernethy 2018).

Six species found in Wyoming are known to be vulnerable to WNS: American perimyotis (*Perimyotis subflavus*)*,* formerly the eastern pipistrelle or tri-colored bat (*Pipistrellus subflavus)*; little brown myotis (*Myotis lucifugus*); northern long-eared myotis (*M. septentrionalis*); long-legged myotis (*M. volans*); Yuma myotis (*M. yumanensis*); and big brown bat (*Eptesicus fuscus*; Coleman and Reichard 2014). The Virginia big-eared bat (*Corynorhinus townsendii virginianus)*, a subspecies of Townsend's big eared bat (*C. townsendii)*, is known to carry the fungus while exhibiting no ill effects (Coleman and Reichard 2014). In Wyoming, Townsend's big-eared bats have been observed sharing hibernacula with several myotis species, 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, long-legged myotis, and big brown bat are widespread. The little brown myotis is one of the most commonly captured and reported bat species in the state (Filipi et al. 2009; Johnson and Grenier 2010a, b; Cudworth et al. 2011; Abel and Grenier 2012a, b; Yandow and Grenier 2013, 2014; Yandow and Beard 2015). It is unknown how WNS will affect the rest of Wyoming's bat species, as they have yet to be exposed to the fungus. Some western species of myotis are considered analogous to an eastern species, such as the long-eared myotis (*M. evotis)* to the northern long-eared myotis, with an important difference being that the western species 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. There are only 7 known little brown myotis hibernacula in Wyoming, and survey data suggest that each of these roosts supports <100 bats of any species. As the number of bats present at a roost site can affect the speed at which *P. destructans* is able to spread between individuals, this difference in roosting density may influence the reservoir competence of western roosts (Langwig et al. 2012).

In the 2018-2019 winter season, our primary goal was to continue the census of hibernating bats before the arrival of WNS and collect samples from hibernacula in Wyoming to test for the presence of *P. destructans*.

METHODS

During the winter of 2018-2019, we conducted hibernation surveys in the Bighorn Mountains in north-central Wyoming. At sites visited during the hibernation season, we counted individual bats and attempted to identify each bat to species. We adhered to all WNS survey and decontamination protocols outlined in the National WNS Decontamination Protocol (USFWS 2016).

Since 2014, we have participated in the US Fish and Wildlife Service WNS surveillance program, using hibernation surveys to collect samples to be tested for the presence of *P. destructans*. Using the National Wildlife Health Center's substrate protocol due to the low numbers of hibernating bats at most of our sites, we swabbed hibernating bats and cave walls and collected substrate from the cave floor to test for the presence of *P. destructans* (USGS National Wildlife Health Center 2017). All samples were sent to the National Wildlife Health Center for genetic analysis designed to detect *P. destructans*.

RESULTS

In the winter of 2018-2019, we surveyed 2 natural caves for the presence of hibernating bats (Table 1) and observed bats at both sites (Sites 102 and 133). In total, we found 24 hibernating bats, including 4 Townsend's big-eared bats, 14 western small-footed myotis, 3 big brown bats, and 3 myotis spp.

Site 102 is a cave on BLM land in the southern Bighorn Mountains that is easily accessible in the summer. This is a well-known destination for local youth during the summer (C. Sheets, personal communication). Site 102 has not been previously documented as a hibernaculum. On this visit, we observed 7 Townsends big-eared bats and 5 myotis spp. (Table 1). This was our 2nd attempt to conduct a winter survey of this cave, as we traveled to this site in the 2017-2018 winter season, but found that winter entry requires vertical equipment. In the 2018-2019 season, we elicited the assistance of select members of the Hole-in-the-Wall Grotto and the Northern Rocky Mountain Grotto for safe entry to the site. During both visits, we saw no signs of human presence in the area around the entry.

Site 133 is a large cave on Forest Service land in the northern Bighorn Mountains. The cave is accessible only through private land after a substantial hike in alpine terrain. This cave has been well-documented as a hibernaculum by previous surveys. On this visit, we observed 31 bats of 4 species, all of which have been previously known to hibernate at this location (Table 1).

We sampled for *P. destructans* at Site 133; results were negative. Twelve sites have been tested in Wyoming in the 6 years since the effort began; this test is the second for Site 133. Though *P. destructans* has been detected at a summer roost in Fort Laramie, all hibernacula tested as part of this effort have been negative for the fungus thus far (Figure 1).

DISCUSSION

Systematic monitoring of bat populations in the state is important for the effective implementation of management responses to all conservation threats to bats, including WNS. Given the large, irregular gaps between hibernation survey years, the variation in survey timing, and the very small hibernating populations present, there are insufficient data to evaluate trends in bat populations at these sites. The presence of the same suite of species as previous surveys suggests that, at a minimum, the previously known hibernacula still supports the complete assemblage of bat species. The addition of a previously unknown hibernacula adds to our overall knowledge of winter habitat use of Wyoming's bats. Consistent, long-term monitoring of important hibernacula and a greater understanding of the timing of arousals within and movement between hibernacula would be useful in monitoring Wyoming's hibernating bat population.

One cave (Site 133) in Sheridan County was tested for *P. destructans*. The majority of samples taken from the cave were from the substrate rather than from bats, as many bats at the site roost out of reach of surveyors. Soil samples were taken from directly underneath bats when possible to maximize chances of *P. destructans* detection should it be present (USGS 2017). Environmental samples are not as effective in early detection of *P. destructans* as samples from bats, and false negatives are possible with either sample type; however, the negative results from the cave are encouraging.

Detection of *P. destructans* within the state has triggered a prearranged set of responses designed to mitigate the effects of WNS on hibernating bats, including increased communication (Abel and Grenier 2012c). Work to revise Wyoming's WNS Plan is ongoing. Both the monitoring of bat populations and the early detection of *P. destructans* are confounded by the fact that Wyoming's bats do not conform to expected patterns of behavior established by studying eastern populations. Current tests for *P. destructans* increase in effectiveness when ≥25 bats are tested, but very few of Wyoming's hibernacula host that many individuals. Large congregations of myotis have not been found in the state, which complicates any effort to monitor the population, as this renders hibernacula counts alone insufficient as a monitoring method for these populations. Our ability to predict the threat posed by WNS and to respond to any threat to bats is limited by our understanding of their year-round habitat use. Current work by the Department is concentrated on locating and quantifying critical roosting habitat of myotis species in Wyoming in order to monitor and mitigate the effect of WNS and other threats to the bat population. Monitoring for the presence of *P. destructans* in the state has shifted to sampling predominately from misting efforts during spring emergence rather than hibernacula, to improve coverage of the state and maximize the possibility of early detection in all areas. The Department will continue to sample for *P. destructans* in known hibernacula where appropriate.

ACKNOWLEDGEMENTS

Funding for this project was provided by USFWS State Wildlife Grants and the Governor's Endangered Species Account Fund, for which we are grateful. Sampling equipment and sample analysis was provided by the National Wildlife Health Lab at the US Geological Survey. We extend a special thanks to S. Sawyer (Hole-in-the-Wall Grotto), C. Froslie (Northern Rocky Mountain Grotto) and WGFD personnel C. Schmidt, E. Whittle, F. Calderon, and F. Stetler for their assistance in the field.

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Table 1. Site number, type of roost, known hibernacula and historically hibernating species, species observed, total number of bats observed, and swabs taken for *Pseudogymnoascus destructans* testing during the most recent hibernacula survey at sites successfully surveyed from January – February 2019 in Wyoming. COTO = Townsend's big-eared bat (*Corynorhinus townsendii*); MYCI = western small-footed myotis (*Myotis ciliolabrum*); MYLU = little brown myotis (*M. lucifugus*); MYSPP = myotis, not identifiable to species; EPFU= big brown bat (*Eptesicus fuscus)*.

Site #	Site type	Previously recorded hibernacula	Bat species historically present	Bat species – current survey (#)	*P. destructans* swabs
102	Cave	No	N/A	COTO (7)	No
				MYSPP (5)	
133	Cave	Yes	COTO, EPFU, MYCI, MYLU, MYSPP	COTO (11)	Yes
				EPFU (3)	
				MYCI (15)	
				MYLU (2)	

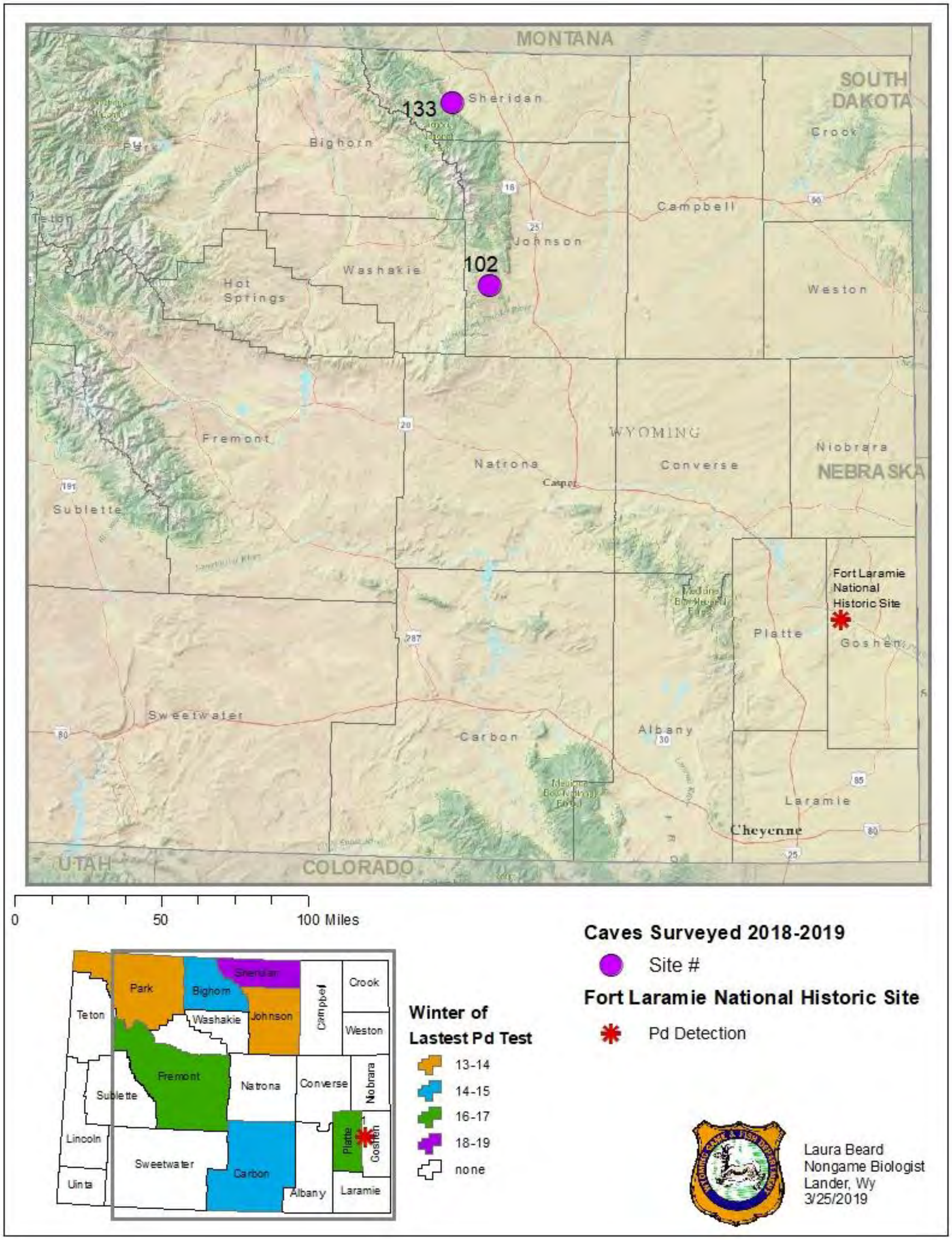

Figure 1. Caves visited in January and February 2019 in Wyoming. Labels indicate site number. The *Pseudogymnoascus destructans* (Pd) detection at Fort Laramie in 2018 is shown in red for reference. Reference map shows counties containing subterranean sites tested for the presence of Pd color-coded by year; all tests have been negative.

WYOMING POCKET MOUSE PROJECT

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Great Basin pocket mouse, Hispid pocket mouse, Olive-backed pocket mouse, Plains harvest mouse, and Silky pocket mouse

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds

PROJECT DURATION: 15 March 2015 – 30 June 2018

PERIOD COVERED: 16 May 2018 – 31 March 2019

PREPARED BY: Kristina Harkins, PhD Candidate, University of Wyoming
Dr. Merav Ben-David, Professor, University of Wyoming
Dr. Doug Keinath, Supervisory Fish and Wildlife Biologist, USFWS

SUMMARY

Improving detection probabilities for rare species is critical when assessing presence or habitat associations. Our goal was to create a new small mammal trapping protocol that improved detection of rare species, such as the olive-backed pocket mouse (*Perognathus fasciatus*). We used 3 trap and bait types and trapped an area 4.4 times larger than the standard grid. We also assessed the effect of captures of non-target species on detection probability of pocket mice. Regardless of species, trap success was higher for Havaharts. We found that bait and trap type selection varied significantly by species, with pocket mice showing strongest selection for Havahart traps baited with bird seed. Increasing grid size, while maintaining a similar trapping effort, resulted in higher detection probability, although our analyses showed that effective grids can be about $^3/_4$ of the size we use to achieve similar results. We were also able to demonstrate that by deploying a combination of different traps and baits it is possible to overcome the potential effect of non-target species (e.g., deer mice, *Peromyscus maniculatus*) on the detection probability of pocket mice. Our results show that simple changes to standard small-mammal trapping methods can dramatically increase the detectability of rare and elusive small mammals. Increasing detection probability of rare components of a community can improve the results and understanding of future studies. See Harkins et al. (2019) for the complete report.

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SMALL MAMMAL COMMUNITIES AND HABITAT ASSOCIATIONS ALONG AN ELEVATION GRADIENT IN SENSITIVE WATERSHEDS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Small mammals

FUNDING SOURCE: United States Fish and Wildlife Service State Wildlife Grant
Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 1 July 2016 – 30 June 2019

PERIOD COVERED: 1 May 2018 – 30 April 2019

PREPARED BY: Dana Nelson, Nongame Biologist

ABSTRACT

Wyoming hosts a diverse assemblage of small mammals, with 49 native rodent and 9 native shrew (*Sorex* spp.) species. Despite a large contribution to biodiversity and the utility of small mammal populations as indicators of ecosystem responses to disturbance, baseline population data are lacking for many rodent and shrew species. Thus, we initiated a project to address these data deficiencies and specifically provide baseline population status; assessments of habitat components on species occurrence, particularly of Species of Greatest Conservation Need (SGCN); and an examination of historic records of small mammal presence to compare with recent captures and distributions. We used an elevation transect as a sampling scheme to maximize diversity of habitats and species sampled. We focused trapping efforts in 2018 on the Atlantic Rim area of Wyoming, west of the Sierra Madre range, due to its potential for energy development in lower elevations. Using 3 types of traps specifically targeting small mammals, we compiled minimum number alive indices for 15 species. We also examined the relationships between overstory and microhabitat variables with species occurrence for 3 SGCN with data from 2 years of sampling: olive-backed pocket mouse (*Perognathus fasciatus*), sagebrush vole (*Lemmiscus curtatus*), and Uinta chipmunk (*Tamias umbrinus*). We detected olive-backed pocket mice in sparsely vegetated habitats characterized by less shrub cover, less grass cover, and more bare ground. We did not observe differences in habitat variables between grids with and without sagebrush vole detections, but all observations were in sagebrush-dominated habitats. Locations where Uinta chipmunks were detected suggest a preference for spruce-fir forests with open understories. Finally, we added historic observations of 13 small mammal SGCN from various agency reports collected between 1979 and 1997. Our field and digitization efforts have contributed 144 records of small mammal SGCN occurrence and have provided baseline population, habitat, and community data for small mammals in 2 under-sampled regions of Wyoming.

INTRODUCTION

Non-volant small mammals, such as rodents and shrews, make up >42% of Wyoming's mammalian diversity (Orabona et al. 2016) and perform many important roles in the ecosystems to which they belong. Most obviously, small mammals serve as a prey base for larger predators. Many small mammals themselves serve as predators to seeds and invertebrates, play a role in seed and fungi dispersal, and contribute to soil aeration (Kaufman et al. 1988, Pearson et al. 2001). In addition to these important contributions to ecosystem function, small mammal populations can serve as useful indicators to the effects of disturbance or ecosystem change (i.e., energy development, mining, logging, climate change) given their limited dispersal capability and specific microhabitat requirements.

Despite these important contributions to biodiversity and ecosystem function, baseline data on small mammals are lacking throughout much of the state. The paucity of data can be attributed to the difficulty of detection and specialized survey requirements, but this has resulted in incomplete knowledge of species population trends and distribution. Many habitat-focused efforts have been conducted by Wyoming Game and Fish Department (Department) regional biologists and graduate students, and several taxa-focused projects by Department nongame biologists have contributed greatly to our knowledge of small mammal distribution. For example, between 1989 and 1994, regional biologists collected trapping data in a targeted habitat type each year (Luce and Stephens 1990; Luce and Cerovski 1991; Cerovski 1992; Hunter and Luce 1993, 1994; Hunter 1995). In the Medicine Bow Mountains, Heyward (2012) sampled small mammals in specific montane forest habitats to understand impacts of mountain pine beetles. Zinke (2017) sampled the Bighorn Mountains specifically in habitats suitable for water vole (*Microtus richardsoni*). In an effort to increase knowledge of pocket mouse (*Chaetodipus* and *Perognathus* sp.) distribution, Harkins et al. (2018) conducted small mammal surveys at a statewide scale, but efforts were focused on grasslands and sagebrush systems. Projects such as these have contributed greatly to our knowledge of small mammal occurrence, but they have focused on specific habitats or taxa, leaving other areas under-sampled and many populations without trend data. Additional data on small mammal occurrence exist in reports from wildlife survey efforts conducted by various agencies, either in advance of development or in early efforts to document diversity patterns. However, most of these records have not been digitized or placed in a searchable, readily usable format. Modernizing datasets and increasing occurrence records facilitates inference on species' distributions, populations, and trends over time.

An elevation gradient serves as an efficient sampling scheme for maximizing the diversity of habitats and small mammal species encountered. At a broader scale, elevation transect data can contribute to inference on global patterns of species diversity (McCain and Grytnes 2010). In an effort to address data gaps in small mammal trends and distribution in Wyoming, we focused on watersheds that are sensitive to energy development at lower elevations, thus providing baseline population data for comparison after disturbance and helping define habitat preferences for management recommendations. Higher elevation sampling grids provide the opportunity to detect montane and subalpine species that are particularly data deficient or can be considered vulnerable to a changing climate (i.e., displacement of range boundaries) or forest disturbances (e.g., logging, insect outbreak, altered fire regimes). Thus, sampling along an elevation gradient allowed us to meet the following objectives over this 2-year project: estimate relative abundance for all captured small mammals, evaluate how vegetation characteristics affect the presence of Species of Greatest Conservation Need (SGCN; WGFD 2017), and increase the records of known occurrence through live-trapping efforts and review of historic trapping documents.

METHODS

We focused field efforts in 2018 on 4 watersheds at the 10-digit HUC scale in the Atlantic Rim area and Sierra Madre Mountains in south-central Wyoming (Figure 1). These watersheds were selected as the study area due to a lack of recent systematic sampling for small mammal communities, a high predicted probability of occurrence of small mammal SGCN (Keinath et al. 2010), existing oil or energy development, potential for future development (Copeland et al. 2013, Keinath and Kauffman 2014), and a large range of elevations.   We narrowed the available study area by the following criteria: on public land, within 800 m of a road, and >1000 m from a producing oil well. Within this available study area, we created a 500 m regular point grid from which to draw spatially balanced samples using the Generalized Random Tessellation Stratified sampling algorithm. We stratified all possible points according to 6 elevation categories extending from the lowest elevation in the study area and selected 5 sample points and 2 oversample points within each elevation strata.

We used these sample points as the centroid of each grid. Trap stations were placed on a 10 × 10 grid with 15 m spacing. Because capture probability can vary by species, we used multiple trap types in an effort to maximize the diversity of mammals captured (Williams and Braun 1983, Harkins et al. 2018). Each trap station received a collapsible Sherman live trap (H.B. Sherman Traps, Inc., Tallahassee, FL; Model LFG) and an extra-small Havahart live trap (Woodstream Corporation, Lititz, PA; Model 1020). Live-traps were baited with a mixture of birdseed and black oil sunflower seeds. To protect captured mammals from inclement conditions, we supplied each trap with Poly-fil bedding and a piece of tarp secured by a rubber band to block direct sunlight and precipitation. Additionally, we placed 5 pitfall traps per grid according to an arrangement of 1 at each corner and 1 at the center of the trapping grid. We modified the pitfall arrays by using 12.7 cm landscape edging as an 8 m drift fence between 2 deli cups (16.3 cm diameter × 17.8 cm height), rather than silt fencing used in 2017 (Nelson 2018). Pitfall placement was occasionally adjusted to utilize natural drift fences (i.e., downed logs), but efforts were made such that no pitfall traps were <40 m apart. We created holes at the bottom of each pitfall trap for drainage and provisioned traps with freezer-killed mealworms as well as live-trap bait mixture.

Procedures for capture and handling of small mammals were concordant with guidelines outlined in the Department's Handbook of Biological Techniques (Cudworth et al. 2013). We checked traps twice daily for 4 consecutive days. Each captured rodent was marked with a uniquely numbered ear tag. We recorded weight, sex, reproductive condition, trap location and type, and standard measurements useful for species identification. After data were collected, we released each rodent at the site of capture; any live-captured shrews (*Sorex* spp.) were euthanized with a lethal dose of isoflurane for identification by dentition.

We examined trends in small mammal relative abundance and species richness using data collected during both years of this project (Nelson 2018). Because unique marks were applied to each captured animal, we determined the minimum number alive (MNA) for each species (Krebs 1966). Catch per unit effort (captures/1000 trap nights) were calculated for both years of data collection for all SGCN. We compared proportions of all captures and the number of species in Sherman, Havahart, and pitfall traps using multinomial exact tests to examine the null hypothesis that captures would be proportional to trap availability. Significance of differences between trap types was determined from pairwise comparisons and using the Bonferroni correction. We compared proportions of falsely closed traps across Sherman and Havahart traps using a binomial test. All statistical analyses were performed using R version 3.4.3

We recorded habitat measurements at 2 scales (overstory and microhabitat) according to methods described by Nelson (2018). We collected overstory vegetation data along transects at each grid to relate structural metrics of woody vegetation to small mammal occurrence at the grid level. For analysis, we simplified these metrics into percent cover by shrubs, trees, and coarse woody debris. We assessed microhabitat variables relevant to non-volant small mammals with a 0.5 × 0.5 m square vegetation frame and Daubenmire cover classes (Daubenmire 1959) at every trap station. Microhabitat variables used in analysis included: percent cover of litter, bare ground, grass, forbs, rock. We compared habitat measurements between grids with SGCN detections and those that did not have detections but fell into that species' predicted distribution. Habitat data from both years of sampling were combined for SGCN captured in both 2017 and 2018. We tested for significance of differences in mean values for each vegetation metric between grids with and without detections with permutation tests due to the small sample size. Permutation tests involved iteratively comparing differences in means between habitat variables with randomly reassigned labels (i.e., detected or undetected). A quasi p-value with $\alpha = 0.05$ was computed by determining the 95% quantiles in the distribution of differences in randomly reassigned means. We first conducted 2,000 iterations of this permutation test and re-ran this test with 10,000 iterations if the resulting quasi p-value was <0.05 to more robustly evaluate significance.

In addition to collecting live trapping and habitat data, we acquired and reviewed data from historic records of small mammal sampling. We examined reports and capture records from a variety of sources, including inventories conducted by BLM, USFS, consulting firms, representatives from energy and mining industry, university students, and Department personnel. We flagged those that contained small mammal trapping data and verified whether they had been previously reported to the Wildlife Observation System (WOS). Small mammal SGCN records were then digitized to include locality, date of observation, and any available habitat information.

RESULTS

We sampled 12 trapping grids between 4 June and 16 August 2018 over 6,913 trap nights, resulting in 585 captures (Table 1, Appendix 1). Our overall catch-per-unit-effort of all small mammal species was 84.6 captures per 1,000 trap nights. We encountered 327 unique individuals representing ≥15 species, including ≥3 SGCN (Table 1). North American deer mouse (*Peromyscus maniculatus*) was the most frequently captured species, representing 55% of all captures. Northern red-backed vole (*Myodes gapperi*) and meadow jumping mouse (*Zapus princeps*) were the next most frequently encountered species. Detections of 5 small mammal species that represent the 1st record in 1 of 4 focal watersheds are presented in Table 2. Species richness was highest at a grid with an elevation of 2,785m with ≥ 7 species captured (Appendix 2).

In 2018, shrews were only captured at elevations ≥2,785 m in montane forests and meadows. We captured 51 individuals representing ≥4 species of shrews; 15 specimens were unable to be identified by dentition. A majority (84%) of shrews were captured in pitfalls, although 6 (12%) were captured in Sherman traps, and 2 (4%) were captured in Havahart traps.

Olive-backed pocket mice (*Perognathus fasciatus*) were captured at 1 grid in 2018. Two individuals were captured: twice in a Havahart trap and 1 time in a Sherman trap. The capture rate within the olive-backed pocket mouse's predicted distribution was 0.81 captures per 1,000 trap nights in 2018 and 0.86 across both years. Grids with detections across both years of this project had lower percent cover by grass ($p = 0.01$), higher percent cover by bare ground ($p < 0.001$), and lower total cover by shrubs ($p = 0.02$) relative to other grids within the olive-backed pocket mouse's predicted distribution (Figure 2).

One sagebrush vole (*Lemmiscus curtatus*) was captured at a single grid dominated by big sagebrush (*Artemesia tridentata*), reflecting a rate of 0.15 captures per 1,000 trap nights within the predicted distribution of the sagebrush vole. There were no statistical differences between habitat variables in the 2 grids with detections from both years and without detections but within the species' predicted distribution, although overall shrub cover appears marginally higher in grids with detections (Figure 3). The capture rate within the sagebrush vole's predicted distribution was 0.23 captures per 1,000 trap nights in 2018 and 0.43 across both years.

Uinta chipmunks (*T. umbrinus*; $n = 7$ captures) were detected at a single grid in the Little Snake – Battle Creek watershed at an elevation of 3,044 m in 2018. Relative to other grids within the chipmunk's predicted distribution, the 2 grids with detections from both years of sampling had higher percent cover by bare ground ($p = 0.02$, Figure 4). The capture rate within the predicted distribution of Uinta chipmunks was 2.7 captures per 1,000 trap nights in 2018 and 1.74 across both years.

If captures in each trap type were proportional to availability (i.e., null hypothesis were true), 47.3% of the total captures would be expected in each of Havahart and Sherman live traps while 5.4% would be expected in pitfall traps. In total, 76.4% of all captures were in Havahart traps (Figure 5). Species detections ($n = 16$) were equal between Havahart and Sherman traps and were similar to expected values based on availability. Pitfall traps caught significantly more species than what would be expected ($n = 7$) given availability ($p = 0.01$). Havahart traps were falsely closed more frequently than expected, making up 75.8% of all false closures (Figure 5), and Sherman traps were closed less frequently than expected ($p < 0.001$). Total captures varied across trap types, with total captures higher than expected in Havahart traps ($p < 0.001$) and lower than expected in Sherman traps ($p < 0.001$). Captures in pitfall traps were equal to the expected value based on availability.

Historic documents (*n* = 57) were examined for small mammal capture information. Of those, 35 contained small mammal capture records with sampling dates ranging from 1979 to 1997. A total of 125 small mammal records representing 13 SGCN have been digitized and added to the WOS (Table 3).

DISCUSSION

Our field efforts from both years of sampling resulted in records of rodent and shrew presence within watersheds susceptible to threats including, but not limited to, energy development and climate change. While detections of SGCN were few, we documented 5 species in 2 watersheds for the first time and are able to make recommendations for future sampling efforts based on habitat characteristics and methodology evaluated in this project.

We contributed 67 records of shrew presence that now represent 16% of all shrew records in the WOS database. Shrews have high metabolic demands, thus captures of all shrews in moist or shaded environments such as montane forests or meadows is expected (Buskirk 2016). Interestingly, 6 (8.9%) captured shrews survived in the pitfall trap from the time of entry until traps were checked. Methods to identify *Sorex* shrews to species without lethal sampling, such as genetic analysis, should be pursued. The 17 shrews unable to be identified by dentition provide further support that alternative identification methods are warranted. From specimens collected over 2 years, only 75% had typical dentition from which we could determine species (i.e., fully erupted teeth, minimal wear). Records of shrew occurrence are sparse, and the inability to correctly identify individuals to species contributes the lack of knowledge on shrew distribution in the state. All shrew specimens have been maintained in Department possession for potential analyses that can provide a tool for identifying live captured shrews and validate identification of those with atypical tooth wear.

The 2 grids with detections of olive-backed pocket mouse in 2017 were in predominantly saltbush (*Atriplex* sp.) habitat in the Bighorn basin, while the grid with a pocket mouse detection in 2018 was dominated by sagebrush. However, the overall shrub cover within the sagebrush-dominated grid was lower than others within the species' predicted distribution, supporting the conclusion made by Manning and Jones (1988) olive-backed pocket mice prefer sparsely vegetated, arid grasslands. Our mean percent cover by bare ground (60%) is higher than what Maxwell and Brown (1968) found, as olive-backed pocket mice in eastern Wyoming were only captured in grassland habitats with <40% bare ground. Both the study by Maxwell and Brown (1968) and our sampling efforts produced a catch-per-unit effort rate of <1 individual per 1,000 trap nights. However, recent efforts by Mahoney (2019) reported a catch-per-unit effort rate of 12.8 individuals per 1,000 trap nights at the Chain Lakes WHMA. Further, Harkins et al. (2018) recorded olive-backed pocket mice as the 4th most frequently captured small mammal during their statewide trapping efforts with 342 detections of this species. These results suggest that olive-backed pocket mouse density is variable throughout its range. While the sample size of 5 individuals recorded in this project is insufficient to determine specific habitat drivers of presence, these records contribute to a growing list of detections from which more robust species distribution models can be based.

Sagebrush voles were unsurprisingly captured on grids dominated by big sagebrush, as is typical for their geographic range (Buskirk 2016). Like olive-backed pocket mice, our catch-per-unit effort rate for sagebrush vole of <1 individual per 1,000 trap nights suggests that sagebrush voles occur at low densities. However, relevant to findings of small mammal bait preference in Wyoming documented by Harkins et al. (2019), sagebrush vole captures could be potentially increased by including bait that more closely matches their typical diet of herbaceous material (Buskirk 2016). We did not observe strong differences between habitat measurements at grids with and without sagebrush vole detections, suggesting that other factors may affect sagebrush vole presence more than the structural characteristics we recorded. A review by Dobkin and Sauder (2004) found a negative influence of livestock grazing on sagebrush vole populations, possibly due to soil compaction or competition for forage. More research is necessary to draw conclusions on overall effects of grazing and other land uses on sagebrush vole populations in Wyoming; additional locations with detections may elucidate characteristics of sagebrush habitat conducive to sagebrush vole presence.

Uinta chipmunks were captured at a higher rate than other SGCN, but were detected at only at a single grid per year of this project, supporting the notion that this species is common within occupied habitat (Buskirk 2016). Both grids with detections were at elevations >3,000 m and much higher than the lower elevation limit of 2,130 m reported by Bergstrom and Hoffman (1991). These grids fell within or were surrounded by the LANDFIRE vegetation class of "Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland" (USGS 2013; Appendix 1), the forest composition that dominates the Medicine Bow National Forest at elevations >3,000 m (Steed 2008). Detections at these grids suggest that Uinta chipmunk may prefer habitats with Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) in the overstory in the south-central portion of their range in Wyoming. The subspecies of Uinta chipmunk present in the Medicine Bow Mountains (*T. u. montanus*) has been associated with closed-canopy coniferous forests that have open understories (Braun et al. 2011, Buskirk 2016). Our captures do not represent a strong departure from existing habitat knowledge but rather suggest this subspecies forays into subalpine meadows like the northwestern subspecies, *T. u. fremontii* (Braun et al. 2011) when those meadows are adjacent to spruce-fir forest. The increased amount of cover by bare ground observed at grids with detections relative to others within the Uinta chipmunk's predicted distribution may provide further evidence that a park-like understory or subalpine meadow may be appropriate habitat, as bare ground could be indicative of a lack of litter and woody cover present in other conifer forests. We recommend future efforts to detect Uinta chipmunk be focused on high elevation spruce-fir forests with an open understory.

Our results suggest that Havahart traps were the most effective of the 3 trap types in terms of total captures and that inclusion of Havahart and pitfall traps along with typical Sherman traps improved the diversity of species encountered. Each rodent SGCN was captured at least once in a Havahart trap. Because of our success rate in capturing shrews in 2018, we suggest that future pitfall sampling efforts use similar materials in pitfall arrays. We found the landscape edging to be an effective drift fence that was easily transported and implemented in several habitat types. Our results support recommendations made by Harkins et al. (2019) that a variety of trap types, and particularly Havahart traps, should be incorporated into sampling efforts to increase the capture probability of difficult to detect species. However, the higher than expected proportion of false closures in Havahart traps is notable, and their use entails additional challenges such as transportation difficulty, more effort to properly set, and higher exposure to inclement conditions (Harkins et al. 2019). We found the method of covering Havahart traps with a piece of tarp secured by a rubber band to be lightweight and effective for implementation in the field, as the tarps could be applied before the first trap set and required little adjustment during checks. When incorporating Havahart traps into a sampling scheme, we recommend the use of tarps over traps as measure to increase animal welfare. In sum, we recommend that future sampling efforts incorporate multiple trap types but that the logistical and animal safety concerns associated with each trap are carefully evaluated relative to project goals.

Through 2 years of field and remote data collection, we have provided useful habitat and baseline population data for each species encountered during trapping effort and have added 144 records of SGCN occurrence to the WOS to improve distribution maps. Our captures provided information on small mammal relative abundance and community composition in areas that have received minimal or only targeted sampling. In total, we have contributed 1,125 records of small mammal occurrence and have improved our knowledge on data deficient and difficult to detect taxa in the state.

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Table 1. Captures and minimum number alive (MNA) of all small mammal species encountered in 2017 and 2018. Total captures includes recaptured individuals. Data from 2017 are from Nelson (2018).

			MNA		Total captures	
Common name	Scientific name	Code	2017	2018	2017	2018
North American deer mouse	*Peromyscus maniculatus*	PEMA	106	172	184	323
Southern red-backed vole	*Myodes gapperi*	MYGA	65	86	97	130
Least chipmunk	*Tamias minimus*	TAMI	34	11	57	12
Vole species, unidentified	*Microtus* spp.	*Microtus*	14	6	19	7
Western jumping mouse	*Zapus princeps*	ZAPR	8	22	10	31
Montane vole	*Microtus montanus*	MIMO	4	0	9	0
Dusky shrew	*Sorex monticolus*	SOMO	7	2	7	2
Ord's kangaroo rat	*Dipodomys ordii*	DIOR	5	6	6	11
Golden-mantled ground squirrel	*Callospermophilus lateralis*	CALA	4	0	5	0
Merriam's shrew	*Sorex merriami*	SOME	5	4	5	4
Long-tailed vole	*Microtus longicaudis*	MILO	3	0	4	0
Uinta chipmunk	*Tamias umbrinus*	TAUM	2	4	3	7
Sagebrush vole	*Lemmiscus curtatus*	LECU	2	1	2	1
Olive-backed pocket mouse	*Perognathus fasciatus*	PEFA	2	2	2	3
Dwarf shrew	*Sorex nanus*	SONA	2	0	2	0
Shrew species, unidentified	*Sorex* spp.	*Sorex*	2	15	2	15
Western heather vole	*Phenacomys intermedius*	PHIN	1	0	1	0
Masked shrew	*Sorex cinereus*	SOCI	0	30	0	30
Northern grasshopper mouse	*Onychomys leucogaster*	ONLE	0	5	0	7
Wyoming ground squirrel	*Urocitellus elegans*	UREL	0	1	0	2
Total			266	367	415	585

Table 2. Summary of small mammal detections from trapping efforts in 2017 and 2018 that represent the 1st known location of these species recorded in the Wildlife Observation System in each 10-digit Hydrological Unit Code watershed. Data from 2017 are from Nelson (2018).

Watershed	Species	Grid (s)	Year
Little Snake River - Battle Creek	*Tamias umbrinus*	SM636	2018
	Sorex cinereus	SM529, SM535	2018
	Sorex merriami	SM529, SM535	2018
	Sorex monticolus	SM535	2018
Savery Creek	*Perognathus fasciatus*	SM319	2018
	Sorex merriami	SM533	2018
	Tamias umbrinus	SC29	2017

Table 3. Summary of the historic small mammal Species of Greatest Conservation Need captures added to the Wildlife Observation System.

Common name	Scientific name	Year(s) of observations	Number added
Dwarf shrew	*Sorex nanus*	1979, 1984, 1986, 1997	5
American pika	*Ochotona princeps*	1979	1
Yellow-pine chipmunk	*Tamias amoenus*	1979, 1987, 1997	6
Cliff chipmunk	*Tamias dorsalis*	1979	1
Uinta chipmunk	*Tamias umbrinus*	1979, 1985, 1987, 1997	87
Northern flying squirrel	*Glaucomys sabrinus*	1979	2
Olive-backed pocket mouse	*Perognathus fasciatus*	1979	7
Silky pocket mouse	*Perognathus flavus*	1995	1
Great Basin pocket mouse	*Perognathus mollipilosus*	1979	1
Canyon deer mouse	*Peromyscus crinitus*	1979	1
Water vole	*Microtus richardsoni*	1979	1
Sagebrush vole	*Lemmiscus curtatus*	1979, 1980, 1995	10
Meadow jumping mouse	*Zapus hudsonius*	1982	2
Total			125

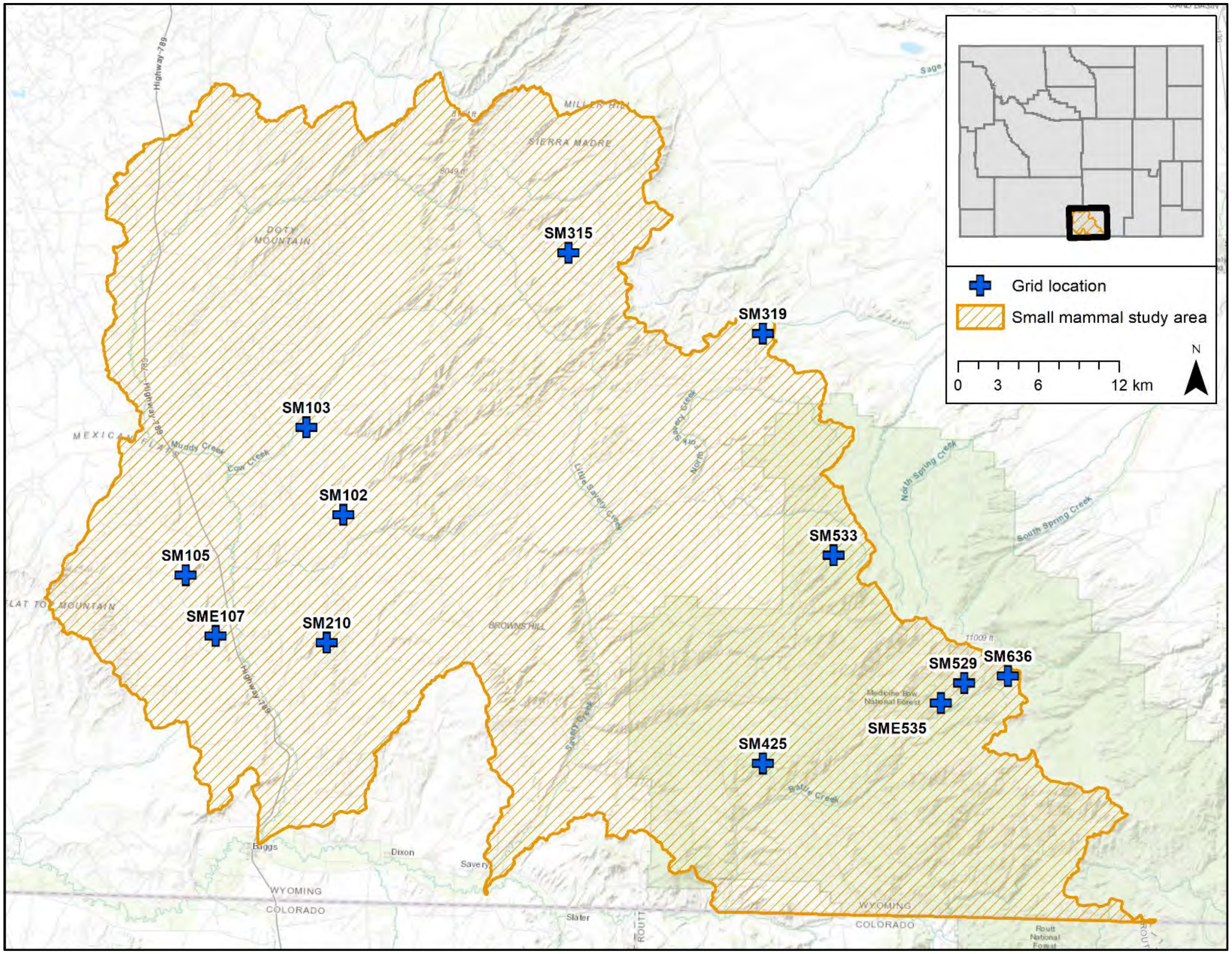

Figure 1. Survey point locations where sampling was conducted for small mammals in June-August 2018. The study area was defined by 4 10-digit HUC watersheds in south-central Wyoming.

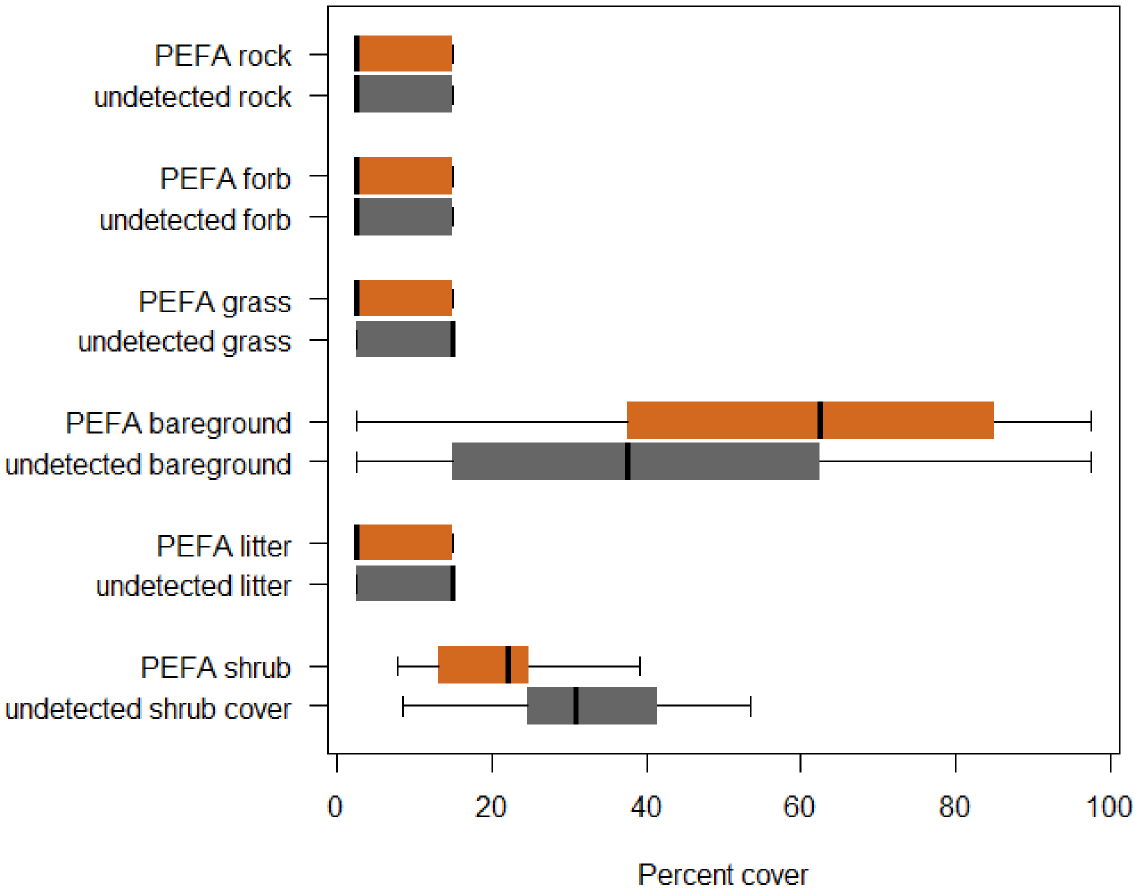

Figure 2. Comparison of overstory and microhabitat variables measured at grids in which olive-backed pocket mice (*Perognathus fasciatus*) were detected (n = 10) and grids in the species' predicted distribution but not detected (n = 6) in 2017 and 2018. Variables for which all measurements were 0 are not presented.

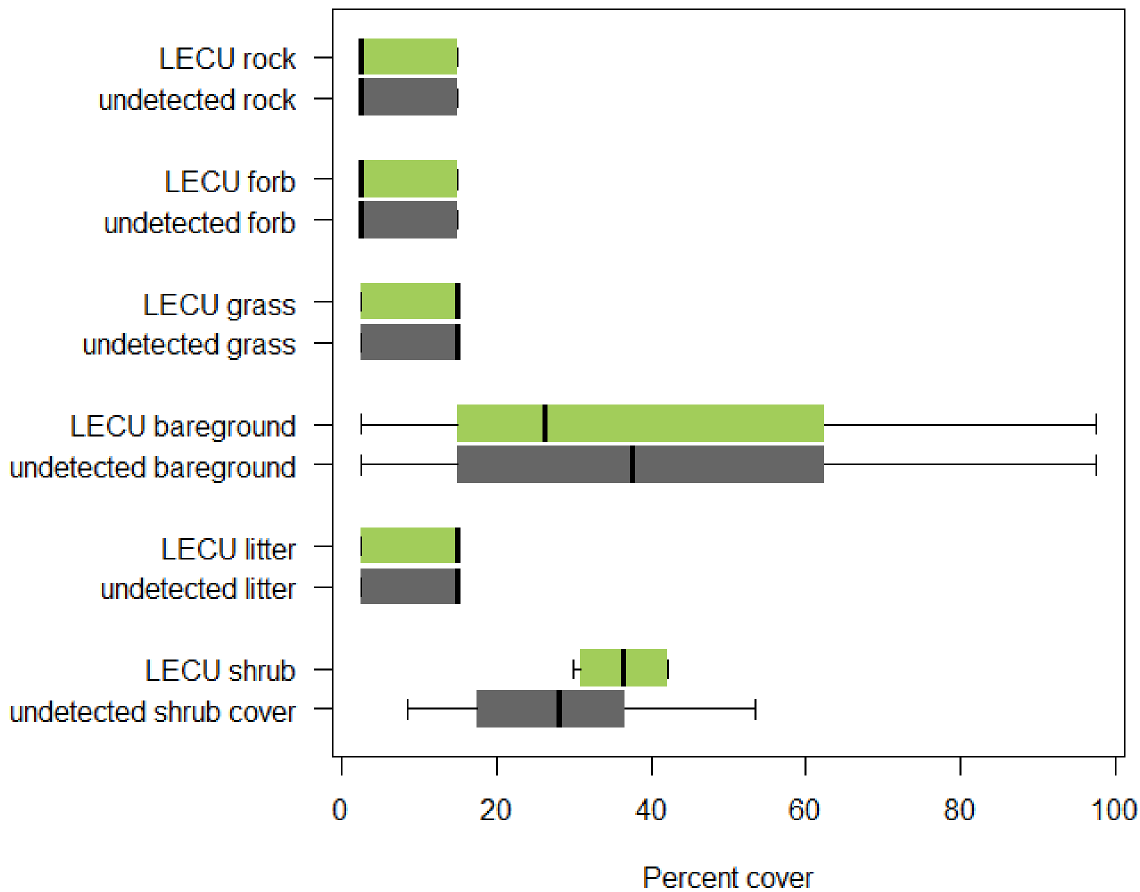

Figure 3. Comparison of overstory and microhabitat variables measured at grids in which sagebrush vole (*Lemmiscus curtatus*) were detected (n = 3) and grids in the species' predicted distribution but not detected (n = 10) in 2017 and 2018. Variables for which all measurements were 0 are not presented.

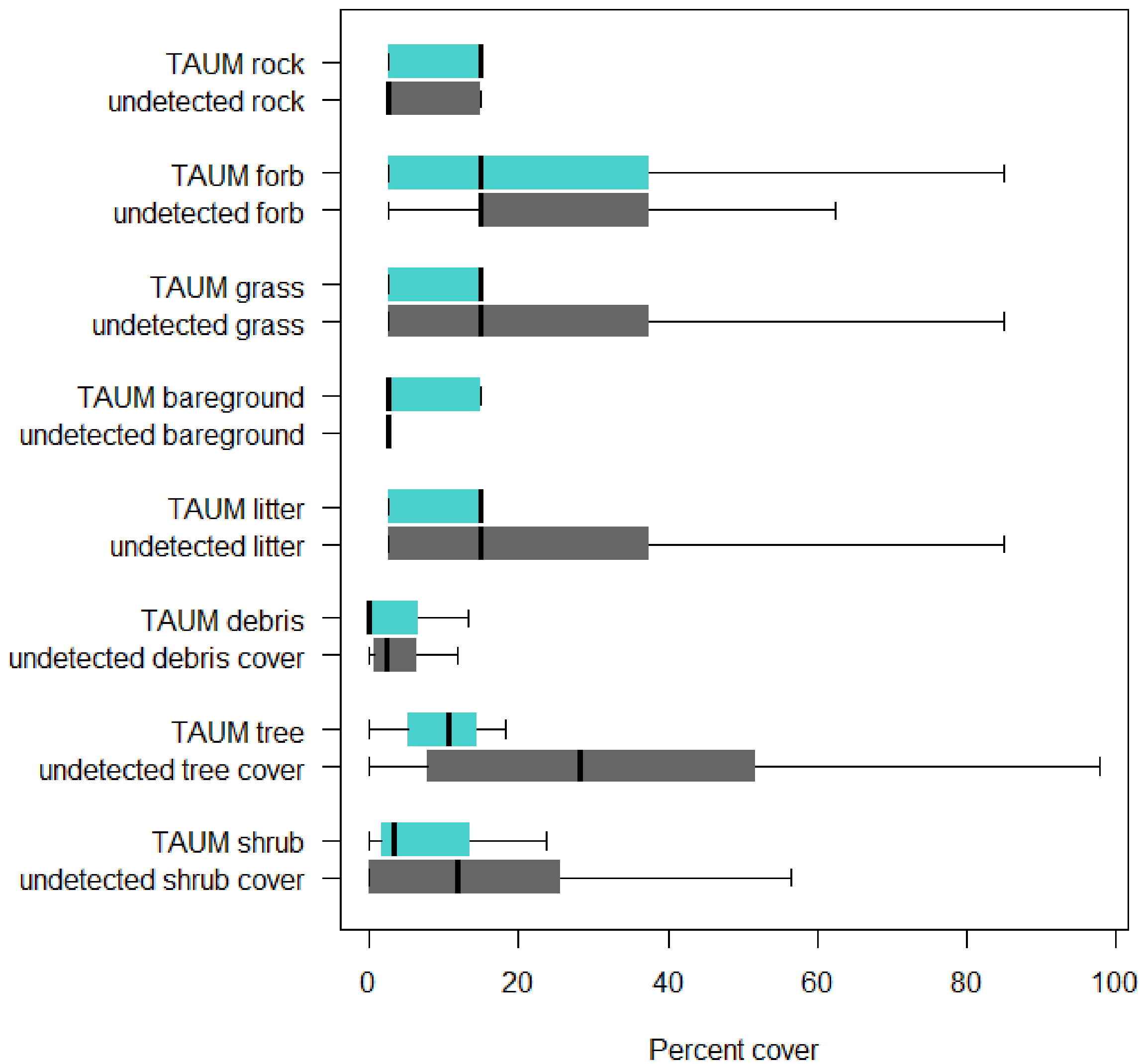

Figure 4. Comparison of overstory and microhabitat variables measured at grids in which Uinta chipmunks (*Tamias umbrinus*) were detected (n = 2) and grids in the species' predicted distribution but not detected (n = 7) in 2017 and 2018.

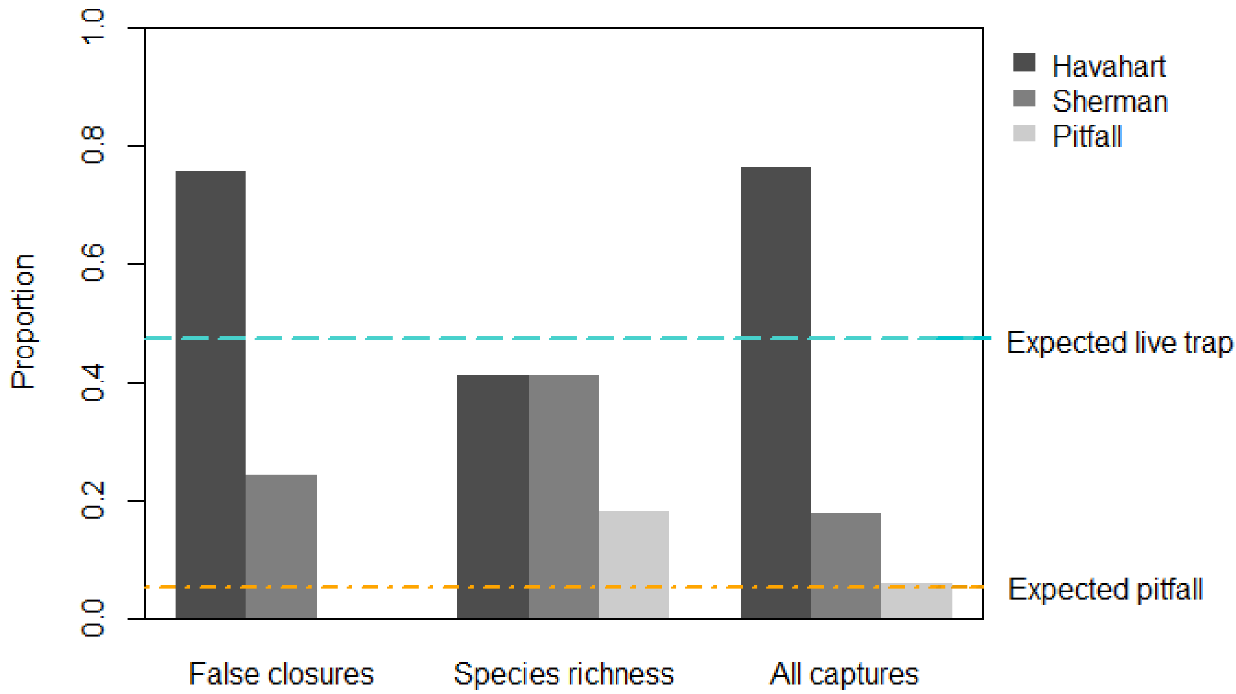

Figure 5. Proportions of falsely closed traps, species richness, and all captures in 3 types of small mammal traps during sampling efforts in 2017 and 2018. Data from 2017 are from Nelson (2018).

Appendix 1. List of all sites surveyed for small mammals between 6 June and 16 August 2018, including elevation, remotely sensed LANDFIRE existing vegetation cover designation (USGS 2013), sampling dates, and GPS location.

Grid	Elev. (m)	Existing vegetation cover designation	Dates	UTM NAD83 Zone 13	
				Easting	Northing
SM102	2,074	Inter-Mountain Basins Montane Sagebrush Steppe	6/26-6/29	283367	4571041
SM103	2,017	Inter-Mountain Basins Montane Sagebrush Steppe	6/26-6/29	280617	4577541
SM105	2,012	Inter-Mountain Basins Montane Sagebrush Steppe	6/19-6/22	271617	4566541
SM107	2,060	Inter-Mountain Basins Montane Sagebrush Steppe	6/5-6/8	273867	4562041
SM210	2,113	Inter-Mountain Basins Montane Sagebrush Steppe	6/12-6/15	282117	4561541
SM315	2,422	Inter-Mountain Basins Montane Sagebrush Steppe	7/10	300117	4590541
SM319	2,431	*Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance	7/17-7/20	614617	4584541
SM425	2,538	Rocky Mountain Aspen Forest and Woodland	8/14-8/16	314617	4552541
SM529	2,785	Rocky Mountain Lodgepole Pine Forest	8/7-8/10	329617	4558541
SM533	2,849	Rocky Mountain Lodgepole Pine Forest	7/24-7/27	319867	4568041
SM535	2,730	Rocky Mountain Lodgepole Pine Forest	8/7-8/10	327867	4557041
SM636	3,044	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	7/28-7/31	332867	4559041

Appendix 2. Minimum number alive (MNA) of all species captured between 6 June and 16 August 2018 in south-central Wyoming. Species are designated by 4 letter codes consisting of the first 2 letters each of species and genus, with the exception of those only identified to genus. Zero values indicate the species was expected to be encountered based on predicted distribution and habitat characteristics (Keinath et al. 2010, Buskirk 2016) but was not captured.

Watershed	Grid name	PEMA	MYGA	SOCI	ZAPR	TAMI	DIOR	ONLE	SOME	TAUM	PEFA	SOMO	LECU	UREL	*Microtus*	*Sorex.*
Little Snake – Battle Creek	SM425	8	1		2	0				0				0		
	SM529	27	31	19	19	2			1	0				0	5	9
	SM535	13	12	10	1	5			1	0		2		0	1	4
	SM636	3	26			0				4						
Lower Muddy Creek	SM102	16				0	0	0			0		0	0		
	SM103	24				1	0	1			0		1	0		
	SM105	18				0	4	1					0	0		
	SM107	18				0	2	2			0		0	1		
	SM210	28				0		1					0	0		
Savery Creek	SM319	10				2		0			2		0	0		
	SM533	6	16			1										
Upper Muddy Creek	SM315	1		1		0	0	0	2		0		0	0		2

DISTRIBUTION AND GENETIC DIFFERENTIATION OF SPOTTED SKUNKS

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Eastern spotted skunk

FUNDING SOURCE: Western Association of Fish and Wildlife Agencies
Wyoming Game and Fish Department Commission Funds
Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 15 August 2016 – 15 August 2020

PERIOD COVERED: 1 May 2016 – December 31 2018

PREPARED BY: Merav Ben-David, Professor
Robert J. Riotto, Graduate student
Zachariah Bell, Graduate student

SUMMARY

The plains spotted skunk (*Spilogale putorius interrupta*), a subspecies of the eastern spotted skunk (*S. putorius*), was petitioned for listing under the US Endangered Species Act due to large, range-wide declines in abundance. Eastern and western spotted skunks (*S. gracilis*) are considered distinct based on purported geographic isolation, mitochondrial DNA, and differing reproductive traits. However, the 2 species cannot reliably be distinguished by phenotypic differences. In addition, the validity of the *S. p. interrupta* subspecies is defined largely on geography. Since April 2017, we obtained 75 samples of spotted skunks (eastern and western) from 10 states. DNA was extracted from all samples and shipped for analysis to the University of Maryland Genomics Science Center. We surveyed 250 of 900 sites and detected skunks in 21 of those. In the Granite Mountains, Vedauwoo, Sybille Canyon, and Curtis Gulch, we caught 28 individuals. Ten adults from the Granite Mountains were fitted with a GPS transmitter and tracked from October 2017 to January 2018. Our tracking suggests that spotted skunks in Wyoming move longer distances than previously reported for other locations. In spring 2018, we will concentrate our camera and live-trapping efforts at the eastern part of the state to target the plains spotted skunks. We will return and survey additional sites on the western side of the state in fall 2018. See Appendix 1 for the full report.

SPECIES OF GREATEST CONSERVATION NEED – BIRDS AND MAMMALS

NONGAME WILDLIFE INVENTORY OF CHAIN LAKES WILDLIFE HABITAT MANAGEMENT AREA

STATE OF WYOMING

NONGAME BIRDS AND MAMMALS: See Table 1

FUNDING SOURCE: Wyoming Game and Fish Department Commission Funds

PROJECT DURATION: 1 February 2018 – 31 October 2018

PERIOD COVERED: 1 February 2018 – 31 October 2018

PREPARED BY: Anika Mahoney, Nongame Biologist

ABSTRACT

Chain Lakes Wildlife Habitat Management Area (WHMA) is 1 of just 9 priority wetland complexes in the state of Wyoming. The WHMA supports a diverse array of wildlife, and its wetlands are particularly valuable given their high quality and isolation within the arid expanses of the Great Divide Basin. Although some components of the biodiversity at Chain Lakes WHMA have been documented, the Wyoming Game and Fish Department lacked a more comprehensive baseline inventory of nongame wildlife. This information was prioritized due to an escalation in oil and gas development within the WHMA. For 6 months in 2018, we conducted surveys of the bird, mammal, reptile, and amphibian communities, targeting 40 Species of Greatest Conservation Need (SGCN) predicted to occur within the WHMA. The objectives of these surveys were to 1) document the presence and habitat associations of nongame species, particularly those designated as SGCN, and 2) identify priority areas for conservation. We defined areas as high priority if they met one of three criteria, 1) high use, 2) high species richness, or 3) use by SGCN.

From 5 April – 11 September, we documented 149 species of wildlife at Chain Lakes WHMA, including 38 SGCN and 15 Sensitive Species as designated by the Bureau of Land Management. Seventy-one percent of SGCN were present in multiple habitat types, suggesting high connectivity among habitats and reflecting the mosaic nature of the land cover within the WHMA. The dominant habitats, salt desert shrublands, sagebrush steppe, and wetlands, all supported SGCN, making all of Chain Lakes WHMA a priority area for conservation. Although all habitats within Chain Lakes are valuable as wildlife habitat, the wetlands received the highest use by wildlife, supported the highest species richness, and contained the highest richness of SGCN. Additionally, wetlands supported the most unique community composition. Overall, Chain Lakes WHMA provides a rare and unique combination of habitats that supports a diverse

array of wildlife, and the wetlands in particular provide a highly valuable resource for migrants, local breeders, and residents.

INTRODUCTION

Chain Lakes Wildlife Habitat Management Area (WHMA) is part of a ~182,000 ha network of 40 management areas in Wyoming that provide habitat for wildlife and recreational opportunities for wildlife enthusiasts. Located within the Great Divide Basin, the Chain Lakes WHMA was created in 1970 in partnership with the Bureau of Land Management (BLM) to protect crucial winter range and migration routes for pronghorn (see Table 1 for scientific names of wildlife species). Subsequent surveys documented use by other high-priority species for conservation including Greater Sage-Grouse leks, nests of Burrowing Owl and Ferruginous Hawk, and resident pygmy rabbit and Great Basin spadefoot. The WHMA also supports an uncommon and highly diverse array of flora, including 16 species ranked as critically imperiled, imperiled, or vulnerable in the state of Wyoming (Heidel 2008, Washkoviak et al. 2018). These include 2 of only 3 populations of meadow milkvetch (*Astragalus diversifolius*; Heidel 2009) and the 3rd record of tiny phacelia (*Phacelia tetramera*) in Wyoming (Heidel 2008). Based on the unique ecological values of the Chain Lakes wetlands, they were designated as 1 of just 9 priority wetland complexes for conservation in the state (Wyoming Joint Ventures Steering Committee 2010). Further validating this designation, a 2015 assessment found the wetlands of Chain Lakes WHMA averaged the highest scores in the state for wetland ecological integrity due to minimal disturbance by human activity, an absence of hydrologic alteration, few non-native plant species, limited habitat fragmentation, and physical and biogeochemical services rendered (Washkoviak et al. 2018).

Although some components of the biodiversity at Chain Lakes WHMA have been documented, the Wyoming Game and Fish Department (Department) currently lacks a more comprehensive baseline inventory of nongame wildlife. This information has been prioritized due to an escalation in oil and gas development within the WHMA. Data relating to the presence and habitat associations of wildlife can provide useful information to guide the siting of industrial infrastructure, estimate the scale of impacts, and set goals for future reclamation efforts to minimize impacts of development to wildlife. To meet this need, we conducted surveys of nongame birds, mammals, reptiles, and amphibians in 2018 at Chain Lakes WHMA. The objectives of these surveys were to:

1. Document the presence and habitat associations of nongame species, particularly those designated as Species of Greatest Conservation Need (SGCN).

2. Identify priority areas for conservation. We defined areas as high priority if they met one of three criteria, 1) high use, 2) high species richness, or 3) use by SGCN.

METHODS

Study Area – Chain Lakes WHMA is a 25,283 ha tract of the Red Desert within the Great

Divide Basin of central Wyoming. The Great Divide Basin receives approximately 16.5 cm of precipitation per year, and elevation within the WHMA ranges from 1,974 to 2,120 m (USGS 2009). Soils are predominantly sandy clay loams derived from sandstone and shale (Munn and Arneson 1998, BLM 2013). The principal land cover types are alkaline wetlands and arid shrub steppe dominated by sagebrush (*Artemisia* spp.), Gardner's saltbush (*Atriplex gardneri*), and greasewood (*Sarcobatus vermiculatus*) shrubs (USGS 2013; Figure 1). The eponymous wetlands of the WHMA constitute ~9% (2,300 ha) of the surface area and are fed by precipitation, runoff, and groundwater seeps. These wetlands range from temporarily to permanently flooded and are the remnants of the once-vast Lake Wamsutter, which occupied ≤200,000 ha 0.5 to 1.0 million years ago (Marrs and Grasso 1993).

In addition to the naturally occurring wetlands, there are 14 water wells on the site. Drilled in the 1950s to provide water for livestock, 7 of these wells are maintained to provide supplemental water for wildlife from spring through fall and provide small areas of additional wetland habitat. Landownership within the WHMA consists of the State of Wyoming lands and federal lands administered by the BLM (Figure 2). The area is leased for the winter grazing of sheep, which occurs from December through March. There are several small herds of feral horses within the fenced boundary of the WHMA, totaling ~15 horses in 2018. Surface development primarily consists of oil and gas industry infrastructure (e.g., well pads, maintained gravel roads, evaporation ponds) in the southwest of the WHMA. There are also the remnants of 2 structures, ~19 miles of gravel roads along the 2 primary arteries of the WHMA, the north-south Riner Road and the east-west Stratton Road, and a network of 2-tracks in varying condition that all pre-date the oil and gas development in the southwest.

Sampling Design – To identify potential SGCN, we compiled a list of those predicted to occur or previously observed within the WHMA (Wildlife Observation System [WOS]; WYGISC 2018; Table 1). The majority of these SGCN are highly specialized in their natural history characteristics and habitat associations, and species-specific surveys were necessary for many species. As described in greater detail below, we used existing protocols when available and expert opinion for site selection and survey protocol design. In all cases, we classified land cover for habitat-based site selection using remotely sensed satellite imagery and field surveys (USGS 2013, USFWS 2014, GeoSpatial Services Saint Mary's University of Minnesota 2017; Table 2). We refer to all wildlife species by their common name, following accepted taxa-specific naming conventions, and present scientific names in Table 1.

Supplemental Water Wells – We placed remote cameras (model HC600 Hyperfire Covert, Reconyx, Holmen, WI, USA) at 7 solar-powered water wells maintained by the Department and BLM Rawlins Field Office to document the wildlife community using supplemental water sources and to target swift fox (Figure 3). To attract mammals, we hammered an 18" chisel-point wooden stake daubed with a skunk lure attractant (100% Pure Quill Skunk Essence, Northland Animal Lure, Bloomer, WI mixed in petroleum jelly) into the ground 5-7 m north of the camera. To minimize false detections, we secured cameras to rebar facing north and cleared grasses and herbaceous vegetation from the field of view. Cameras recorded bursts of 3 photographs per detection followed by a 2-second quiet period and operated 24 hours per day. We checked cameras approximately once per month to ensure functionality.

Incidental Observations – We recorded incidental wildlife observations of rare or high-priority species as well as observations in unusual habitats. Observers recorded date, species, count or calling intensity (see Estes-Zumpf et al. 2017), UTMs, residence status (resident, passage migrant, local breeder, or unknown), and habitat.

Migrating Waterbirds – To document the species and relative numbers of wetland-associated birds, including waterfowl, shorebirds, and wading birds, using Chain Lakes WHMA for migration stopover habitat, we conducted counts at wetlands during spring and fall migration. To survey a broad array of wetland conditions within the WHMA, we used a remotely sensed wetland GIS layer created by Saint Mary's University of Minnesota (Geospatial Services Saint Mary's University of Minnesota 2017) based on National Wetland Inventory data to select survey sites. We grouped wetlands into 3 classes based on water regime – 1) permanent and semi-permanent, 2) seasonally flooded, and 3) intermittently or temporarily flooded. We excluded wetlands in class 3 from sampling. We retained all class 1 wetlands for surveying (n = 19), and placed the maximum possible number of sampling points within class 2 wetlands with 500 m spacing between each point (n = 18). Because the wetlands of Chain Lakes experience annual and seasonal fluctuations in water levels, we eliminated dry sites during ground-truthing, resulting in 17 class 1 and 1 class 2 wetlands (Figure 4). As sites dried or filled with water throughout the season, we discontinued or implemented surveys accordingly.

We surveyed each wetland every 5 to 10 days to minimize double-counting migrating individuals. Surveys were conducted mornings (sunrise to 4 hours post-sunrise) and evenings (4 hours prior to sunset to sunset). To account for potential variation in use with time of day, we alternated the timing of the survey for each wetland, so no wetlands were surveyed exclusively in the mornings or evenings. We selected observation points for surveying wetlands in the field to maximize the observer's ability to detect waterbirds. Surveyors began scanning wetlands from as great a distance as possible upon their approach to the wetland to avoid flushing birds prior to counting, and walked as much of the wetland perimeter as needed to visually scan the entire shoreline and waters of each sampled wetland. Surveyors spent ≥5 minutes at each wetland, but were allowed to spend as long as needed to identify all wetland bird species and count all individuals (adapted from Loges et al. 2014). We considered birds detected ≤100 m of a wetland as associated with that wetland and recorded separate UTMs for species >100 m from wetlands. Surveyors recorded date, time of day, survey duration, and species counts at each sampled wetland.

Breeding Secretive Marsh Birds – Two secretive marsh birds, American Bittern and Virginia Rail, were predicted to occur at Chain Lakes WHMA. To document the presence and distribution of these SGCN, we conducted call-back point count surveys. We selected survey sites by identifying areas of potential habitat using aerial imagery and field surveys. We defined potential habitat as wetlands with dense stands of emergent vegetation with shallow to intermediate water depths and a muddy substrate. American Bittern have been documented in wetlands ≥1 ha (Hanowski and Niemi 1986). Virginia Rail have a higher frequency of occurrence in larger areas of suitable habitat (1-20 ha; Brown and Dinsmore 1986); however, the species has also been documented in wetlands ≥0.013 ha (Richmond et al. 2010). Given the generally small patches of suitable habitat within the Chain Lakes WHMA, we considered sites ≥0.01 ha to be potential breeding habitat (n = 8). After ground-truthing, we retained 1 sampling site for 2018 (Figure 5). We surveyed this site following the Statewide Nongame Bird and Mammal Program (henceforth, the Nongame Program) protocol for Secretive Marsh Bird Sampling (Orabona and Patla 2013).

Breeding Colonial Waterbirds – The colonial waterbird SGCN in Wyoming (Black-crowned Night-Heron, White-faced Ibis, Forster's Tern, Caspian Tern, Black Tern, Franklin's Gull, Snowy Egret, Cattle Egret, Western Grebe, Clark's Grebe, and American White Pelican) generally require larger bodies of water, particularly with islands, trees, or larger areas of emergent vegetation for breeding habitat (see Orabona and Patla 2013 for details). Given the size of the waterbodies, the lack of islands and trees, and the limited areas of emergent vegetation, there was no suitable breeding habitat for these species on Chain Lakes WHMA.

Breeding Long-billed Curlew – To document the presence of breeding Long-billed Curlew, we defined potential breeding habitat as grass-dominated areas adjacent to wetlands or wetter areas (see Orabona and Patla 2013). Using aerial imagery and field surveys, we identified 7 areas of potential breeding habitat in 2018 and placed survey points in each of those areas (Figure 5). We conducted surveys at these sites following the Nongame Program's statewide protocol to estimate occupancy and density for Long-billed Curlew (Orabona and Patla 2013). Due to logistical constraints, a single observer conducted point counts.

Breeding Landbirds – To document the species and relative numbers of breeding landbirds (including SGCN Brewer's Sparrow, Common Nighthawk, Loggerhead Shrike, Mountain Plover, Sagebrush Sparrow, and Sage Thrasher), we conducted point-count transects (adapted from Hanni et al. 2018) in each of the dominant habitat types. To select survey sites, we grouped LANDFIRE Existing Vegetation Types (USGS 2013) into 3 broad categories: 1) salt desert shrubland, 2) sagebrush steppe, and 3) wetlands, where wetlands included playa, greasewood playa, and dune grassland land cover (Table 2). We then overlaid the WHMA with a 450 m^2 grid. Each grid cell was classified by dominant habitat type (Figure 6). We selected 4 cells of each habitat at random with spatial stratification as survey sites (n = 12; Figure 6; Stevens and Olsen 2004). We placed 4 points in each survey site, spaced 250 m apart and 100 m from the cell edge. Surveyors conducted 6-minute point count surveys at each point, identifying species, age, sex, and distance to each detected individual (Hanni et al. 2018). We used these data to assess total use (sum of counts), species richness, and SGCN richness. Due to time constraints, we did not adjust estimates of occupancy and abundance for detection probability.

Breeding Burrowing Owl – Burrowing Owls are secondary burrow nesters, reliant on burrows created by other animals for nesting habitat, and frequently nest in burrows created by prairie dogs. To document breeding Burrowing Owls at Chain Lakes WHMA, we identified 6 sites as potential nesting habitat based on observations of Burrowing Owl individuals or scat (incidental detections in 2018 and previous observations accessed through WOS) and prairie dog colonies (Figure 7). We conducted surveys for Burrowing Owl breeding activity following the Nongame Program's protocol and identified nest burrows when possible (Orabona and Patla 2013).

Breeding Short-eared Owl – To document the presence of Short-eared Owl, we established and conducted 2 point-transect survey routes following the Western *Asio flammeus*

Landscape Survey Protocol (Miller et al. 2016; Figure 8). Routes were surveyed twice during the peak of the courtship period when Short-eared Owls are most detectable. Observers recorded date, time, weather, minute of detection, distance to detection, and habitat.

Amphibians – Two amphibian SGCN, western tiger salamander and northern leopard frog, were predicted to occur within the WHMA, and the Great Basin spadefoot was detected in previous surveys (WYGISC 2018; WOS). To detect toads and frogs, we conducted aural walking surveys. We combined this survey effort with migratory waterbird surveys, and, as such, visited all permanent or semi-permanent wetlands with water present every 5-10 days within 4 hours of sunrise or sunset (see Migrating Waterbirds for greater detail on site selection). Observers spent ≥5 minutes at each wetland, but were allowed to spend as long as needed to identify all species and to estimate calling intensity. Observers recorded the date, time period, species, and calling intensity of calling anurans (as described in Estes-Zumpf et al. 2017). To detect aquatic larvae of amphibians, we conducted dip netting at all wetlands with water and aquatic vegetation at the time of the survey in late July (Figure 9). Observers walked the shoreline of these wetlands and dip netted areas with debris, emergent vegetation, and silty bottoms. The length of the shoreline sampled varied based on the amount of suitable habitat present. Observers recorded the time spent, distance traveled, species counts, and water pH at each wetland.

Reptiles – We conducted 250 m walking surveys to target the 2 reptile SGCN, greater short-horned lizard and prairie rattlesnake. We used breeding landbird survey sites, since they were selected at random with spatial distribution across the WHMA by habitat (Figure 10; see Breeding Landbird methods for details). Observers recorded date, species, count, and habitat type.

Bats – To detect and identify bats, we placed bioacoustics recorders (model Song Meter 2, Wildlife Acoustics, Maynard, Massachusetts) at 3 sites (Figure 11). We selected 2 wetland and 1 rock outcrop site that would maximize our potential to detect bats (L. Beard, personal communication). Recordings were identified to species when possible.

White-tailed Prairie Dog – There were no previous reports of prairie dogs within the boundaries of Chain Lakes WHMA in the Department's WOS. We identified potential prairie dog colonies based on aerial imagery (ESRI, Redlands, California), field surveys, incidental observations, and previous observations of Burrowing Owl, given the owl's close association with prairie dog colonies. We classified sites as active colonies if scat or individuals were detected. We mapped the perimeter of active colonies following the Nongame Program's ground survey protocol (Cudworth et al. 2013).

Small Mammal Community – To identify species of the small mammal community and to target 2 SGCN predicted to occur in the WHMA, olive-backed pocket mouse and sagebrush vole, we conducted small mammal trapping. We trapped at a single site selected at random within each of the 3 dominant land cover types (salt desert shrubland, sagebrush steppe, and wetlands, with wetlands including playa, greasewood playa, and dune grassland land cover; Table 2, Figure 12). We trapped at each site for 3 nights using a 4 × 15 grid with 20-m spacing between trap stations (K. Harkins, personal communication). We placed small Havahart traps

(Woodstream Corporation, Lititz, Pennsylvania) at each station and small collapsible Sherman traps (H.B. Sherman Traps, Inc., Tallahassee, Florida) at every other station within the grid. Traps were provisioned with bird seed (a commercial mix dominated by white millet, nyjer, and sunflower seeds, baked to prevent sprouting), a piece of carrot to provide moisture, and synthetic bedding to provide warmth. The variation in temperature was extreme during out trapping efforts, ranging from ~7 to 35°C. We minimized temperature-related stress for animals by closing traps during the day. Traps were opened after 1830 and closed no later than 1000 the following morning. We identified small mammals to species, and recorded age and sex when possible (Cudworth et al. 2013).

Wyoming Pocket Gopher **–** There are 2 potential species of pocket gopher in Chain Lakes WHMA, the Wyoming pocket gopher (a SGCN and habitat specialist) and the northern pocket gopher (a widespread and common generalist). Although pocket gophers live the majority of their lives in complex tunnel systems below ground, their presence can be detected through the mounds of fresh soil which seal tunnels from the surface. While pocket gophers are highly detectable due to these mounds, the 2 species can only be reliably distinguished in the field by differences in pelage that are observed in-hand.

To document the species and occupancy rate of pocket gophers in potential Wyoming pocket gopher habitat in Chain Lakes WHMA, we conducted walking surveys for pocket gopher mounds and trapped at a subset of these mounds (Griscom et al. 2010; B. Britto, personal communication). Based on the habitat associations described in the Wyoming Species Account (WGFD 2017), we used LANDFIRE Existing Vegetation Type (USGS 2013) to classify the following dominant land cover types as potential Wyoming pocket gopher habitat: sparsely vegetated systems, saltbush shrublands, dwarf sagebrush shrubland and steppe, semi-desert shrub-steppe, greasewood flat, or barren. We overlaid the WHMA with a 1.3 km^2 grid, and retained grid cells with ≥75% suitable habitat and within 0.8 km of a road, resulting in 101 km^2 of more contiguous suitable habitat (adapted from Griscom et al. 2010). We selected survey sites from these cells at random with spatial stratification (n = 21; Figure 12; Stevens and Olsen 2004). Surveyors walked fixed, parallel transects with 100 m spacing within each cell, recording the date and duration of survey, the suitability of the habitat for Wyoming pocket gopher, UTMs, counts, and estimated age of detected pocket gopher mounds (Griscom et al. 2010).

We conducted live trapping of pocket gophers at 28 mound complexes at 4 sites with fresh burrowing activity. Three of these sites were identified through mound surveys, and 1 was selected due to habitat and ease of accessibility. To place traps, we identified fresh mounds based on soil color. Using a shovel or hand-held trowel, we dug mounds until a tunnel was identified. Using a surveyor pin flag, we explored the direction and openness of the tunnel, and selected straighter tunnels to place traps (B. Britto, personal communication). We used small, aluminum, folding Sherman traps (H.B. Sherman Traps, Inc., Tallahassee, Florida) and Harmony traps (Harmony Metalworks, Laramie, Wyoming). The Wyoming Pocket Gopher does not appear to respond to traditional small mammal baits (seeds, grains, peanut butter, carrot, etc.), so we used 2.5-5 cm cubes of sweet potato to provide food and moisture instead (B. Britto, personal communication). Traps were placed level with the tunnel and were mostly covered with soil to provide thermal insulation and increase likelihood of trap success. To minimize stress to pocket gophers due to extremes in temperature, we set traps after 1730 in the evening and conducted our first trap check by 0630. We then checked traps every 1-2 hours until ~1100, or at which time it was too hot to continue trapping (>27°C). We moved or added traps as fresh mounds were detected in a trapping area. We identified captured pocket gophers to species, and recorded length of body, tail, and right hind foot, as well as weight.

***Pygmy Rabbit* –** We selected sites and conducted surveys for pygmy rabbits following the Nongame Program's pygmy rabbit monitoring protocol (Cudworth et al. 2013). At the finer scale within our study area, the Nongame Program's potential sampling grids generally did not fall in the big sagebrush (*Artemisia tridentata)* habitat with which the pygmy rabbit is strongly associated during winter months (and during our proposed survey period). Therefore, we duplicated the site selection protocol using an alternative 30 m^2-cell land cover GIS layer that more accurately identified sites dominated by big sagebrush within the WHMA (USGS 2013). To create a single sagebrush category, we grouped several sagebrush land cover classes (Table 2). We overlaid the WHMA with a grid of 400 m^2 cells, and retained cells with ≥75% sagebrush land cover. We selected a subset of these grids at random with spatial distribution across the WHMA (Stevens and Olson 2004), and conducted walking surveys for pygmy rabbit presence (Figure 13). We deviated from the established protocol in one regard, by recording all pygmy rabbit scat, regardless of freshness. We assumed that pygmy rabbit scat may persist for ≤3 years on the landscape, given estimates for Greater Sage-Grouse droppings in similar conditions (Boyce 1981); therefore, we define pygmy rabbit presence as within the last 3 years. Based on field survey data, we then estimated the probability of occupancy of suitable winter habitat by pygmy rabbit corrected for detection probability using single-season occupancy models (MacKenzie et al. 2002, Fiske and Chandler 2011).

***Swift Fox* –** The entirety of Chain Lakes WHMA represents potential habitat for the SGCN swift fox. Swift fox can be difficult to detect due to their year-round use of burrows as refuge for adults and pups. We placed remote cameras at man-made water sources to detect swift fox, adapted from the Nongame Program's protocol (Figure 14; see the Supplemental Water Wells methods and Cudworth et al. 2013 for details).

***Conservation Value* –** To assess and summarize the conservation value of the landscape within Chain Lakes WHMA, we considered 3 components that each describe an aspect of conservation value: 1) count of use of all species by habitat type, 2) species richness by habitat, and 3) use weighted by conservation status by habitat. We compared species composition among habitat types using Jaccard distances, which measures the dissimilarity between pairs of communities on a scale from 0 to 1, where 0 represents no difference between communities and 1 represents complete difference between communities (Jaccard 1908). We compared relationship between the measures of conservation value (use, SGCN use, and species richness) using Spearman's correlation coefficient (ρ; Spearman 1904).

Given the short duration of this study, we expect that our field-based documentation of habitat associations is not comprehensive, particularly for rarely observed passage migrants, which can be more variable in their habitat use. Therefore, we took a conservative approach to assessing biodiversity in relation to habitat type by recording 1) the habitat(s) in which a species was detected in the field (field-observed habitat) and 2) any additional habitats present within the WHMA that a species could use based on prior documentation given its life cycle stage (including mammalian species accounts produced by the American Society of Mammalogists, MNHP and MFWP 2018, Poole 2018).

RESULTS

From 5 April – 11 September 2018 we documented 149 species of wildlife at Chain Lakes WHMA, including 38 SGCN and 15 Sensitive Species (Table 1; BLM 2010, WGFD 2017). We present species or community-specific results first, and then present findings describing landscape conservation value grouped across taxa where possible.

Supplemental Water Wells – Cameras operated 10 April – 11 July, for a total of 518 days of effort at 7 sites (Figure 3). In 36,424 photos, we identified 31 species of wildlife as well as feral horses and domestic sheep (Tables 3 and 4). Of these species, 7 were SGCN, including 4 detections of swift fox at 2 sites (Figure 15; see Swift Fox results for additional details). Mule deer were detected at 3 sites - the sole detections of this species during the course of this study. Feral horses were present at 4 of the 7 sites.

Incidental Observations – From 5 April – 11 September, we documented 431 observations of 114 wildlife species through incidental observations. Although these observations provide valuable information on species presence within Chain Lakes WHMA, they are spatially biased toward areas that were more frequently visited. As such, we generally avoid presenting them graphically, to preclude false spatial associations. All observations were reported to the WOS.

Migrating Waterbirds – We surveyed wetlands to record migrating waterbirds from 10 April – 31 May and 30 June – 11 September. During these spring and fall periods, we counted 4,760 individuals of 62 species across 19 wetland sites (Tables 1 and 5). We detected 9 SGCN during waterbird surveys: American Bittern, American Pipit, American White Pelican, Black-crowned Night-Heron, Franklin's Gull, Great Blue Heron, Peregrine Falcon, Western Grebe, and White-faced Ibis. None of these SGCN were detected in other survey efforts, nor were they suspected to be breeding locally, demonstrating the importance of Chain Lakes WHMA as foraging and refuge habitats for high-priority wetland-associated species.

The wetlands supported high use, high species richness, and use by SGCN for migrating waterbirds, and therefore qualify threefold as a high priority area for conservation. Our measures of conservation value, use, species richness, and use by SGCN, were positively correlated for migrating waterbird sites in 2018. However, use and species richness were strongly positively correlated (Spearman's $\rho = 0.83$), while use and SGCN richness were only moderately positively correlated (Spearman's $\rho = 0.54$). Therefore, sites with high use generally also had high species richness; however, the highest numbers of SGCN were not always found at those sites (Figures 17 and 18).

Breeding Secretive Marsh Birds – We conducted call-back point count surveys targeting Virginia Rail and American Bittern at a single potentially suitable site within the WHMA (Figure 5). Virginia Rail was detected on 28 June (Figure 5). American Bittern was not detected during breeding secretive marsh bird surveys; however, 1 bittern was recorded during migrating waterbird surveys on 22 May (Figure 5). Based on these detections, Chain Lakes WHMA provides suitable migratory stopover habitat for both species and breeding habitat for Virginia Rail.

Breeding Long-billed Curlew – We conducted point count surveys targeting breeding Long-billed Curlew at 7 sites (Figure 5). Sites were visited on 25 April and 9 May. We detected no breeding Long-billed Curlew during our survey; however, Long-billed Curlew was detected as an incidental observation on 3 separate occasions in early spring (11 – 24 April; Figure 5). Detection solely during this time period suggests that Chain Lakes WHMA provides suitable habitat for migratory stopover use for this SGCN.

Breeding Landbirds – To document breeding landbirds, we conducted point count surveys (n = 48) at 12 sites (4 point counts per site) between 5 – 22 June. We detected 491 individuals of 27 avian species, including 9 SGCN. The SGCN consisted of 3 sagebrush-obligate songbirds, Brewer's Sparrow, Sagebrush Sparrow, and Sage Thrasher, the grassland-obligates Mountain Plover and Upland Sandpiper, and several more generalist species, Common Nighthawk, Golden Eagle, Loggerhead Shrike, and Short-eared Owl.

Breeding landbird use, species richness, and SGCN richness varied by site with high values in each habitat type (Figures 19 – 21). When summed across sites by habitat, use, species richness, and SGCN richness were highest in wetlands (Figure 22). Although wetlands had just 16% higher use, they supported 33% more species than salt desert shrublands and 43% more species than sagebrush steppe. SGCN richness was also highest in wetland habitat when summed across sites (n = 6); however, the differences in SGCN richness between wetlands, salt desert shrublands (n = 5), and sagebrush steppe (n = 4) was less pronounced, and the highest single value for SGCN richness was recorded at a salt desert shrubland site. Many species (44%) were detected in multiple habitats (Figure 22).

Sagebrush obligate songbirds were the most broadly distributed SGCN in these surveys, with all 3 present at all sagebrush steppe sites (n = 4; Figure 23). Brewer's Sparrow and Sage Thrasher were detected at 11 of 12 total sampling sites, while Sagebrush Sparrow was detected at 8 of 12 sites (Figure 23). Generalists Loggerhead Shrike and Common Nighthawk were detected at 2 sites each, while Mountain Plover, Upland Sandpiper, Golden Eagle, and Short-eared Owl were detected at just 1 site each (Figure 24). We also recorded additional incidental observations of Mountain Plover in suitable habitat during the breeding period (Figure 25). The detection of habitat-obligate birds at points in other habitats illustrates the mosaic nature of the landscape at Chain Lakes WHMA, as well as these species' use of varying habitat types for different activities or life stages. Given the timing of these surveys, Chain Lakes WHMA provides habitat suitable for breeding for all the species detected, with the exception of the Golden Eagle, which is limited by nest site substrates, and instead used Chain Lakes WHMA as foraging habitat.

Breeding Burrowing Owl – We conducted surveys for breeding Burrowing Owls at 6 sites between 19 April – 11 June. During these surveys, we detected 13 Burrowing Owls at 3 sites, including 2 active and occupied nest burrows that each produced young (Figure 7). We also detected adult owls at 2 additional locations through incidental observations.

Breeding Short-eared Owl – We conducted Short-eared Owl surveys on 2 survey routes (Figure 8). A single observer visited each route on 19 April and 16 May. We detected 1 Short-eared Owl in wetland habitat on 16 May (Figure 8). In addition to this formal survey, we detected Short-eared Owl on 5 additional occasions, approximately once per month from 10 April to 1 August (Figure 8).

Although Short-eared Owl can use a variety of grass and shrubland habitats (Wiggins et al. 2006), all of our observations in Chain Lakes WHMA were in wetland-associated grasslands or greasewood playas. Although we were unable to confirm breeding on the site via the detection of a nest or recently fledged young, our observations confirm that Chain Lakes WHMA provides foraging habitat and may be suitable for breeding.

Other Raptor Nests – There are 3 known nest sites for Ferruginous Hawk and Great Horned Owl in the WHMA. These nest sites were monitored by the BLM in 2018, so we did not conduct formal surveys for these species. However, through incidental observation, we confirmed active, occupied nests of Ferruginous Hawk on both man-made nesting platforms in 2018. The western Ferruginous Hawk nest successfully fledged young, while the eastern nest appeared to fail following a storm with heavy rain and hail. Following this storm, adults were never again detected at the nest platform, and we observed no subsequent evidence of young. We also incidentally detected a potential Great Horned Owl nest and 2 adults inside the old barn structure at Stratton Camp on 9 May. Given the early timing of nesting for this species, we were unable to confirm whether the nest was active in 2018. On 13 June the majority of the nest structure had fallen to the ground, and we found no nestlings or egg fragments in the nest remains. We continued to incidentally observe ≤2 roosting adult Great Horned Owl in the barn subsequent to the nest's destruction.

Greater Sage-Grouse – Approximately 39% of Chain Lakes WHMA (9,768 ha) is designated as Greater Sage-Grouse Core Area habitat (State of Wyoming 2015), and there are 2 active leks within the WHMA (Figure 26). Since these leks are surveyed through other efforts, we did not conduct surveys targeting Greater Sage-Grouse. We did incidentally observe Greater Sage-Grouse adults and chicks (94 individuals in 14 observations) within the WHMA in all habitat types, including dwarf sagebrush steppe, salt desert shrubland, and greasewood-dominated shrublands and playas (Figure 24).

Amphibians – To detect amphibians, including the SGCN Great Basin spadefoot and western tiger salamander, within Chain Lakes WHMA, we conducted walking and netting surveys. During aural walking surveys 10 April – 31 May and 30 June – 11 September, we recorded 27 observations of 1 species, the boreal chorus frog, at 13 wetland sites (Figure 9). We also detected calling boreal chorus frog incidentally at 7 additional wetland sites, including an observation at a wetland created by the solar-powered water well site TC11 (Figure 9). From 26 – 31 July, we conducted dip netting surveys for aquatic larvae of amphibians at 6 wetlands (Figure 9). In 104 minutes of active surveying and 575 m of shoreline sampled, we detected 4 aquatic larvae of western tiger salamander at 1 wetland (Figure 9). We also detected a terrestrial adult western tiger salamander incidentally at 1 additional site, the solar-powered water well TC11 (Figure 9). We had no detections of Great Basin spadefoot in 2018, an SGCN previously detected through vocalizations at a single site within the WHMA (record retrieved from WOS).

Reptiles – We targeted the 2 reptile SGCN, greater short-horned lizard and prairie rattlesnake, predicted to occur within the WHMA by conducting walking surveys. From 5 – 22 June, we conducted 12, 250-m walking transect surveys, but detected no reptiles. Through incidental observations, we detected 30 individuals of 2 species, greater short-horned lizard and northern sagebrush lizard (Figure 10). These detections occurred exclusively in upland habitats, with the majority in salt desert shrubland and rock outcrops.

Bats – We placed bioacoustic recorders at 3 sites to detect and identify bats in Chain Lakes WHMA (Figure 11). Recorders operated between 9 May – 7 July, for a total of 47 days of sampling. All bat calls were recorded between 9 – 15 May, and, given this timing, were likely from bats in migration. A single call by silver-haired bat was recorded at the rock outcrop site, while all other calls were recorded at a single wetland site (Figure 11). We identified 3 species from these calls, the SGCN little brown myotis and western small-footed myotis, as well as the silver-haired bat. Many calls were unidentifiable but in the 40kHz range, which are indicative of bats in the Myotis genus. In addition to the identified species, the long-eared myotis (*Myotis evotis*) and long-legged myotis (*M. volans*) may also occur in the WHMA (L. Beard, personal communication).

White-tailed Prairie Dog – Between 5 April – 11 September, we identified 5 active white-tailed prairie dog colonies (Figure 7). From 25 – 31 July, we mapped the perimeter of these colonies, resulting in 21 acres of active white-tailed prairie dog colony. Several of these colonies were closely spaced, creating 2 general aggregations of prairie dogs within the WHMA.

Small Mammal Community – From 25 June – 1 August, we conducted 546 trap nights across 3 sites (Figure 12). In 546 trap nights, we had 119 captures of 7 species (22% capture rate). We captured both target species, sagebrush vole (captures = 1; Minimum Number Known Alive [MNKA] = 1) and olive-backed pocket mouse (captures = 16; MNKA = 7). Based on these captures, the relative abundance of olive-backed pocket mouse within Chain Lakes WHMA equals 12.8 individuals per 1,000 trap-nights, a number that far exceeds 2 prior studies in Wyoming, which both report <1 individual per 1,000 trap nights in suitable habitat within the species' distribution (Maxwell and Brown 1968, Nelson 2018). Although our methods differed substantively from Maxwell and Brown (1968) in the trap types and bait used, they were similar to those used by Nelson (2018). Use, species richness, and SGCN richness varied among the habitats. When adjusted for trap-night effort, wetland habitat had the highest use (25 captures per night), while sagebrush steppe and salt desert shrubland habitats were similar with 10 and 8 captures per trap night, respectively. However, the salt desert shrubland site had the highest species richness, with 6 of the 7 total species detected, while wetlands had slightly lower richness ($n = 5$), and sagebrush steppe had the fewest species ($n = 3$). The target species were the only SGCN detected, and salt desert shrublands had the highest SGCN richness, with both sagebrush vole and olive-backed pocket mouse detected in salt desert shrubland, while olive-backed pocket mouse was detected in all 3 land cover types. Although salt desert shrublands had the lowest use (8 captures per trap-night), it had the highest species richness and the highest SGCN richness. We note that we were only able to trap 1 site per habitat type, so these results do not reflect the entirety of the small mammal community in each habitat, and, in particular, we would expect the sagebrush vole to be present in the sagebrush steppe habitat.

Wyoming Pocket Gopher – Chain Lakes WHMA provides large continuous areas of habitat suitable for Wyoming pocket gopher, in addition to many more hectares of habitat in less continuous configurations (Figure 13). We conducted mound surveys for pocket gophers from 24 April – 14 June, and detected mounds at 15 of 21 sites, a naïve occupancy rate of 71% in more contiguous Wyoming pocket gopher habitat (Figure 13). From 6 – 17 August, we live-trapped for pocket gophers at 28 mound complexes at 4 sites for a total of 97 trap nights (Figure 13). We captured 6 northern pocket gophers (6% capture rate), but no Wyoming pocket gophers. Although we were unsuccessful in documenting the Wyoming pocket gopher, a study by University of Wyoming graduate student B. Britto was conducted concomitantly with our efforts, which documented Wyoming pocket gopher within ~8 km of the WHMA in very similar habitat (B. Britto, personal communication). Furthermore, the same study has documented Wyoming pocket gopher in close proximity to northern pocket gopher, so the presence of northern pocket gopher within the WHMA does not preclude the presence of Wyoming pocket gopher. Therefore, we find it highly probable that the WHMA provides habitat for Wyoming's only endemic mammal, the Wyoming pocket gopher.

Pygmy Rabbit – The pygmy rabbit is a sagebrush obligate with much of its available wintering habitat (taller, denser patches of big sagebrush) concentrated in the southern $^1/_3$ of the WHMA (Figure 14). We surveyed 10 grids in wintering habitat between 5 – 12 April, and detected evidence of pygmy rabbits at 4 grids (Figure 14). When adjusted for the probability of detecting pygmy rabbit scat or individuals (p = 0.86, SE = 0.14), we assessed a 0.41 probability of occupancy throughout available habitat (SE = 0.16). Accordingly, we estimate that of the 5,616 ha of potentially suitable wintering habitat, 2,303 ha were occupied by pygmy rabbit in the last 3 years.

Swift Fox – We detected SGCN swift fox at 2 of 7 remote camera sites and in 5 additional incidental observations (Figure 15). All detections were in the northern portion of the WHMA in salt desert or dwarf sagebrush shrublands; however, given the swift fox's known habitat associations, the entirety of the WHMA represents potential suitable habitat for this species.

Conservation Value – Two surveys, those targeting the breeding landbird and small mammal communities, had effort distributed equally across the 3 primary habitat types, which allows for a comparison of use across habitats. Both of these survey efforts documented the highest use in wetlands ($n_{landbird}$ = 183; n_{mammal} = 28), with similar values in sagebrush steppe ($n_{landbird}$ = 154; n_{mammal} = 10) and salt desert shrubland ($n_{landbird}$ = 154; n_{mammal} = 8). Across all detections, including incidental observations, species richness varied by habitat type (Figure 27), with 89% of species (n = 132) occurring in wetlands, 53% in sagebrush steppe (n = 79), 52% in greasewood-dominated shrublands (n = 77), 51% in salt desert shrubland (n = 76), and 16% in rock outcrops (n = 23). Trends in species richness were similar among observed habitat associations and habitat associations documented in the literature (Figure 27). Species composition provides additional information regarding the differences among the species that make up richness counts. There was high variation in species composition among habitats (Table 6). Of the habitat types, wetlands hosted the highest number of habitat specialists, with

59 species that were not observed or predicted to occur in any other habitat type. Chain Lakes WHMA has a few areas of rock outcroppings in the southern half of the property. Although rock outcroppings represent a small proportion of total land cover and had relatively low species richness within the WHMA, this wildlife community was the most distinct, with ≥70% difference in species composition from all other habitat types (Table 6). The shrubland habitats (salt desert, sagebrush steppe, and greasewood) were most similar to one another with ≥80% overlap of species (Table 6). Across all detections, including incidental observations, the count of SGCN (richness) was also highest in wetlands, with 32 of the 38 SGCN detected in wetlands, 17 SGCN in salt desert shrublands, and 15 SGCN in sagebrush steppe.

Within wetlands, surveys targeting migrating waterbirds and calling amphibians allow us to assess rates of use for these taxa within wetlands (Figure 17 and 9). In 2018, use was highest at wetlands with larger areas of open water, which were distributed across the east-west corridor of wetland habitat within the WHMA. Similarly, Short-eared Owl observations, detections of SGCN bats, and suitable habitat for secretive marsh birds were all limited to wetland habitats with longer periods of inundation in 2018. Given the apparent ground-water connectivity of the wetlands, the areas with larger amounts of water are highly changeable within and across years (M. Pollack and G. Hiatt, personal communication), and we recommend the entirety of the wetland habitat be considered as having potential for high use.

DISCUSSION

Chain Lakes WHMA is characterized by a mosaic of land cover types and provides valuable habitat for a diverse array of wildlife. The wetlands of Chain Lakes are rare in the arid expanse of the Great Divide Basin and make up the WHMA's most unique feature. In 2018, the dominant habitats (salt desert shrubland, sagebrush steppe, and wetlands) all supported SGCN, and 71% of these high conservation priority species used multiple habitats. These numbers suggest high connectivity among habitats and imply that the conservation of a single habitat within the WHMA would be insufficient to maintain the current wildlife diversity. As such, the entirety of Chain Lakes WHMA is a high priority for conservation.

Among the dominant habitat types, wetlands received the highest use by wildlife, supported the highest species richness, and comprised the highest richness of SGCN. Additionally, wetlands supported the most unique community composition. Of the 149 species of birds, mammals, reptiles, and amphibians documented within the WHMA, 89% (n = 133) were associated with wetlands, including 32 of the 38 detected SGCN. Furthermore, the highest numbers of habitat specialists were found in wetlands, with 39% of all species and 58% of SGCN detected solely in wetlands. Moreover, prior wetland surveys documented a rare plant community with 16 species of conservation priority (Heidel 2008 and Washkoviak et al. 2018). The combination of high quality water, an intact landscape with few invasive species, and little human activity has created an oasis for wildlife within the Chain Lakes WHMA. Given the limited nature of available water in the Red Desert, the high quality and fragility of the wetlands, and the high use by many species, we find the wetlands to be the highest priority habitat for conservation within the WHMA.

The wetland-associated wildlife community exhibit varying needs, but many species are directly or indirectly sensitive to water quality. Amphibians in particular exhibit a high sensitivity to pollutants in water (Egea-Serrano et al. 2012). Additionally, all 3 of the bat species and many of the bird species detected are insectivorous during all or parts of their life cycle. Degradation of water quality within Chain Lakes WHMA could alter the structure of the insect community, which can also act as a reservoir for toxicants and facilitate bioaccumulation of toxicants in food webs (Van Gestel and Van Straalen 1994, Lindqvist and Block 1997, Faulkner and Lochmiller 2000).

In addition to water quality, wetland size, depth, and vegetation structure is also important to wetland-associated wildlife. During migration, shorebirds use wetlands with suitable foraging conditions consisting of shallow water, mudflats, and sparse to moderate vegetation cover (Weber and Haig 1996, Davis and Smith 1998, Webb et al. 2010), while geese and diving ducks are more likely to be present in larger wetlands, and dabbling ducks are most abundant in larger wetlands with moderate vegetation cover. Breeding marsh birds need dense emergent vegetation for cover and nest substrates. Many upland birds and mammals make daily or seasonal movements to wetter habitats with more vegetation or higher numbers of insects for drinking and foraging, and their numbers contribute to the biodiversity we documented in the wetlands.

Although the bodies of water at Chain Lakes WHMA are modest in size (<22 ha, Geospatial Services Saint Mary's University of Minnesota 2017) and, in 2018, had relatively limited patches of dense emergent aquatic vegetation, the wetlands of Chain Lakes span a large area (~2,300 ha) that provides a mosaic of conditions that meet the needs of many species. This mosaic of conditions is prevalent throughout Chain Lakes WHMA, and there are few clear delineations between habitat types. Many species were detected in and supported by >1 habitat type. Therefore, in order to conserve biodiversity and wetland function within the WHMA, a watershed perspective must be adopted with adequate buffers that include upland habitats and a variety of wetland conditions in order to conserve biodiversity and wetland function. As stated in the Department's "*Wings in the Wetlands*":

> "Good wetland management also includes good upland management because wetlands are part of a system that includes the uplands… Wetlands are interconnected with other wetlands throughout the water system, so manipulation of one wetland influences others in the watershed."

Wildlife exhibit context-dependent responses to human disturbance, based on factors including time of year, time of day, size of waterbody, visibility due to surrounding vegetation and topography, as well as habituation to baseline levels of human activity. The bodies of permanent open water on Chain Lakes ranged in size from 0.06 to 22 ha (Geospatial Services Saint Mary's University of Minnesota 2017). These wetlands experience little human activity, particularly during the spring migration, when frequent precipitation and high winds discourage recreational use. Given the small size of the waterbodies and the relative lack of human activity, the birds and other wildlife using these features may be particularly sensitive to human activity within close proximity.

The greatest immediate threat to Chain Lakes WHMA is posed by escalating natural gas development, and the potential for a significant negative impact by industrial development within Chain Lakes WHMA is high given the rarity, fragility, and untrammeled quality of the wetlands and the scarcity of such a resource within the surrounding landscape. Overall, Chain Lakes WHMA provides a rare and unique combination of habitats that supports a diverse array of wildlife, and the wetlands in particular provide a highly valuable resource for migrants, local breeders, and residents. The combination of high quality water, an intact landscape with few invasive species, and little human activity creates an oasis for wildlife within the greater surrounds of the Red Desert.

We note the following for informing the timing of future survey efforts. Based on our compiled detections of passage migrants, surveys should begin earlier and end later to capture the full duration of migration at Chain Lakes WHMA (Figure 16). Also, we observed higher levels of prairie dog activity earlier in the season, and suggest colony mapping efforts at Chain Lakes WHMA take place earlier in the summer to maximize the observers' ability to detect active mounds.

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Table 1. All wildlife species detected through formal surveys, remote trail cameras, and incidental observations on Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 April to 11 September 2018. Species are shown with their Species of Greatest Conservation Need (SGCN) tier designation (WGFD 2017). Species designated as Sensitive by the Bureau of Land Management are noted in bold font (BLM 2010). We report the habitat type(s) in which species were detected in the field. For reference, we also note SGCN that were previously documented or predicted to occur within the WHMA (records retrieved from the Department's Wildlife Observation System and Keinath et al. 2010), but were not detected during the survey conducted in 2018. Feral horses and domestic sheep were also present in all habitat types.

Detected taxa	Common name	Scientific name	SGCN tier	Status R|B|M|U*	Habitat (W|D|S|G|R|M|U)†
Birds	American Avocet	*Recurvirostra americana*		B,M	W
	American Bittern	*Botaurus lentiginosus*	II	U	W
	American Coot	*Fulica americana*		M	W
	American Goldfinch	*Spinus tristis*		M,U	W,D,G
	American Kestrel	*Falco sparverius*	III	U	W
	American Pipit	*Anthus rubescens*	III	M	W
	American White Pelican	*Pelecanus erythrorhynchos*	II	M	W
	American Wigeon	*Mareca americana*		M,U	W
	Ash-throated Flycatcher	*Myiarchus cinerascens*	II	M	S
	Baird's Sandpiper	*Calidris bairdii*		M	W
	Bank Swallow	*Riparia riparia*		U	W
	Barn Swallow	*Hirundo rustica*		U	W
	Black-bellied Plover	*Pluvialis squatarola*		M	W
	Black-crowned Night-Heron	*Nycticorax nycticorax*	II	M	W
	Black-necked Stilt	*Himantopus mexicanus*		M,U	W
	Blue-winged Teal	*Spatula discors*		M,U	W
	Brewer's Blackbird	*Euphagus cyanocephalus*		U	W
	Brewer's Sparrow	***Spizella breweri***	**II**	**B,M**	**W,D,S,G**
	Broad-tailed Hummingbird	*Selasphorus platycercus*		M	U
	Brown-headed Cowbird	*Molothrus ater*		B,M	W,S
	Bufflehead	*Bucephala albeola*		U	W

Table 1. Continued.

Detected taxa	Common name	Scientific name	SGCN tier	Status R|B|M|U*	Habitat (W|D|S|G|R|M|U)†
Birds	Bullock's Oriole	*Icterus bullockii*		M	W,D,G
	Burrowing Owl	***Athene cunicularia***	**I**	**B**	**W,D,S,G**
	California Gull	*Larus californicus*		M,U	W
	Canada Goose	*Branta canadensis*		B,M	W
	Chipping Sparrow	*Spizella passerina*		M,U	D,S,G
	Cinnamon Teal	*Spatula cyanoptera*		U	W
	Clay-colored Sparrow	*Spizella pallida*		M	S
	Cliff Swallow	*Petrochelidon pyrrhonota*		U	W,D
	Common Nighthawk	***Chordeiles minor***	**III**	**B,M**	**W,S**
	Common Poorwill	*Phalaenoptilus nuttallii*		B	S
	Common Raven	*Corvus corax*		R,B	W,D,S,G,R,M
	Common Yellowthroat	***Geothlypis trichas***	**III**	**U**	**W**
	Cooper's Hawk	*Accipiter cooperii*		U	W
	Dark-eyed Junco	*Junco hyemalis*		M	W
	Dusky Flycatcher	*Empidonax oberholseri*		M	D,S,G
	Eared Grebe	*Podiceps nigricollis*		M,U	W
	Eastern Kingbird	*Tyrannus tyrannus*		M	W
	Eurasian Collared-Dove	*Streptopelia decaocto*		U	D,G
	Ferruginous Hawk	***Buteo regalis***	**II**	**B**	**W,D,S,G,R**
	Franklin's Gull	*Leucophaeus pipixcan*	II	M,U	W
	Gadwall	*Mareca strepera*		M,U	W
	Golden Eagle	*Aquila chrysaetos*	II	U	W,D,S,G
	Great Blue Heron	*Ardea herodias*	II	M	W
	Great Horned Owl	*Bubo virginianus*		B	S,M
	Greater Sage-Grouse	***Centrocercus urophasianus***	**II**	**R,B**	**W,D,S,G**
	Greater Yellowlegs	*Tringa melanoleuca*		M	W
	Green-tailed Towhee	*Pipilo chlorurus*		M	W

Table 1. Continued.

Detected taxa	Common name	Scientific name	SGCN tier	Status R|B|M|U*	Habitat (W|D|S|G|R|M|U)†
	Green-winged Teal	*Anas crecca*		B,M	W
	Hooded Merganser	*Lophodytes cucullatus*		M	W
	Horned Lark	*Eremophila alpestris*		B	W,D,S,G
	Killdeer	*Charadrius vociferus*		B	W,D,S
	Lark Bunting	*Calamospiza melanocorys*		B	W,D,S,G
	Lark Sparrow	*Chondestes grammacus*		M,U	W,D,S,G
	Least Sandpiper	*Calidris minutilla*		M	W
	Lesser Yellowlegs	*Tringa flavipes*		M	W
	Lincoln's Sparrow	*Melospiza lincolnii*		M	W
	Loggerhead Shrike	***Lanius ludovicianus***	**II**	**B**	**W,D,S,G**
	Long-billed Curlew	***Numenius americanus***	**II**	**U**	**W,D,G**
	Long-billed Dowitcher	*Limnodromus scolopaceus*		M	W
	MacGillivray's Warbler	*Geothlypis tolmiei*	II	M	W,D,S,G
	Mallard	*Anas platyrhynchos*		U	W
	Marbled Godwit	*Limosa fedoa*		M	W
	Marsh Wren	*Cistothorus palustris*		B	W
	Mountain Bluebird	*Sialia currucoides*		M	W
	Mountain Plover	***Charadrius montanus***	**I**	**B**	**D,S**
	Mourning Dove	*Zenaida macroura*		B	W,D,S,G
	Northern Harrier	*Circus hudsonius*		B	W,D,S
	Northern Pintail	*Anas acuta*		M,U	W
	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*		U	W
	Northern Shoveler	*Spatula clypeata*		M,U	W
	Orange-crowned Warbler	*Oreothlypis celata*		M	W,D,S,G,R
	Osprey	*Pandion haliaetus*		M,U	W
	Peregrine Falcon	***Falco peregrinus***	**II**	**U**	**W**

Table 1. Continued.

Detected taxa	Common name	Scientific name	SGCN tier	Status R|B|M|U*	Habitat (W|D|S|G|R|M|U)†
	Pied-billed Grebe	*Podilymbus podiceps*		U	W
	Pine Siskin	*Spinus pinus*		M	D,G
	Prairie Falcon	*Falco mexicanus*		U	W,S,R
	Redhead	*Aythya americana*		M,U	W
	Red-necked Phalarope	*Phalaropus lobatus*		M	W
	Red-winged Blackbird	*Agelaius phoeniceus*		B	W
	Ring-billed Gull	*Larus delawarensis*		M	W
	Ring-necked Duck	*Aythya collaris*		U	W
	Rock Wren	*Salpinctes obsoletus*		B	R
	Ruddy Duck	*Oxyura jamaicensis*		U	W
	Rough-legged Hawk	*Buteo lagopus*		M	S
	Rufous Hummingbird	*Selasphorus rufus*	II	M	W
	Sage Thrasher	***Oreoscoptes montanus***	**II**	**B**	**W,D,S,G**
	Sagebrush Sparrow	***Artemisiospiza nevadensis***	**II**	**B**	**W,D,S,G**
	Sandhill Crane	*Antigone canadensis*		M	W
	Savannah Sparrow	*Passerculus sandwichensis*		B	W
	Say's Phoebe	*Sayornis saya*		M,U	D,G
	Scaup spp.	*Aythya spp.*		U	W
	Semipalmated Sandpiper	*Calidris pusilla*		M	W
	Short-eared Owl	*Asio flammeus*	II	U	W
	Snow Goose	*Anser caerulescens*		M	W
	Solitary Sandpiper	*Tringa solitaria*		M	W
	Song Sparrow	*Melospiza melodia*		U	W
	Sora	*Porzana carolina*		B	W
	Spotted Sandpiper	*Actitis macularius*		U	W
	Swainson's Hawk	*Buteo swainsoni*	II	U	D,G
	Townsend's Warbler	*Setophaga townsendi*		M	W,D,G

Table 1. Continued.

Detected taxa	Common name	Scientific name	SGCN tier	Status R|B|M|U*	Habitat (W|D|S|G|R|M|U)†
	Tree Swallow	*Tachycineta bicolor*		U	W
	Turkey Vulture	*Cathartes aura*		U	D,G
	Upland Sandpiper	***Bartramia longicauda***	**II**	**U**	**W**
	Vesper Sparrow	*Pooecetes gramineus*		B	W,D,S
	Violet-green Swallow	*Tachycineta thalassina*		U	W,D,G
	Virginia Rail	*Rallus limicola*	III	B	W
	Western Grebe	*Aechmophorus occidentalis*	II	U	W
	Western Kingbird	*Tyrannus verticalis*		M,U	D,G
	Western Meadowlark	*Sturnella neglecta*		B	W,D,S,G
	Western Sandpiper	*Calidris mauri*		M	W
	White-crowned Sparrow	*Zonotrichia leucophrys*		M	W
	White-faced Ibis	***Plegadis chihi***	**II**	**U**	**W**
	White-rumped Sandpiper	*Calidris fuscicollis*		M	W
	Willet	*Tringa semipalmata*		B	W
	Wilson's Phalarope	*Phalaropus tricolor*		B	W
	Wilson's Snipe	*Gallinago delicata*		B	W
	Wilson's Warbler	*Cardellina pusilla*		M	W,D,S,G
	Yellow Warbler	*Setophaga petechia*		M	W
	Yellow-breasted Chat	*Icteria virens*		M	W
	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		M,U	W
	Yellow-rumped Warbler	*Setophaga coronata*		M	W,D,G
Herpetofauna	Boreal chorus frog	*Pseudacris maculata*		R	W
	Greater short-horned lizard	*Phrynosoma hernandesi*	II	R	D,S,G
	Northern sagebrush lizard	*Sceloporus graciosus graciosus*		R	D,S,G,R
	Western tiger salamander	*Ambystoma mavortium*	III	R	W

Table 1. Continued.

<table>
<tr><th>Detected taxa</th><th>Common name</th><th>Scientific name</th><th>SGCN tier</th><th>Status R|B|M|U*</th><th>Habitat (W|D|S|G|R|M|U)†</th></tr>
<tr><td>Mammals</td><td>American badger</td><td>Taxidea taxus</td><td></td><td>R</td><td>D,S,G</td></tr>
<tr><td></td><td>Bushy-tailed woodrat</td><td>Neotoma cinerea</td><td></td><td>R</td><td>R</td></tr>
<tr><td></td><td>Coyote</td><td>Canis latrans</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Least chipmunk</td><td>Tamias minimus</td><td></td><td>R</td><td>W,D,S,G,R</td></tr>
<tr><td></td><td>Little brown myotis</td><td>Myotis lucifugus</td><td>II</td><td>U</td><td>W</td></tr>
<tr><td></td><td>Mule deer</td><td>Odocoileus hemionus</td><td></td><td>R</td><td>W,D,S</td></tr>
<tr><td></td><td>North American deermouse</td><td>Peromyscus maniculatus</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Northern grasshopper mouse</td><td>Onychomys leucogaster</td><td></td><td>R</td><td>W,D,G</td></tr>
<tr><td></td><td>Northern pocket gopher</td><td>Thomomys talpoides</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Olive-backed pocket mouse</td><td>Perognathus fasciatus</td><td>III</td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Ord’s kangaroo rat</td><td>Dipodomys ordii</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Pronghorn</td><td>Antilocapra americana</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Pygmy rabbit</td><td>Brachylagus idahoensis</td><td>II</td><td>R</td><td>S</td></tr>
<tr><td></td><td>Sagebrush vole</td><td>Lemmiscus curtatus</td><td>II</td><td>R</td><td>D,S</td></tr>
<tr><td></td><td>Silver-haired bat</td><td>Lasionycteris noctivagans</td><td></td><td>U</td><td>W</td></tr>
<tr><td></td><td>Swift fox</td><td>Vulpes velox</td><td>II</td><td>R</td><td>D,S,G</td></tr>
<tr><td></td><td>Sylvilagus spp.</td><td>Sylvilagus spp.</td><td></td><td>R</td><td>U</td></tr>
<tr><td></td><td>Thirteen-lined ground squirrel</td><td>Ictidomys tridecemlineatus</td><td></td><td>R</td><td>D,S,G</td></tr>
<tr><td></td><td>Elk</td><td>Cervus canadensis</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>Western small-footed myotis</td><td>Myotis ciliolabrum</td><td>II</td><td>U</td><td>W</td></tr>
<tr><td></td><td>White-tailed jackrabbit</td><td>Lepus townsendii</td><td></td><td>R</td><td>W,D,S,G</td></tr>
<tr><td></td><td>White-tailed prairie dog</td><td>Cynomys leucurus</td><td>II</td><td>R</td><td>D</td></tr>
<tr><td></td><td>Wyoming ground squirrel</td><td>Urocitellus elegans</td><td></td><td>R</td><td>D,S,G</td></tr>
</table>

Table 1. Continued.

Previously documented taxa	Common name	Scientific name	SGCN tier
Birds	Snowy Plover	*Charadrius nivosus*	III
Herpetofauna	**Great Basin spadefoot**	***Spea intermontana***	**II**
Predicted taxa	**Common Name**	**Scientific name**	**SGCN tier**
Birds	**Bald Eagle**	***Haliaeetus leucocephalus***	**II**
	Black Tern	*Chlidonias niger*	II
	Black-throated Gray Warbler	*Setophaga nigrescens*	II
	Canyon Wren	*Catherpes mexicanus*	III
	Clark's Nutcracker	*Nucifraga columbiana*	II
	Forster's Tern	*Sterna forsteri*	II
	Willow Flycatcher	*Empidonax traillii*	III
Herpetofauna	**Northern leopard frog**	***Lithobates pipiens***	**II**
	Prairie rattlesnake	*Crotalus viridis*	III
Mammals	**Wyoming pocket gopher**	***Thomomys clusius***	**I**

*Status within Chain Lakes WHMA was defined as resident (R), local breeder (B), passage migrant (M), or unknown (U) based on previous surveys, known habitat associations, time of year, continuous presence throughout the survey period, and/or evidence of reproduction.

†Habitat at time of initial observation, defined by the primary land cover categories of wetland (W), salt desert shrubland (D), sagebrush steppe (S), upland greasewood (G), rock outcrop (R), manmade (M), or unknown (U).

Table 2. LANDFIRE/GAP land cover map units grouped into more general categories based on aerial imagery and ground-truthing for habitat-based sampling on Chain Lakes Wildlife Habitat Management Area in 2018. Full descriptions of LANDFIRE/GAP classes are available online at https://www.landfire.gov/documents/LF-GAPMapUnitDescriptions.pdf.

System code	System name	GAP Existing vegetation type	WGFD grouping
3049	Rocky Mountain Foothill Limber Pine-Juniper Woodland	Limber Pine Woodland	Wetland
3135	Inter-Mountain Basins Semi-Desert Grassland	Grassland	Wetland
3139	Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	Grassland	Wetland
3141	Northwestern Great Plains Mixedgrass Prairie	Mixedgrass Prairie	Wetland
3162	Western Great Plains Floodplain Forest and Woodland	Western Riparian Woodland and Shrubland	Wetland
3164	Rocky Mountain Wetland-Herbaceous	Western Herbaceous Wetland	Wetland
3181	Introduced Upland Vegetation-Annual Grassland	Introduced Annual Grassland	Wetland
3182	Introduced Upland Vegetation-Perennial Grassland and Forbland	Introduced Perennial Grassland and Forbland	Wetland
3252	Rocky Mountain Subalpine/Upper Montane Riparian Shrubland	Western Riparian Woodland and Shrubland	Wetland
3253	Western Great Plains Floodplain Shrubland	Western Riparian Woodland and Shrubland	Wetland
3254	Western Great Plains Floodplain Herbaceous	Western Riparian Woodland and Shrubland	Wetland
3292	Open Water	Open Water	Wetland
3495	Western Great Plains Depressional Wetland Systems	Depressional Wetland	Wetland
3923	Western Cool Temperate Developed Ruderal Shrubland	Developed-Upland Shrubland	Wetland
3001	Inter-Mountain Basins Sparsely Vegetated Systems	Sparse Vegetation	Salt Desert Shrubland
3006	Rocky Mountain Alpine/Montane Sparsely Vegetated Systems	Sparse Vegetation	Salt Desert Shrubland
3066	Inter-Mountain Basins Mat Saltbush Shrubland	Salt Desert Scrub	Salt Desert Shrubland
3153	Inter-Mountain Basins Greasewood Flat	Greasewood Shrubland	Salt Desert Shrubland
3294	Barren	Barren	Salt Desert Shrubland
3072	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	Low Sagebrush Shrubland and Steppe	Sagebrush Steppe

Table 2. Continued.

System code	System name	GAP Existing vegetation type	WGFD grouping
3080	Inter-Mountain Basins Big Sagebrush Shrubland	Big Sagebrush Shrubland and Steppe	Sagebrush Steppe
3086	Rocky Mountain Lower Montane-Foothill Shrubland	Deciduous Shrubland	Sagebrush Steppe
3125	Inter-Mountain Basins Big Sagebrush Steppe	Big Sagebrush Shrubland and Steppe	Sagebrush Steppe
3126	Inter-Mountain Basins Montane Sagebrush Steppe	Big Sagebrush Shrubland and Steppe	Sagebrush Steppe
3127	Inter-Mountain Basins Semi-Desert Shrub-Steppe	Desert Scrub	Sagebrush Steppe
3220	Artemisia tridentata ssp. vaseyana Shrubland Alliance	Big Sagebrush Shrubland and Steppe	Sagebrush Steppe
3183	Introduced Upland Vegetation-Annual and Biennial Forbland	Introduced Annual and Biennial Forbland	Greasewood Flat

Table 3. Wildlife species detected at 7 remote cameras sites in Chain Lakes Wildlife Habitat Management Area between 10 April and 11 July 2018. Species' conservation designations by the Wyoming Bureau of Land Management (BLM) and as Species of Greatest Conservation Need (SGCN) tier by the Wyoming Game and Fish Department are also noted (BLM 2010, WGFD 2017).

Taxa	Common name	Scientific name	BLM sensitive species	SGCN tier
Birds	Brown-headed Cowbird	*Molothrus ater*		
	Burrowing Owl	*Athene cunicularia*	Y	I
	Chipping Sparrow	*Spizella passerina*		
	Common Raven	*Corvus corax*		
	Ferruginous Hawk	*Buteo regalis*	Y	II
	Golden Eagle	*Aquila chrysaetos*		II
	Greater Sage-Grouse	*Centrocercus urophasianus*	Y	II
	Horned Lark	*Eremophila alpestris*		
	Killdeer	*Charadrius vociferus*		
	Lark Bunting	*Calamospiza melanocorys*		
	Lark Sparrow	*Chondestes grammacus*		
	Mourning Dove	*Zenaida macroura*		
	Northern Harrier	*Circus cyaneus*		
	Prairie Falcon	*Falco mexicanus*		
	Red-tailed Hawk	*Buteo jamaicensis*		
	Red-winged blackbird	*Agelaius phoeniceus*		
	Sage Thrasher	*Oreoscoptes montanus*	Y	II
	Savannah Sparrow	*Passerculus sandwichensis*		
	Vesper Sparrow	*Pooecetes gramineus*		
	Western Meadowlark	*Sturnella neglecta*		
Mammals	American badger	*Taxidea taxus*		
	Coyote	*Canis latrans*		
	Least chipmunk	*Tamias minimus*		
	Mule deer	*Odocoileus hemionus*		
	Ord's kangaroo rat	*Dipodomys ordii*		
	Pronghorn	*Antilocapra americana*		
	Swift fox	*Vulpes velox*	Y	II
	Elk	*Cervus canadensis*		
	White-tailed jackrabbit	*Lepus townsendii*		
	White-tailed prairie dog	*Cynomys leucurus*	Y	II
	Wyoming ground squirrel	*Urocitellus elegans*		

Table 4. Remote camera locations, days of deployment, and counts of total species and Species of Greatest Conservation Need (SGCN) of wildlife at supplemental water wells in Chain Lakes Wildlife Habitat Management Area between 10 April and 11 July 2018. Easting and northing data were collected in UTM, NAD83, Zone 13N.

Remote camera	Easting	Northing	Days deployed	Count of SGCN	Count of species
TC01	260146	4652916	92	4	14
TC02	268412	4654321	92	0	9
TC09	263861	4644635	31	2	14
TC11	257682	4649479	80	2	10
TC12	255708	4644429	39	2	12
TC13	263786	4647785	92	3	23
TC14	273941	4654177	92	5	20

Table 5. Locations and counts of avian species, including Species of Greatest Conservation Need (SGCN) detected at wetland sites during spring and fall migration stop-over use surveys in Chain Lakes Wildlife Habitat Management Area between 10 April and 11 September 2018. Easting and northing data were collected in UTM, NAD83, Zone 13N.

Site	Easting	Northing	Total count	Species richness	SGCN richness	Sum of SGCN tier
W102	257513	4650901	2020	48	7	15
W103	266368	4650590	611	32	3	6
W101	254972	4652160	408	20	1	2
W118	263376	4650065	355	27	2	4
W113	259753	4650864	317	12	0	0
W117	256390	4651559	221	15	0	0
W119	266034	4650427	178	16	0	0
W104	260354	4650840	171	9	0	0
W110	269040	4651180	111	17	0	0
W112	267321	4650960	88	13	0	0
W108	263488	4649794	68	19	0	0
W114	259569	4650867	64	18	2	4
W105	261486	4650569	43	10	0	0
W204	256490	4651060	42	2	1	2
W106	262679	4650632	22	4	0	0
W116	255949	4651431	15	6	0	0
W111	270532	4650837	8	3	0	0
W107	263437	4649938	2	1	0	0
W212	271240	4650560	0	0	0	0

Table 6. Estimates of dissimilarity of species composition by habitat type at Chain Lakes Wildlife Habitat Management Area in 2018. Jaccard distances range from 0 – 1, with 0 being no difference in species and 1 being complete difference in species (Jaccard 1908). We defined wetlands as including open water, emergent vegetation, playa, greasewood with playa substrate, and grassy dunes. Salt desert shrublands were dominated by bare ground and saltbush (*Atriplex spp.*). Sagebrush steppe was dominated by sagebrush (*Artemisia spp.*). Greasewood shrublands were dominated by greasewood (*Sarcobatus vermiculatus*), but generally had several sub-dominant shrubs also present, including saltbush, rabbitbrush (*Chrysothamnus* or *Ericameria* spp.), spiny horsebrush (*Tetradymia spinose*), or sagebrush. Greasewood shrublands also received less frequent and shorter duration flooding than greasewood playas, which were grouped with wetlands.

	Wetland	Salt desert shrubland	Sagebrush steppe	Greasewood shrubland
Salt desert shrubland	0.55			
Sagebrush steppe	0.53	0.17		
Greasewood shrubland	0.54	0.11	0.20	
Rock outcrop	0.84	0.71	0.70	0.71

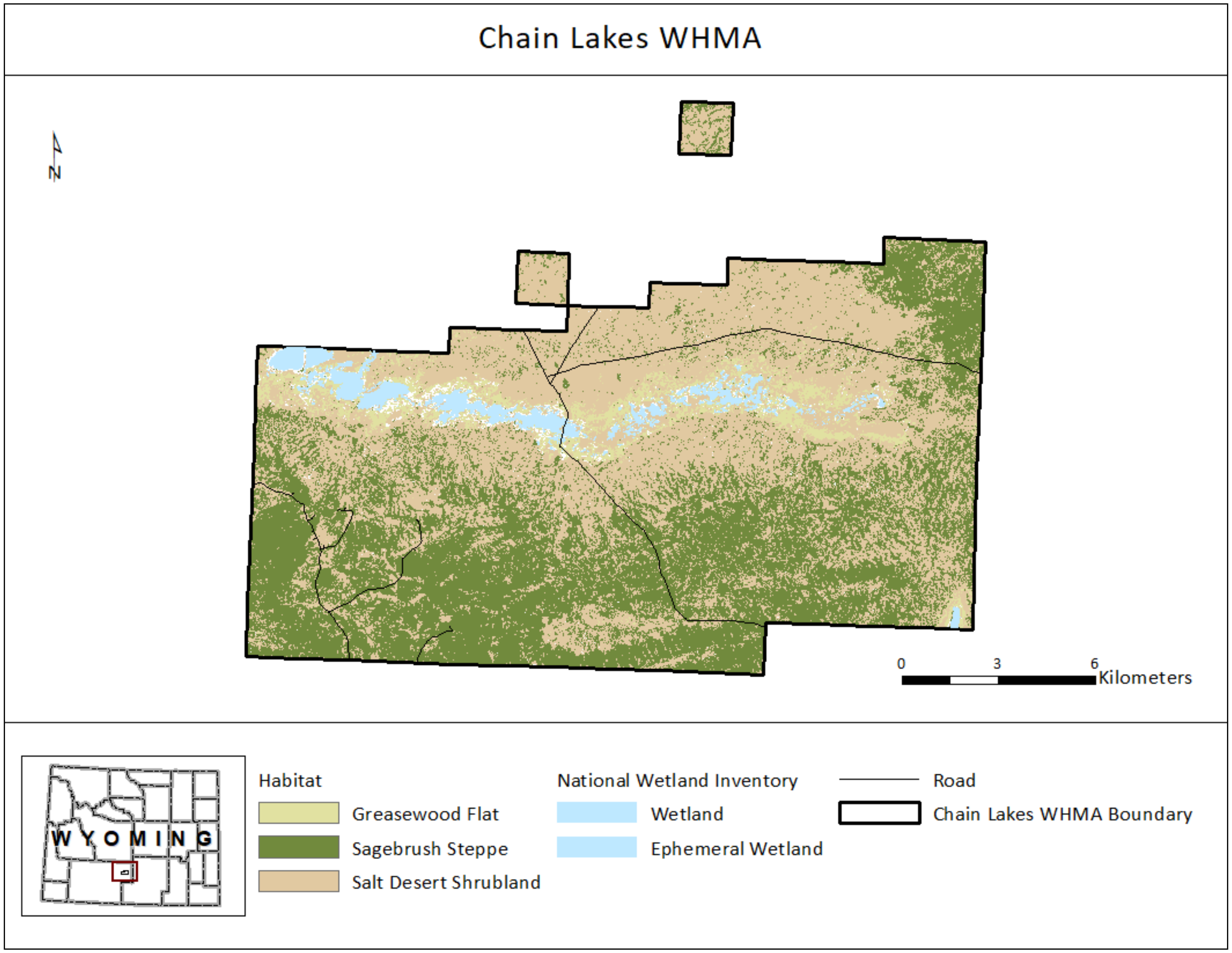

Figure 1. Dominant habitat types at Chain Lakes Wildlife Habitat Management Area (WHMA), based on LANDFIRE data for terrestrial land cover and National Wetland Inventory data for wetland land cover (USGS 2013, Geospatial Services Saint Mary's University of Minnesota 2017).

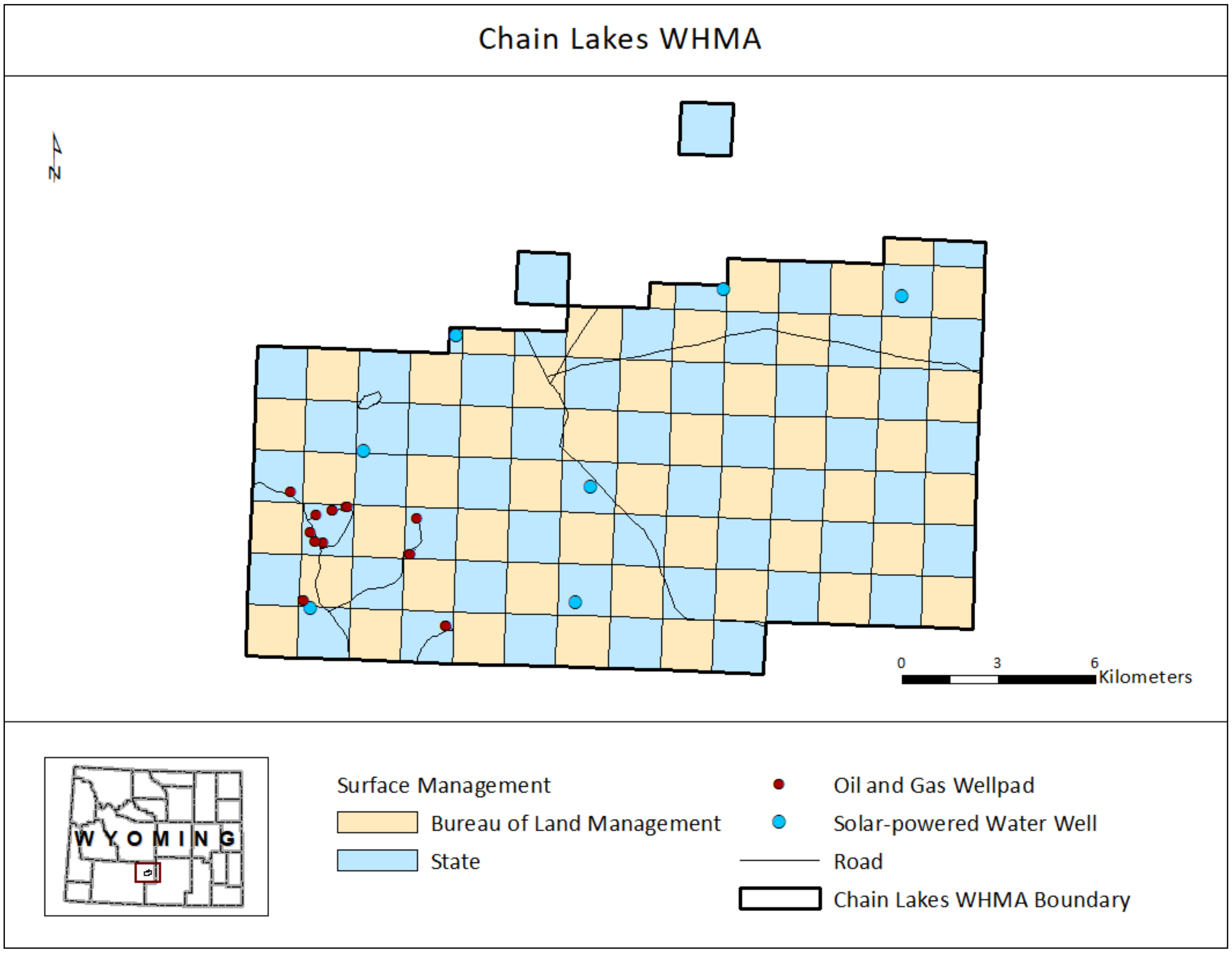

Figure 2. Chain Lakes Wildlife Habitat Management Area (WHMA) surface management, oil and gas well pads, solar-powered water wells, and roads with surface maintenance as of July 2018. Oil and gas well pads are based on aerial imagery from July 2017 (ESRI, Redlands, California) and field observations of well pads in August 2018.

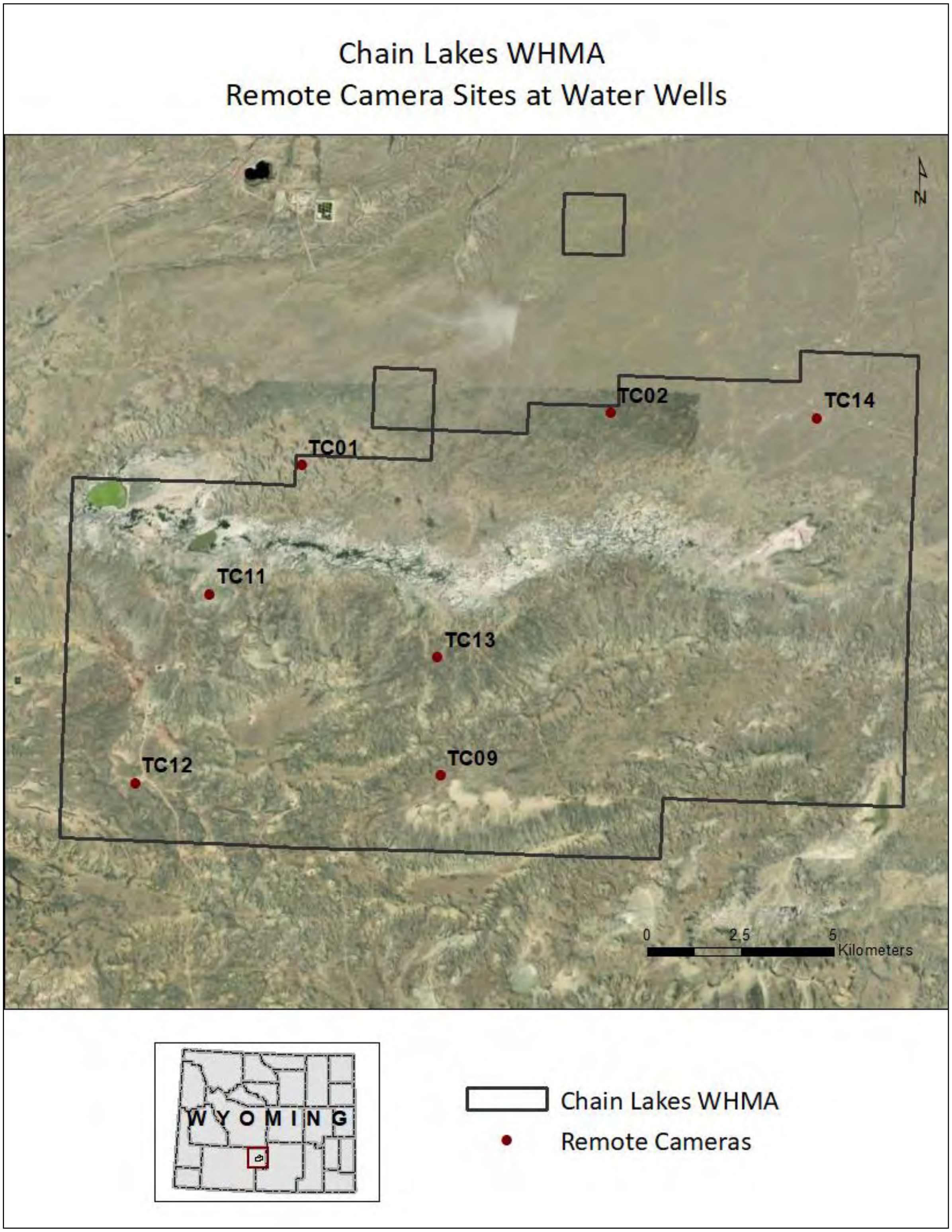

Figure 3. Remote camera sites at solar-powered supplemental water wells within the Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018.

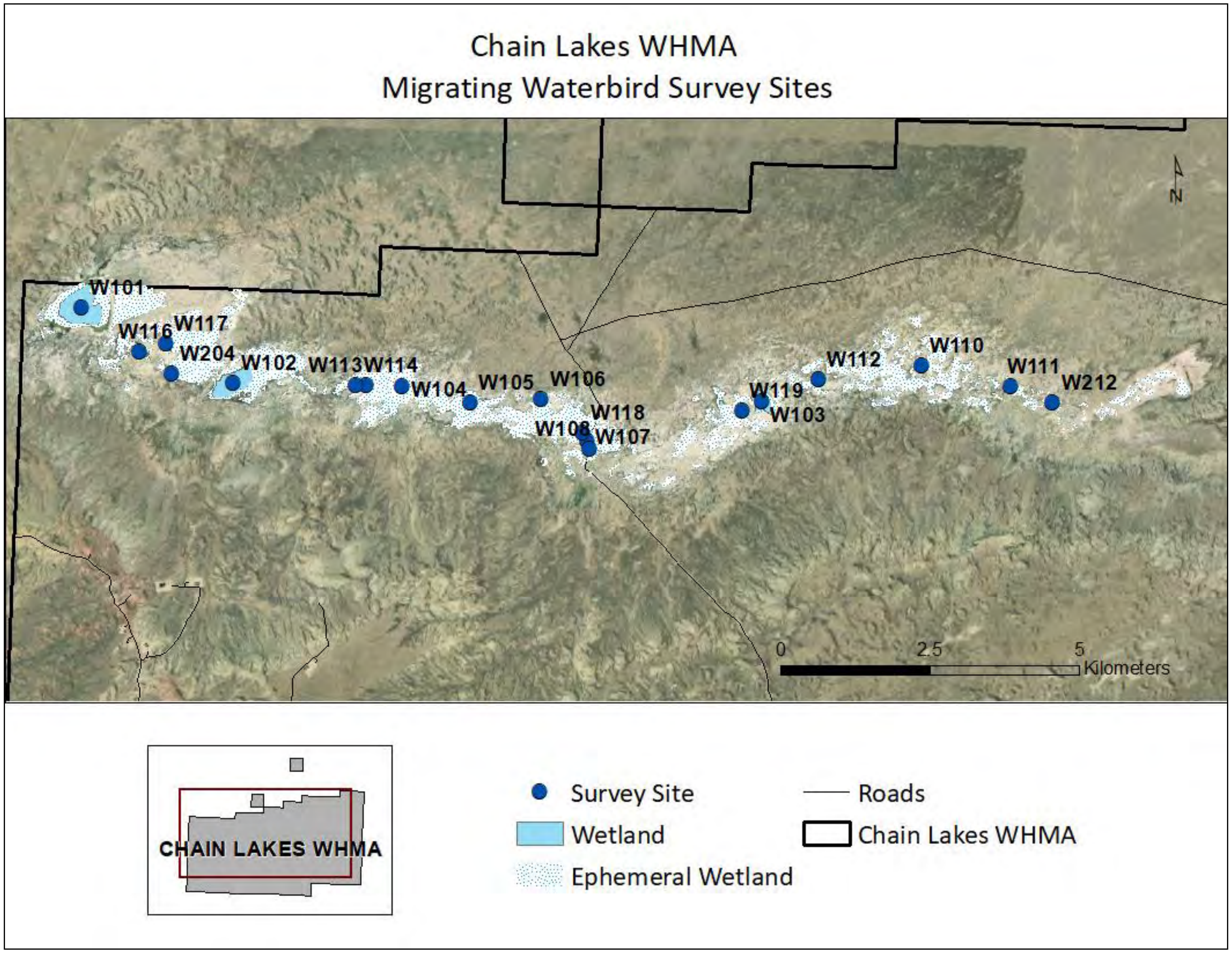

Figure 4. Survey sites ($n = 19$) for migrating waterbirds at Chain Lakes Wildlife Habitat Management Area (WHMA). Sites were added and dropped as water levels changed throughout the course of the surveys. Surveys were conducted weekly from 10 April – 31 May and 30 June – 11 September 2018.

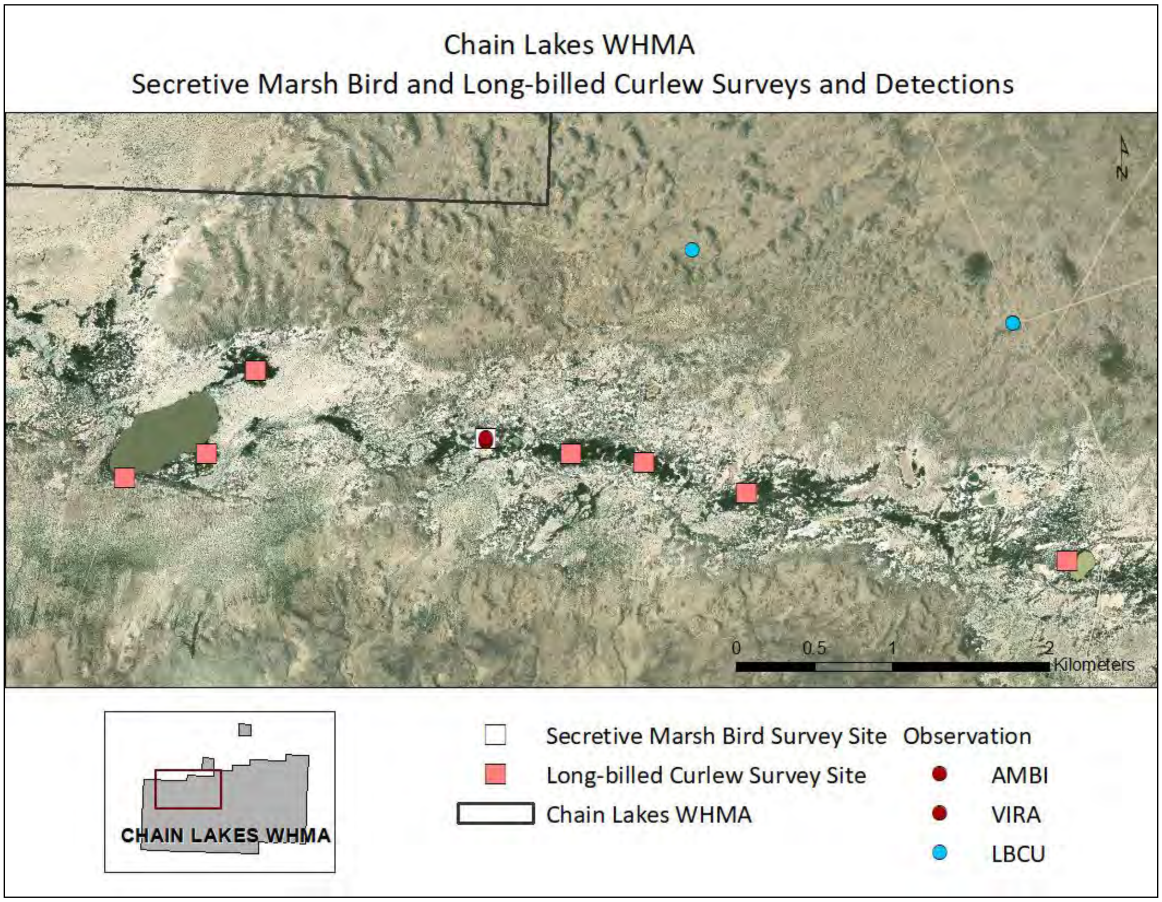

Figure 5. Virginia Rail (VIRA), American Bittern (AMBI), and Long-billed Curlew (LBCU) survey sites and observations from 5 April to 11 September 2018 in Chain Lakes Wildlife Habitat Management Area (WHMA). Observations are shown for both incidental and survey-based detections. American Bittern and Long-billed Curlew were detected through migration stop-over surveys and incidental observation respectively, and, given the timing of these observations, both were suspected to be passage migrants. Virginia Rail was detected during the breeding secretive marsh bird survey and is likely a local breeder.

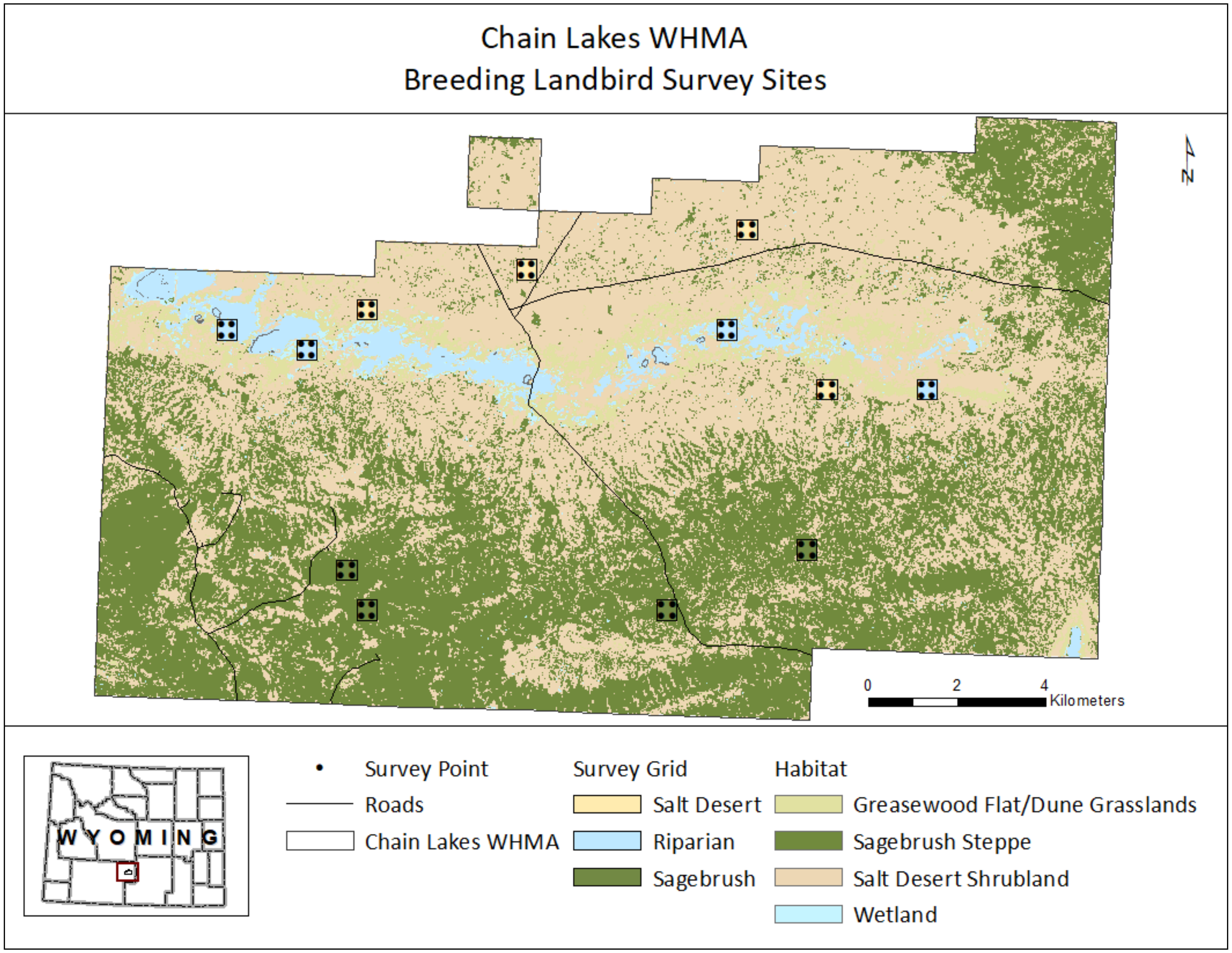

Figure 6. Survey sites for breeding landbird point counts on Chain Lakes Wildlife Habitat Management Area (WHMA) conducted 5 – 22 June 2018.

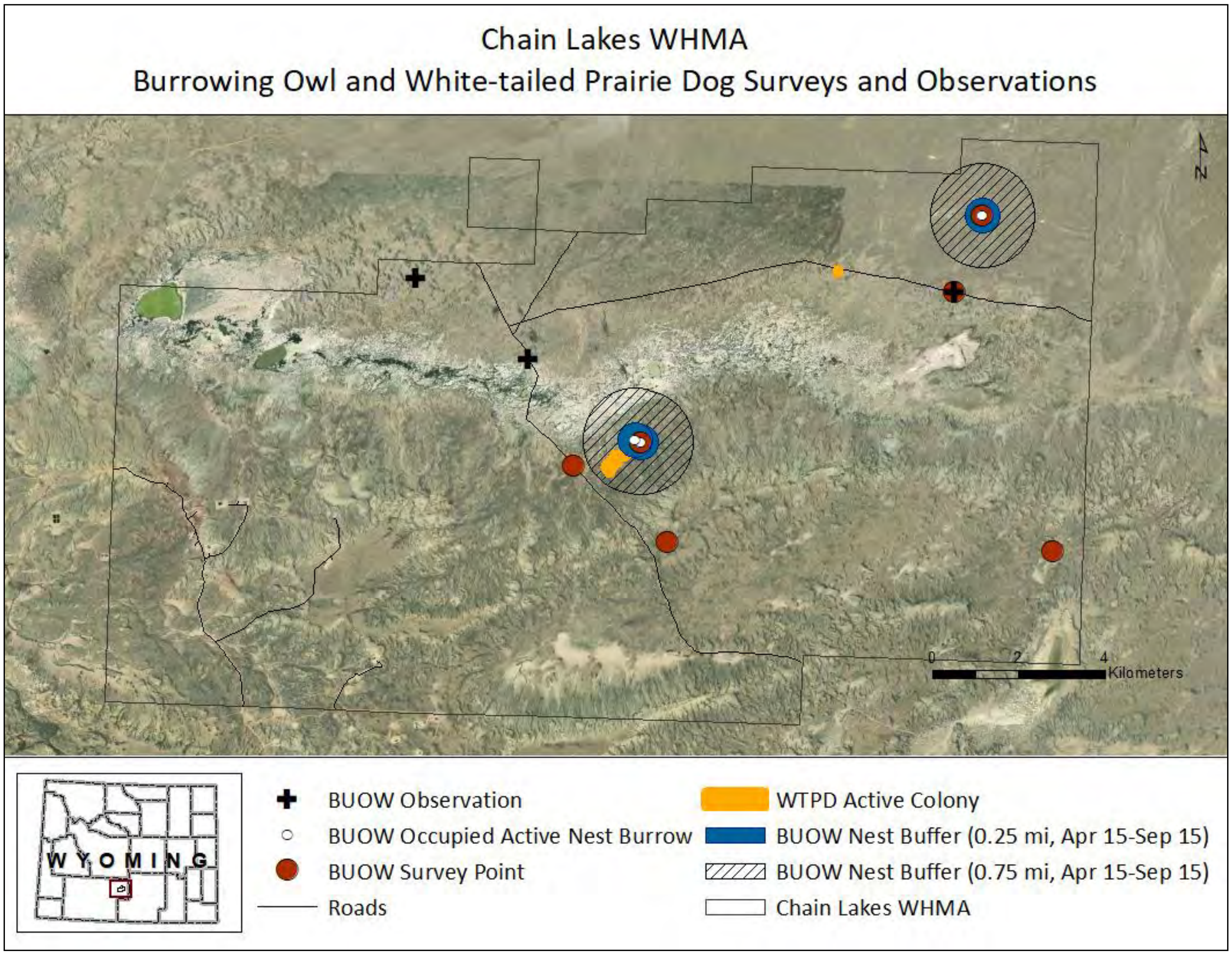

Figure 7. Observations and survey points for Burrowing Owl (BUOW) and active white-tailed prairie dog (WTPD) colonies in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018. Note that we present both actively used entrances for the southern-most nest. Also shown are buffers for surface disturbance or disruptive activities as recommended by the BLM (2010) and USFWS (2018).

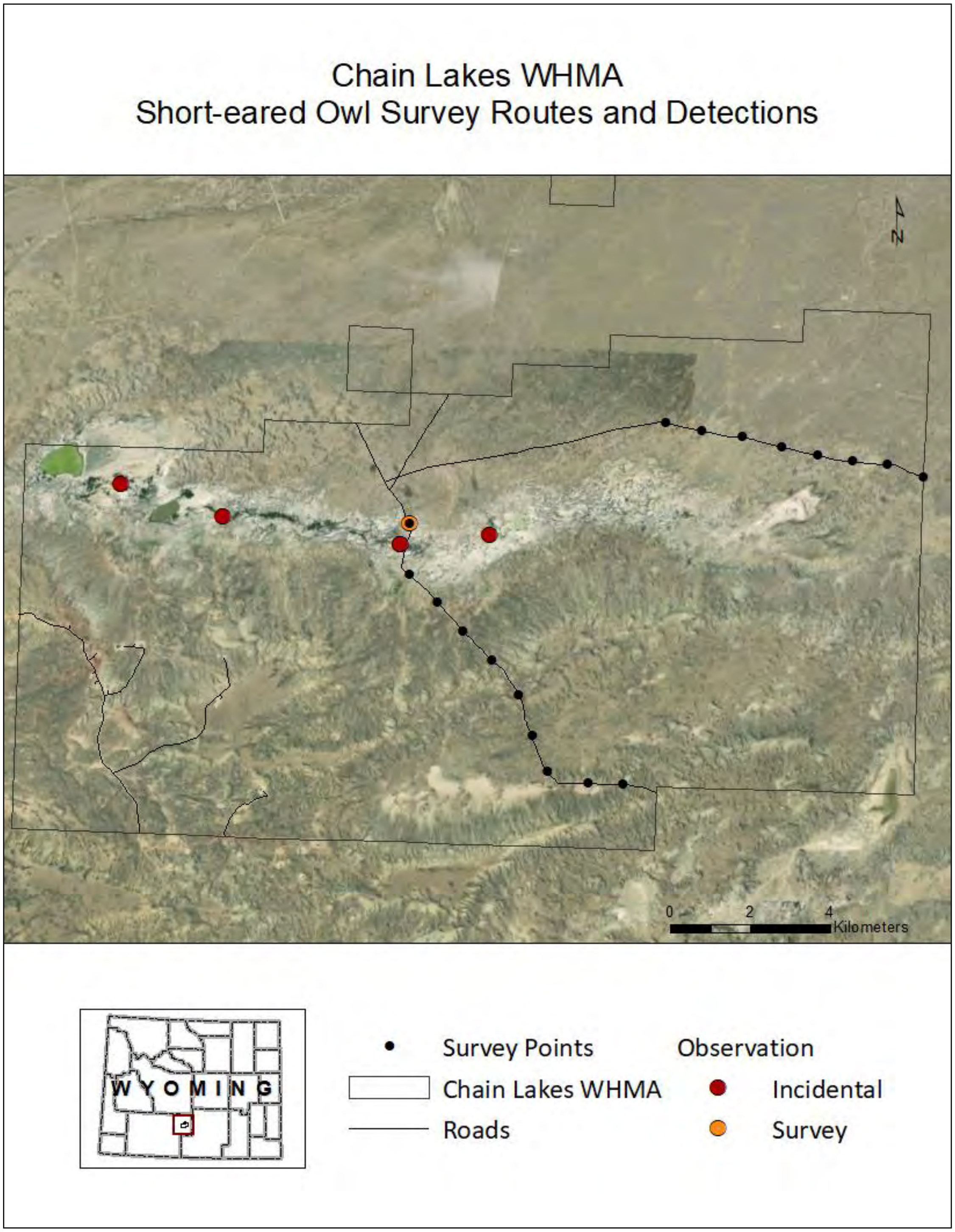

Figure 8. Short-eared Owl point-transect survey routes and observations from 5 April - 11 September 2018 in Chain Lakes Wildlife Habitat Management Area (WHMA). Observations are shown for both incidental and survey-based detections. Short-eared Owl was detected during breeding landbird point count surveys and during a targeted Short-eared Owl point-transect surveys. All detections occurred in wetland-associated habitats.

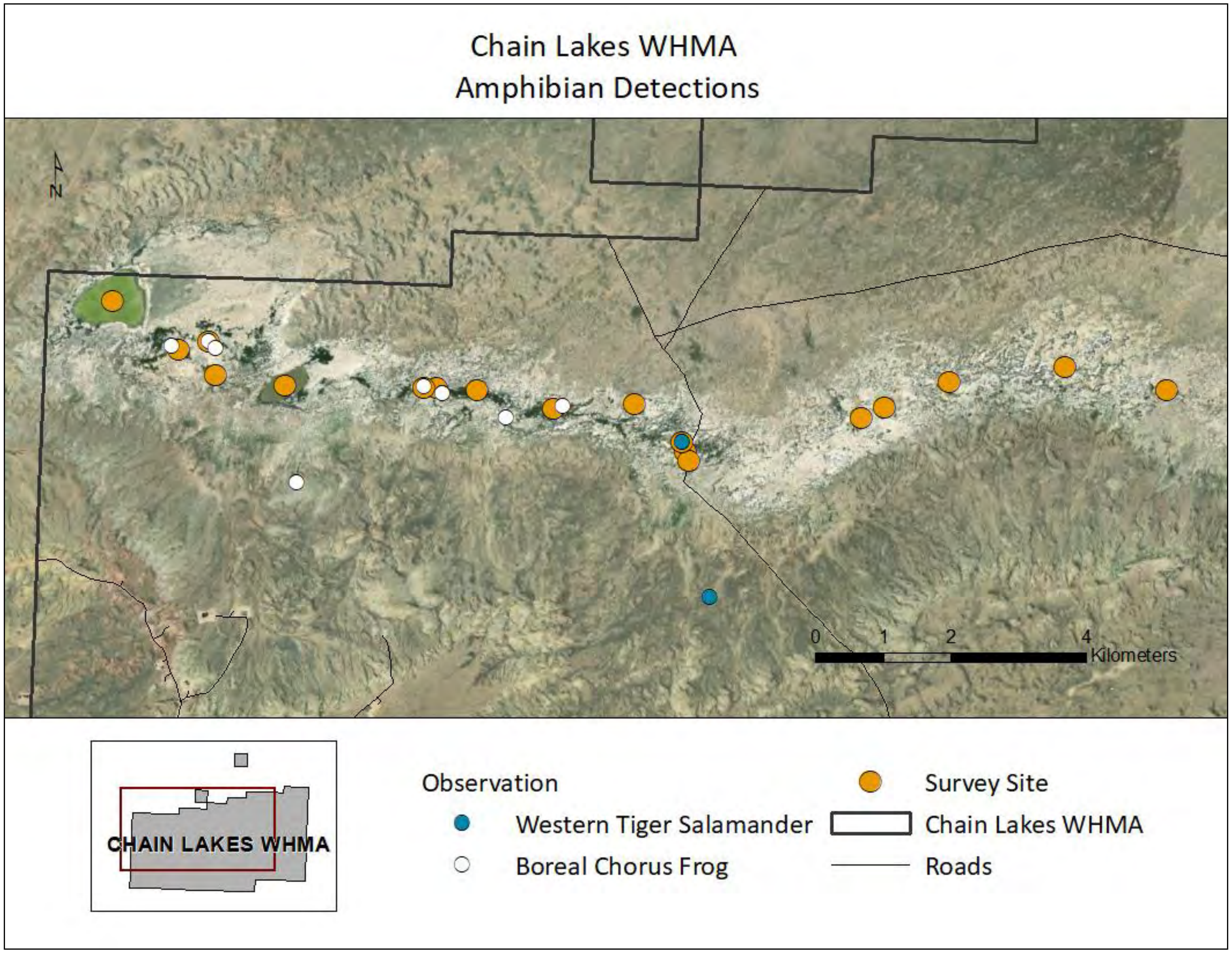

Figure 9. Location of survey sites and detections of amphibians in Chain Lakes Wildlife Habitat Management Area (WHMA) between 5 April - 11 September 2018.

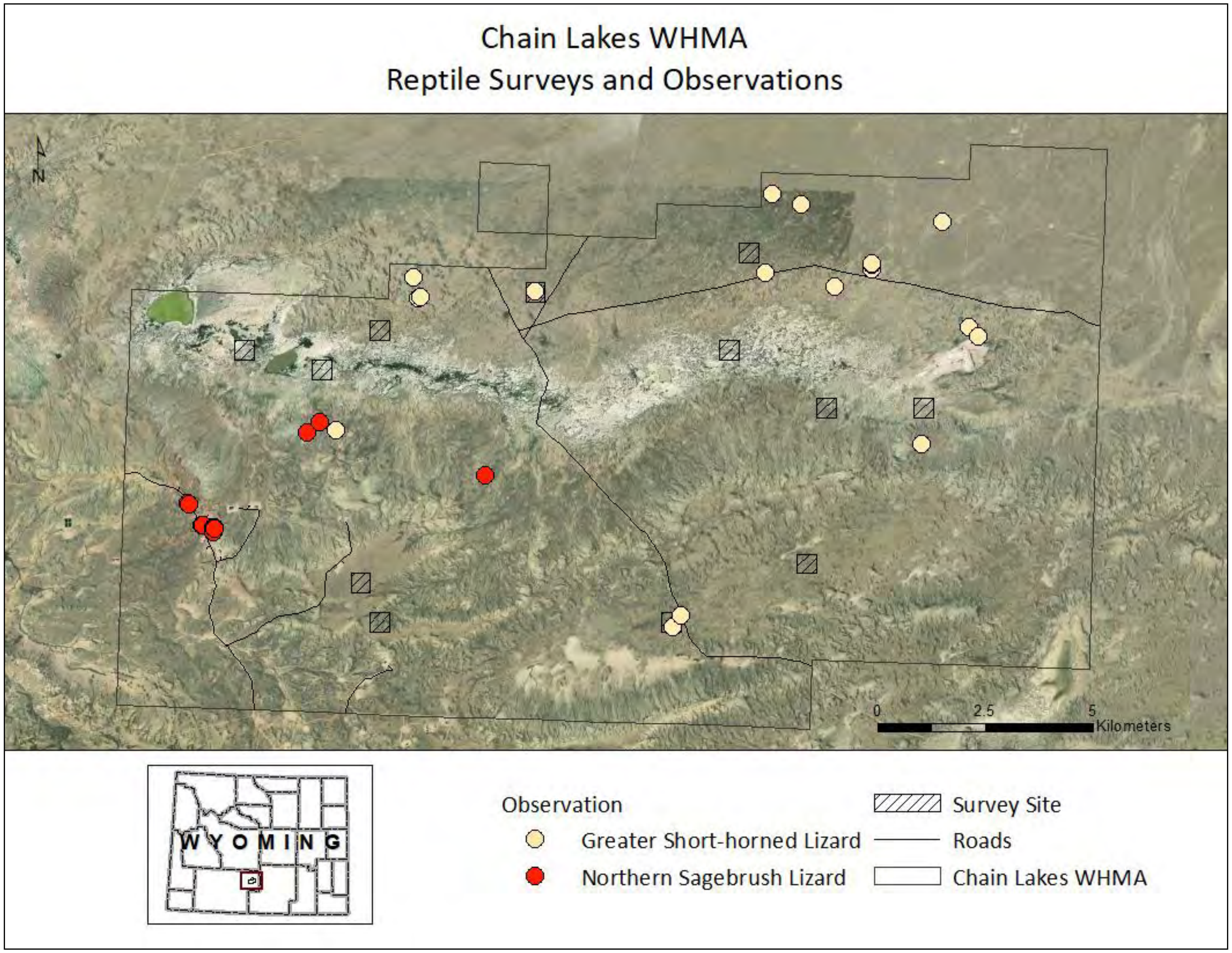

Figure 10. Survey sites and detections of reptiles in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018.

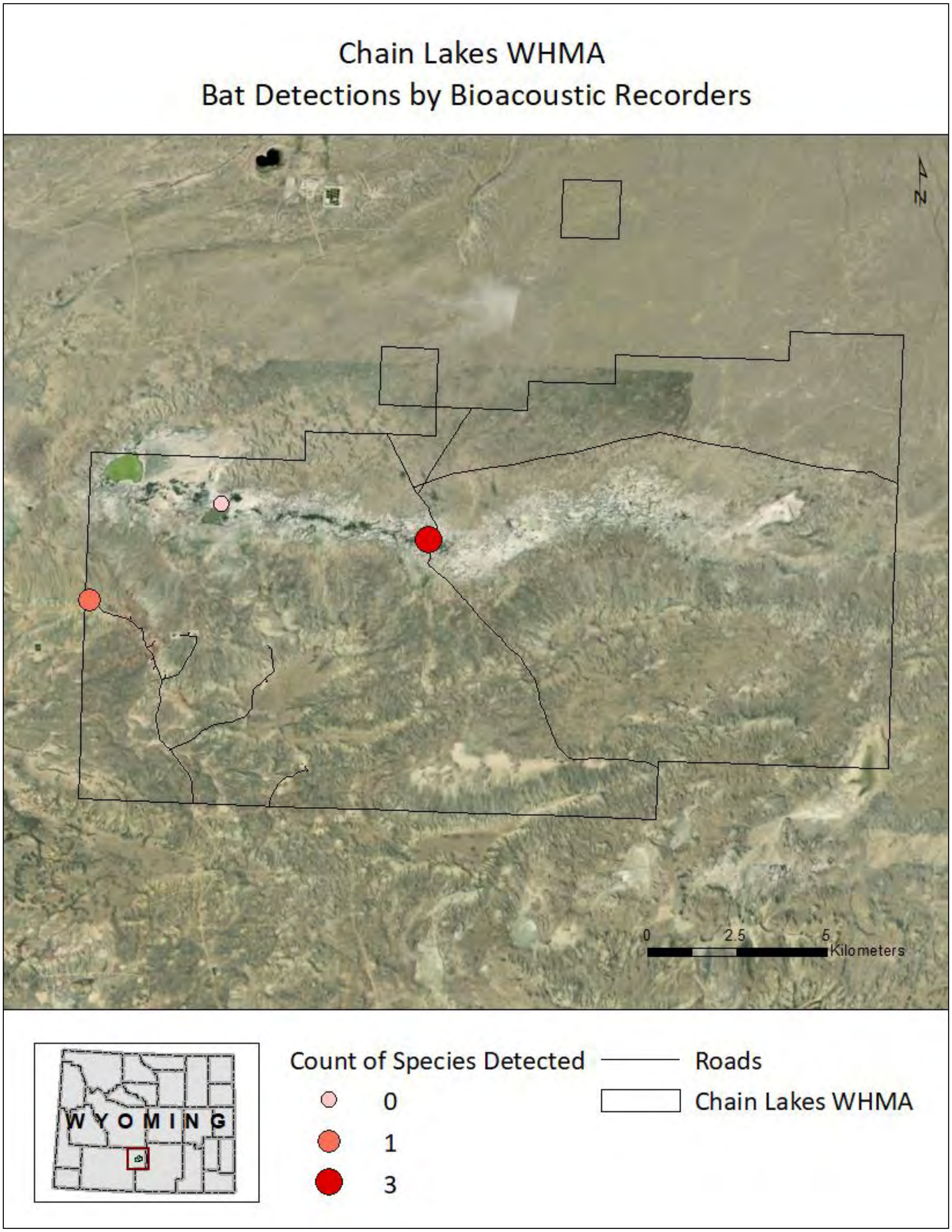

Figure 11. Location of bioacoustic detectors and count of bat species detected 9 May – 7 July 2018 in Chain Lakes Wildlife Habitat Management Area (WHMA).

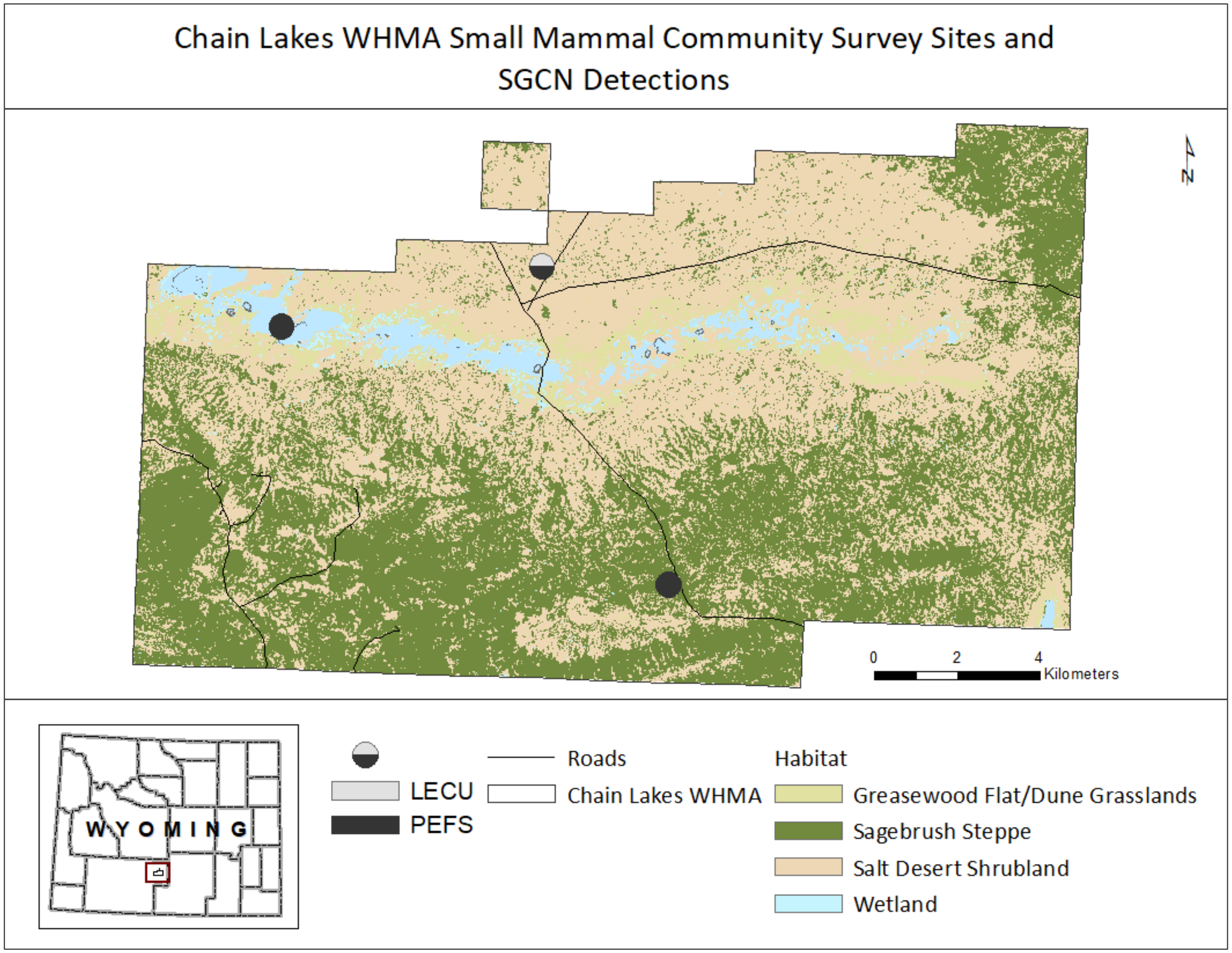

Figure 12. Small mammal community live-trapping survey locations (*n* = 3) and presence of Species of Greatest Conservation Need (SGCN), sagebrush vole (LECU) and olive-backed pocket mouse (PEFS), in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018.

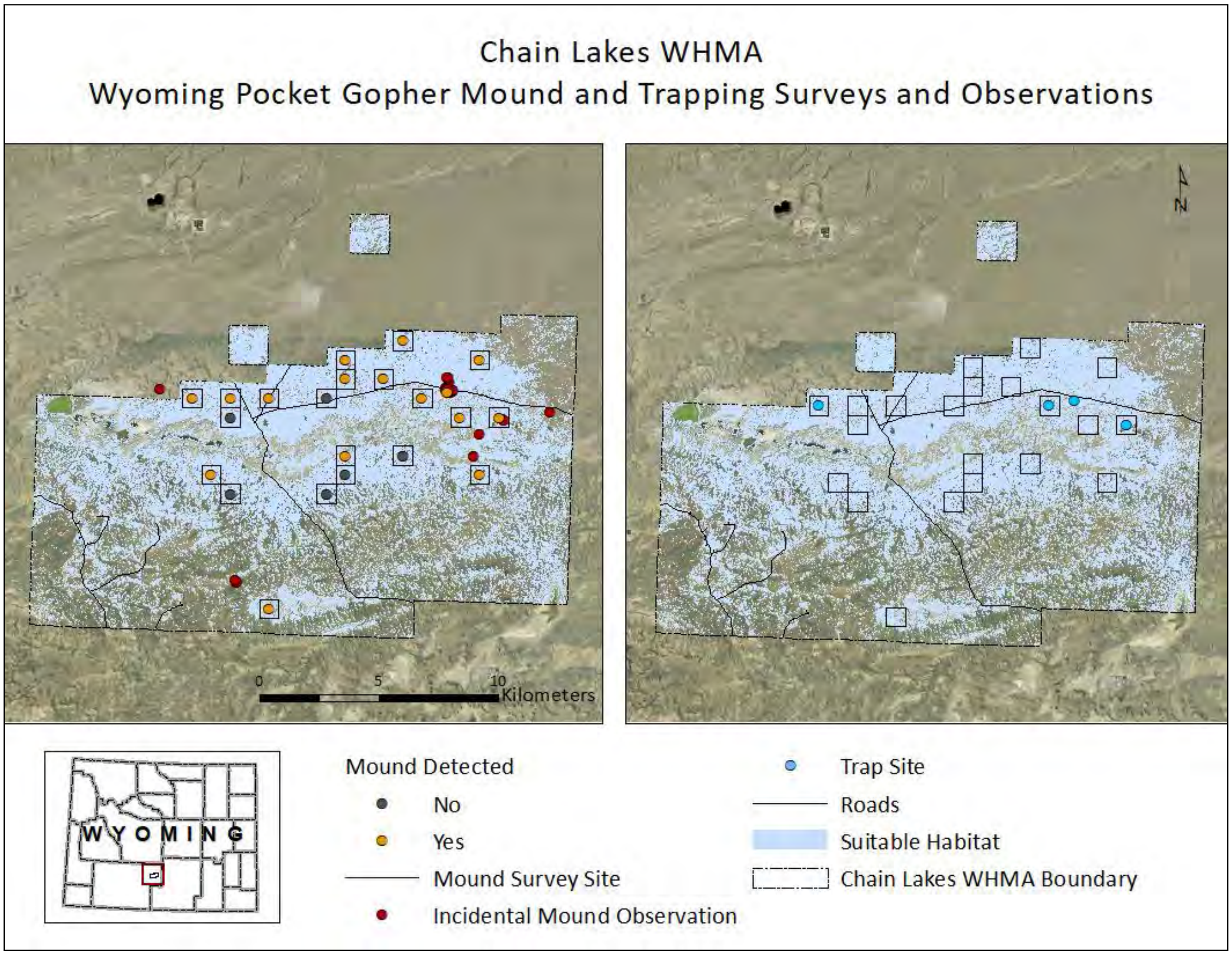

Figure 13. Wyoming pocket gopher potential suitable habitat and survey sites in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018. No Wyoming pocket gopher were captured, and northern pocket gopher were captured at the 3 eastern-most trap sites.

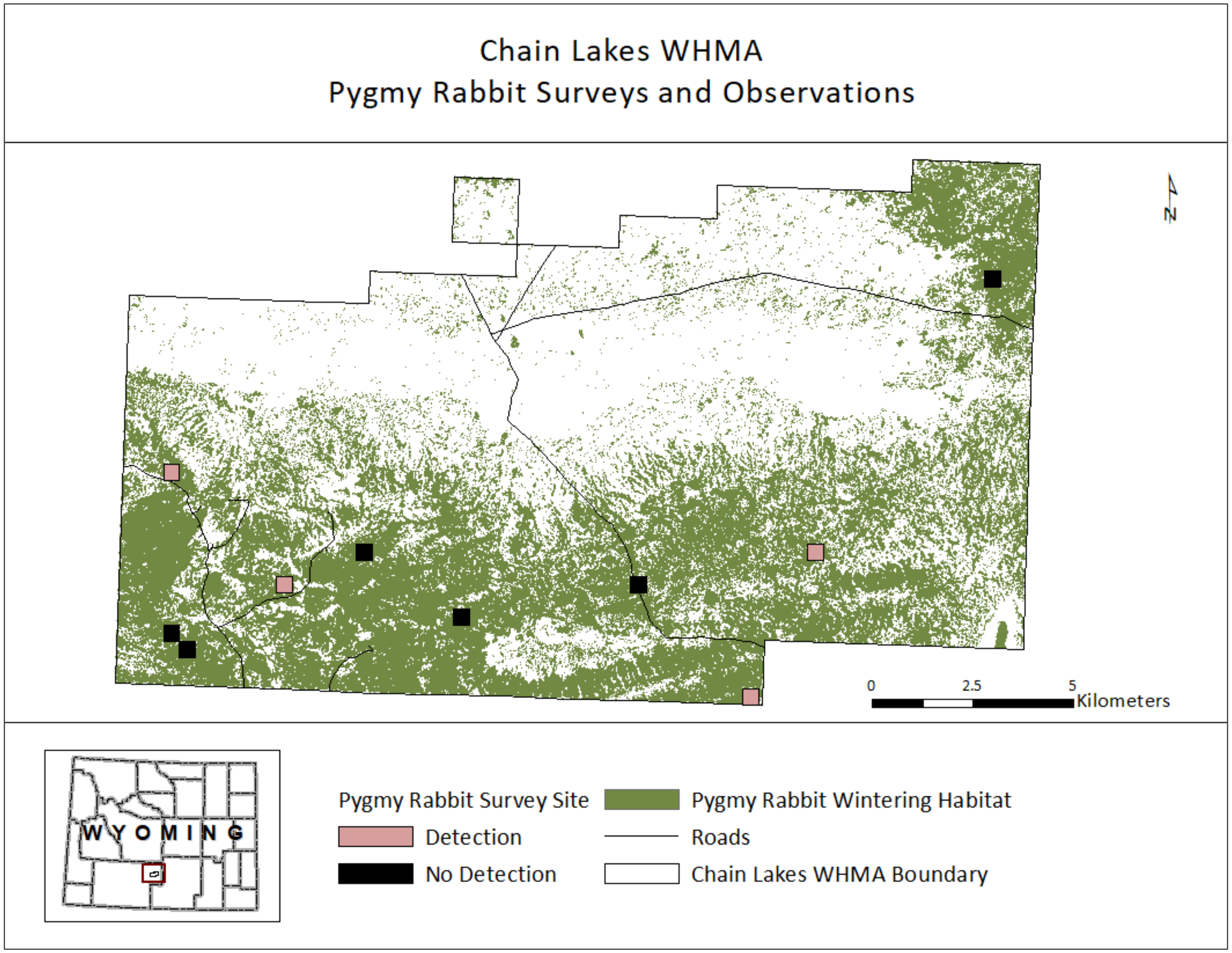

Figure 14. Pygmy rabbit wintering habitat, survey sites (n = 10), and observations (n = 4) at Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018. We defined potential wintering habitat as areas with land cover dominated by big sagebrush (*Artemisia tridentata*, LANDFIRE Existing Vegetation Type, USGS 2013).

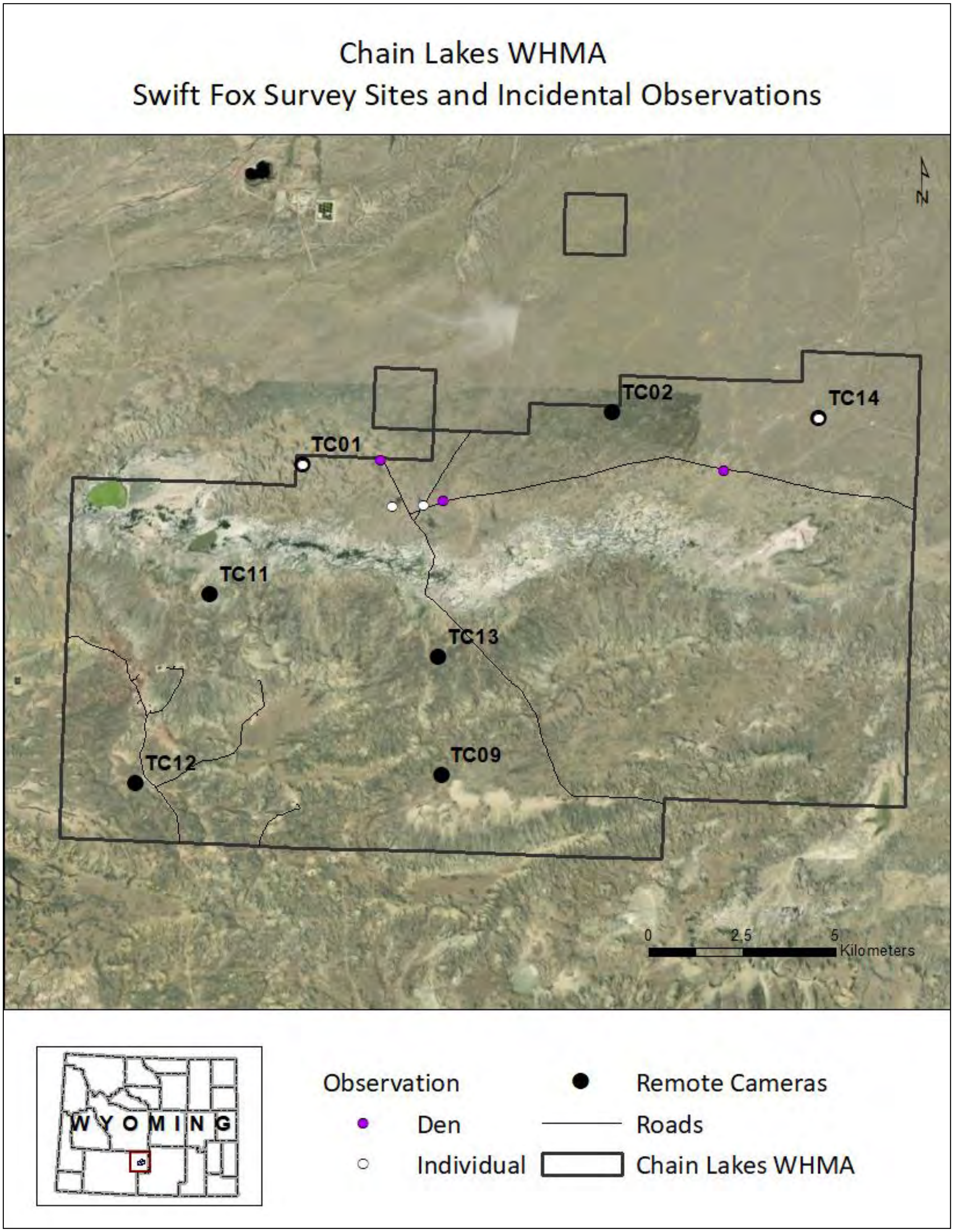

Figure 15. Swift fox remote camera survey sites and observations in Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 April to 11 September 2018.

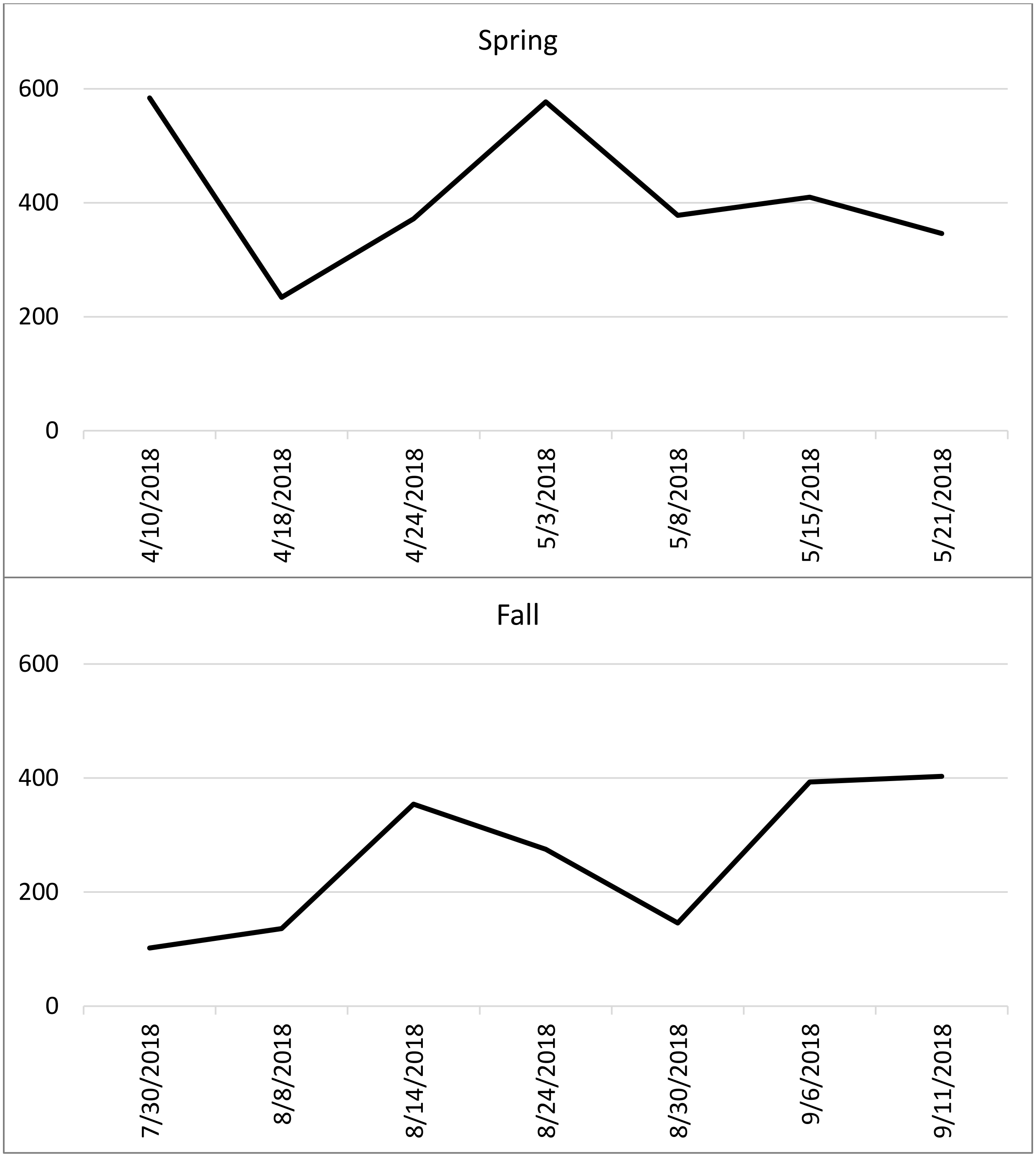

Figure 16. Weekly count of birds detected during migratory stopover surveys of wetlands in Chain Lakes Wildlife Habitat Management Area. Counts were conducted every 5 to 10 days from 10 April – 31 May and 30 June – 11 September 2018.

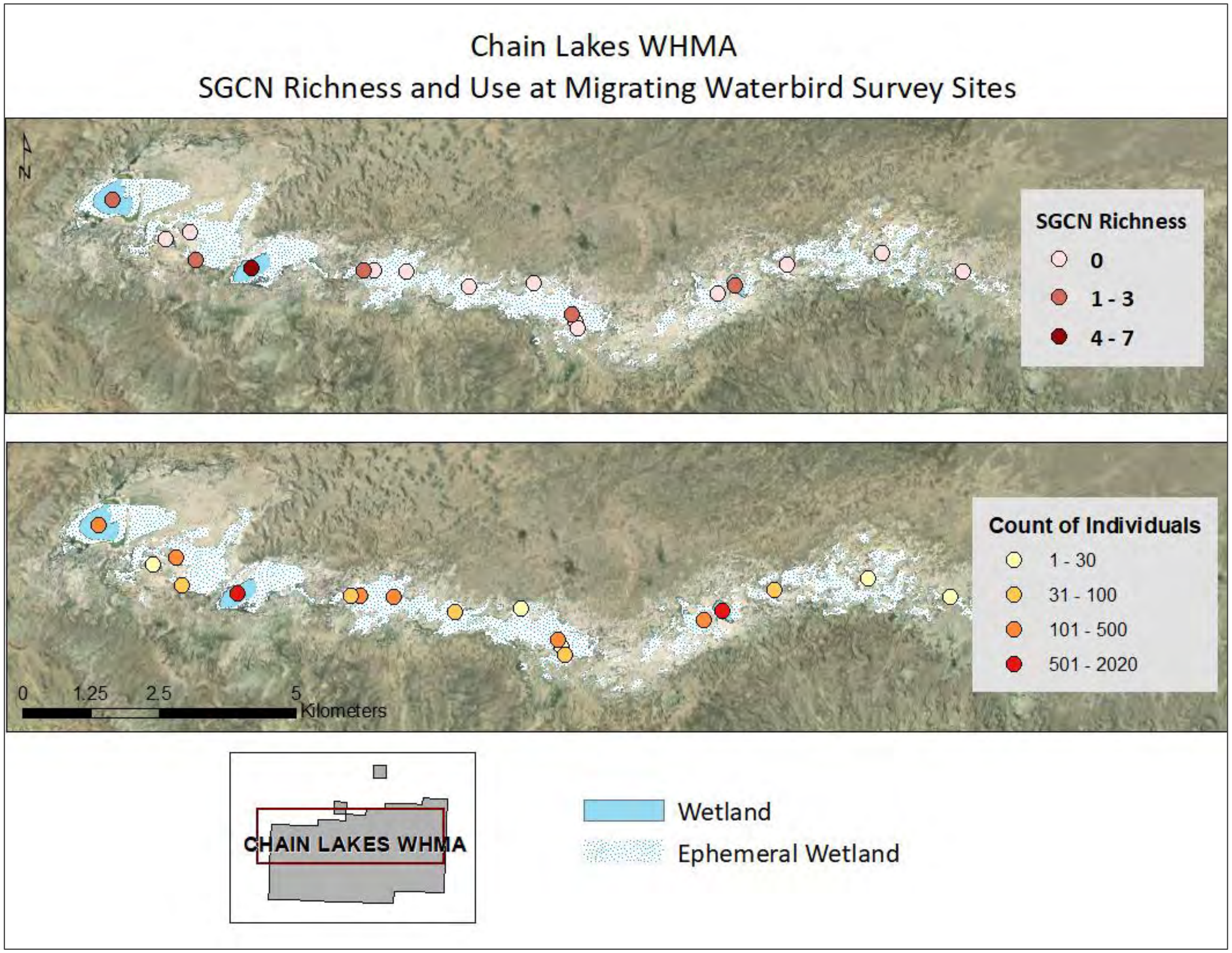

Figure 16. Counts of birds during migratory stopover surveys of wetlands in Chain Lakes Wildlife Habitat Management Area (WHMA). Data are summarized by Species of Greatest Conservation Need (SGCN) richness (WGFD 2017; top panel) and count of all individuals (bottom panel). Counts were conducted every 5 to 10 days from 10 April – 31 May and 30 June – 11 September 2018.

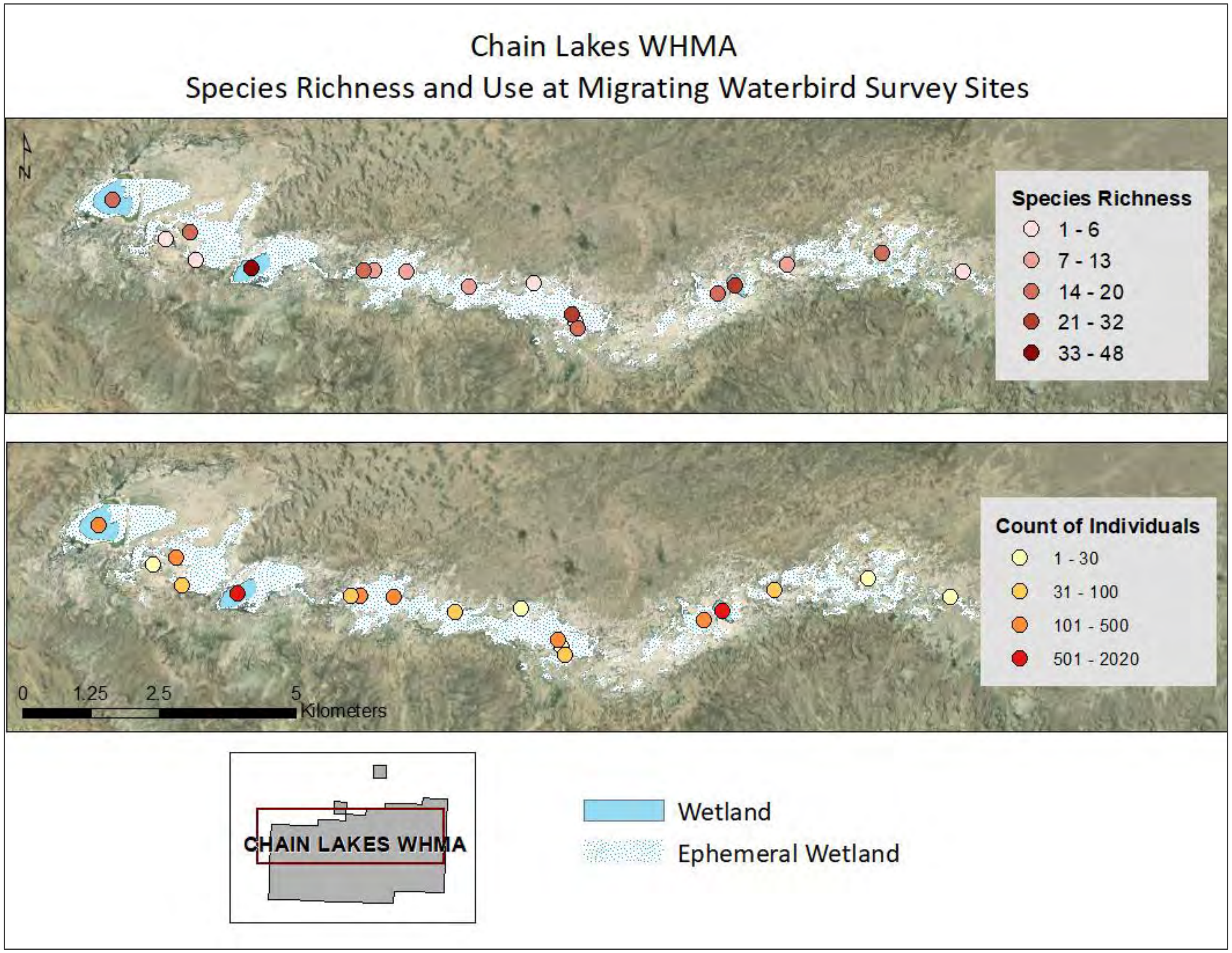

Figure 18. Counts of birds during migratory stopover surveys of wetlands in Chain Lakes Wildlife Habitat Management Area (WHMA). Data are summarized by species richness (top panel) and count of all individuals (bottom panel). Counts were conducted every 5 to 10 days from 10 April – 31 May and 30 June – 11 September 2018.

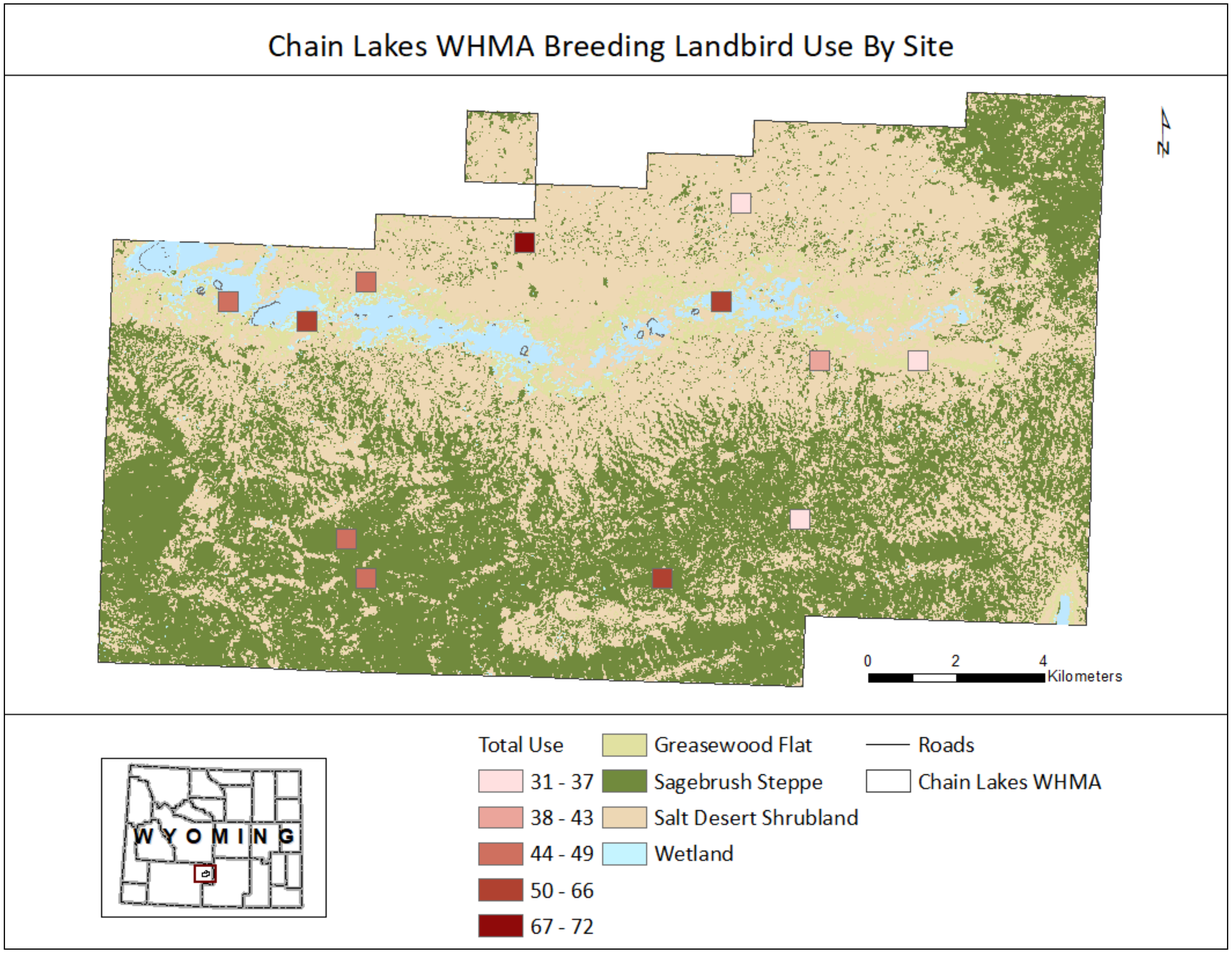

Figure 19. Survey locations (n = 12) and use (count of all individuals) by birds detected during breeding landbird point counts in Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 – 22 June 2018.

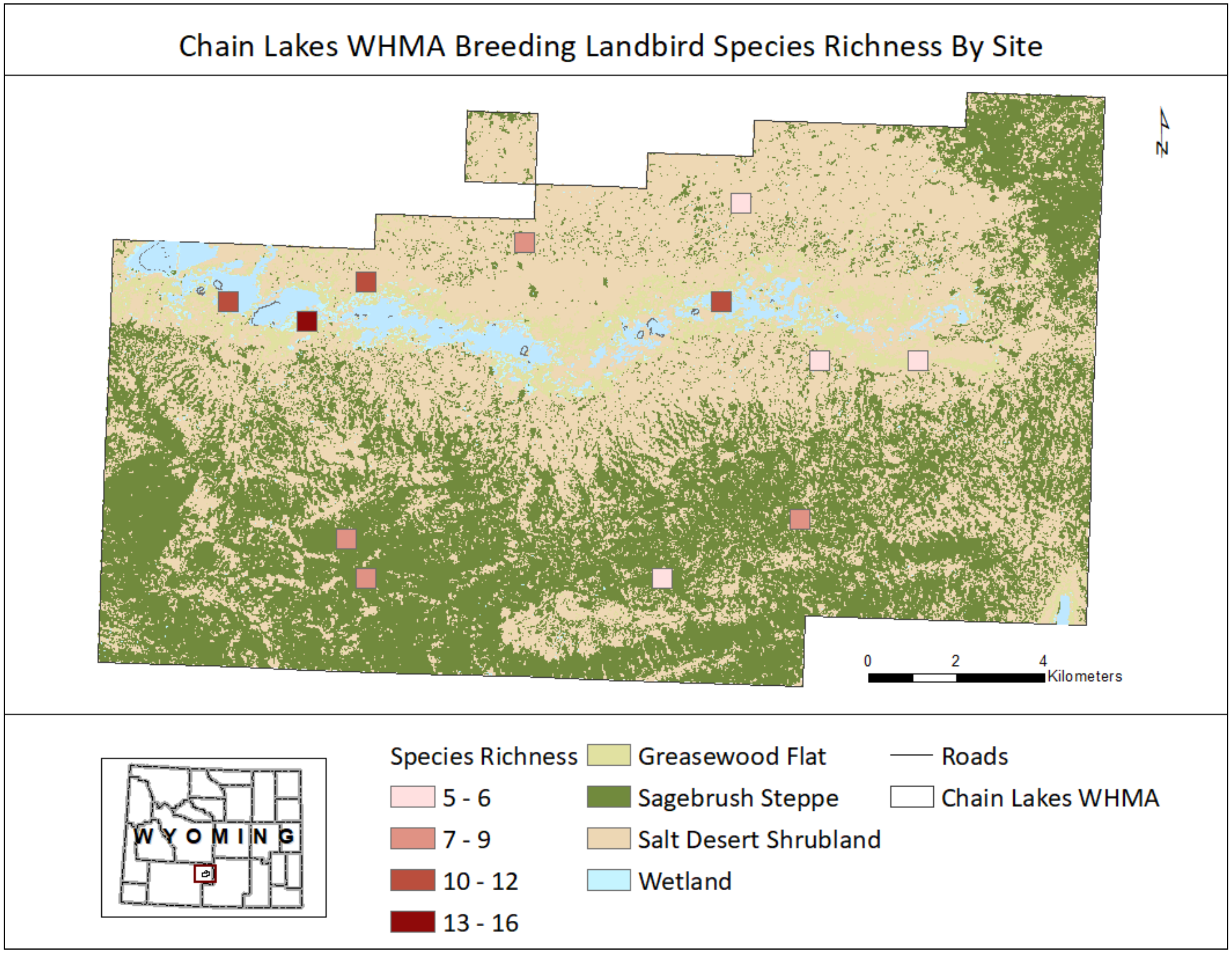

Figure 20. Survey locations (n = 12) and species richness of birds detected during breeding landbird point counts in Chain Lakes Wildlife Habitat Management Area from 5 – 22 June 2018.

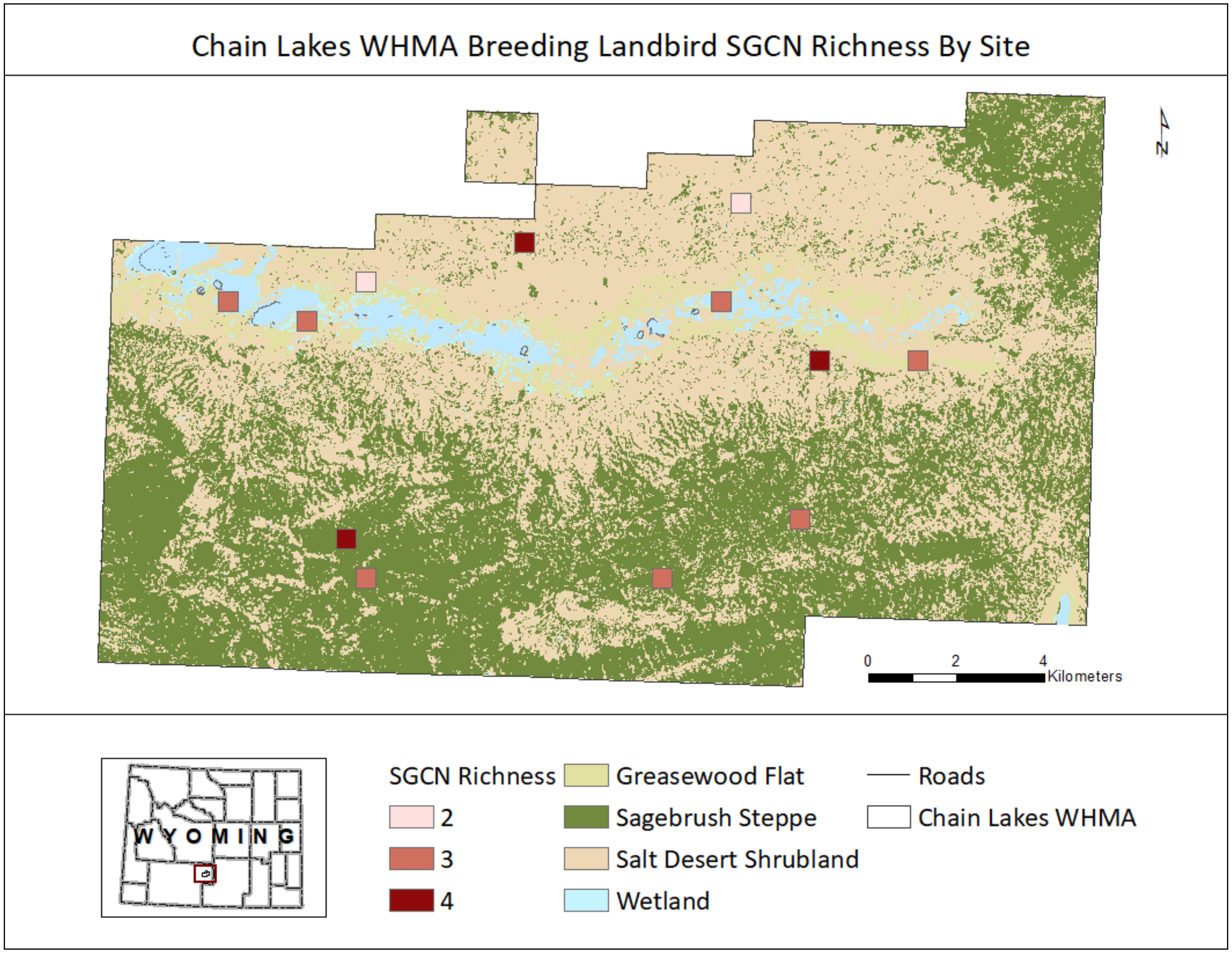

Figure 21. Survey locations (n = 12) and Species of Greatest Conservation Need (SGCN) richness of birds detected during breeding landbird counts in Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 – 22 June 2018.

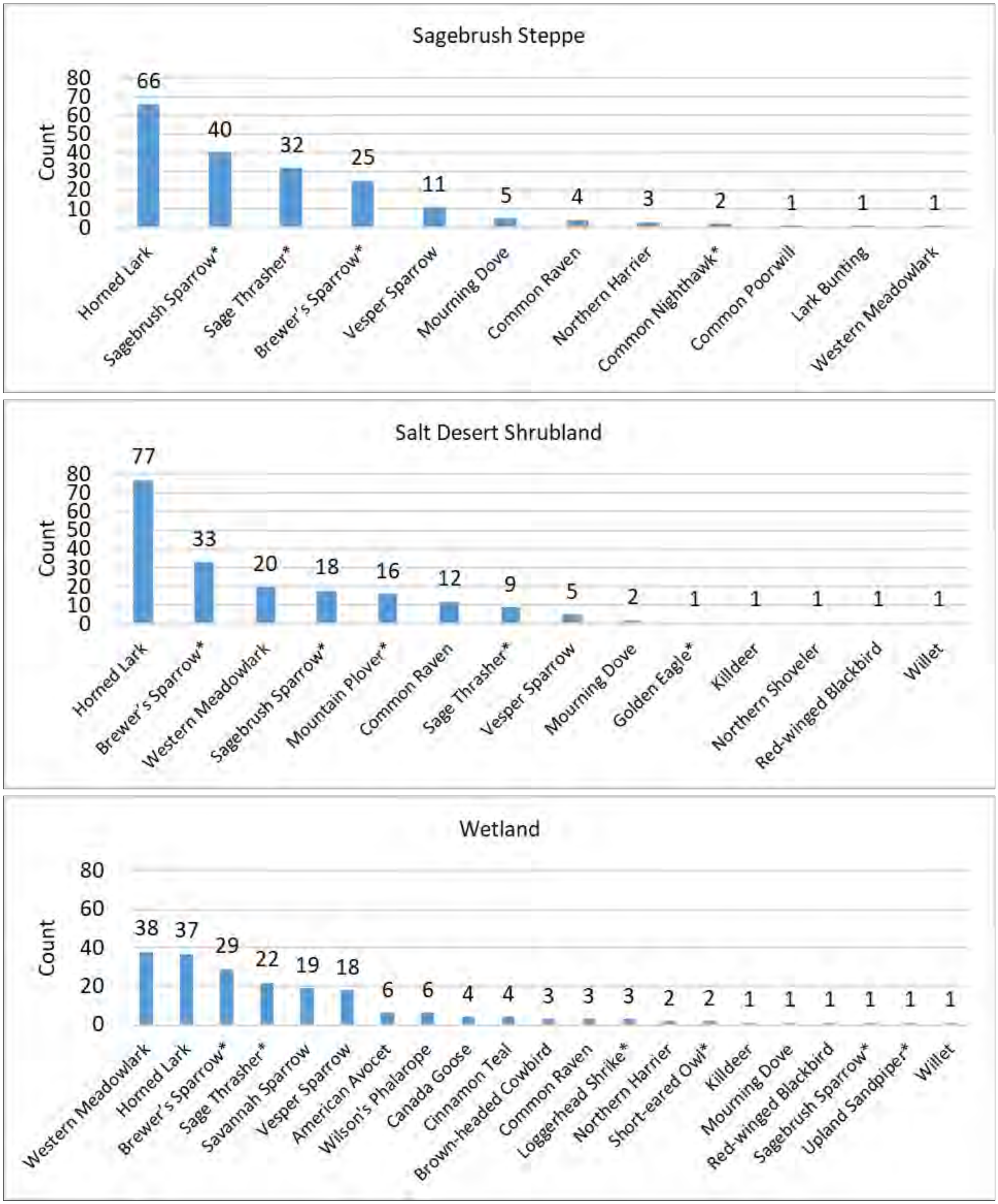

Figure 22. Counts of breeding landbird species by habitat, sagebrush steppe (*n* = 154), salt desert shrubland (*n* = 154), and wetland (*n* = 183), summed across 4 survey sites per habitat. Point counts were conducted 5 – 22 June 2018 in Chain Lakes Wildlife Habitat Management Area. *denotes Species of Greatest Conservation Need (WGFD 2017).

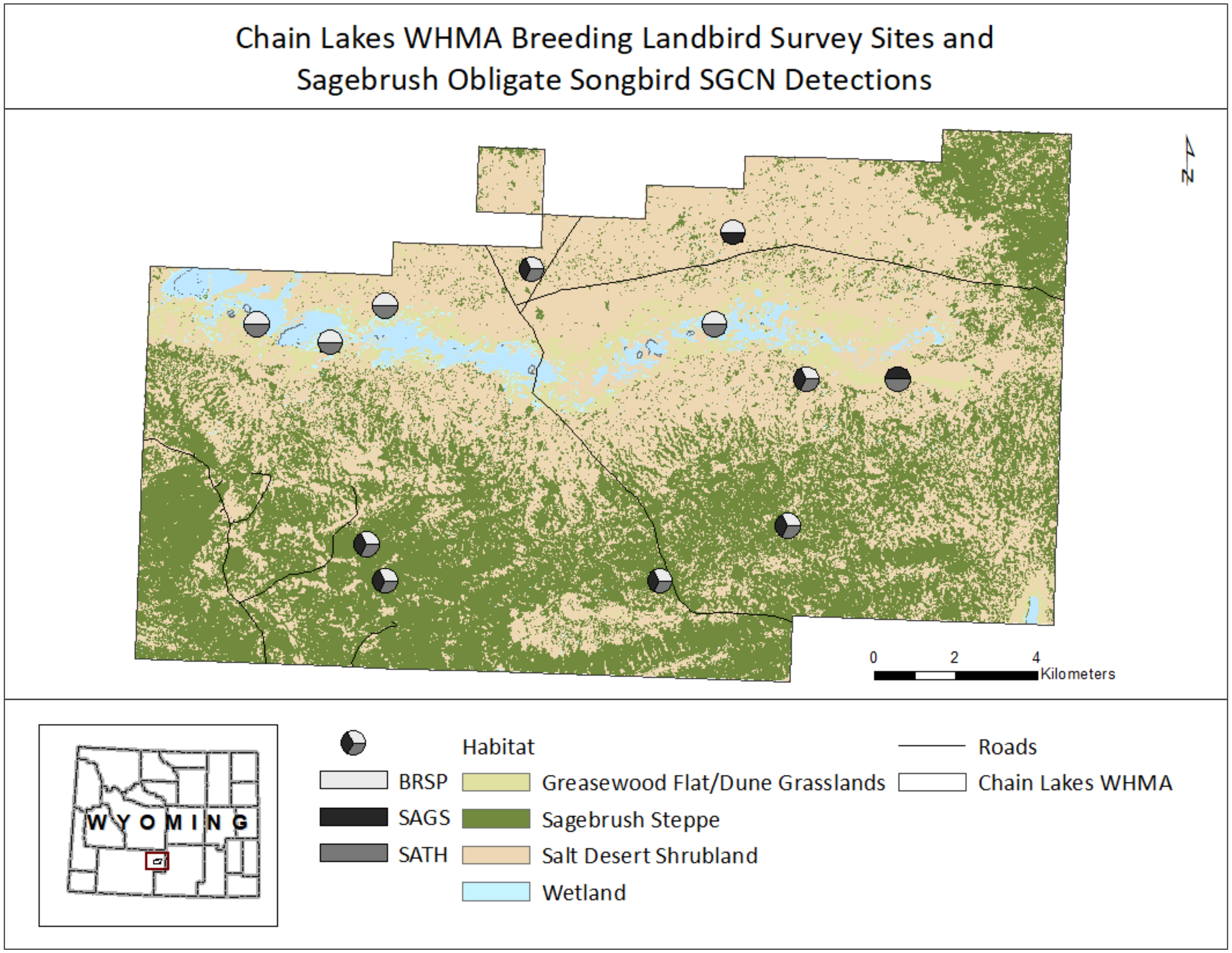

Figure 23. Occupancy by sagebrush obligate songbird Species of Greatest Conservation Need (SGCN), Brewer's Sparrow (BRSP), Sage Thrasher (SATH), and Sagebrush Sparrow (SAGS), at breeding landbird point count survey locations (n = 12) in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018.

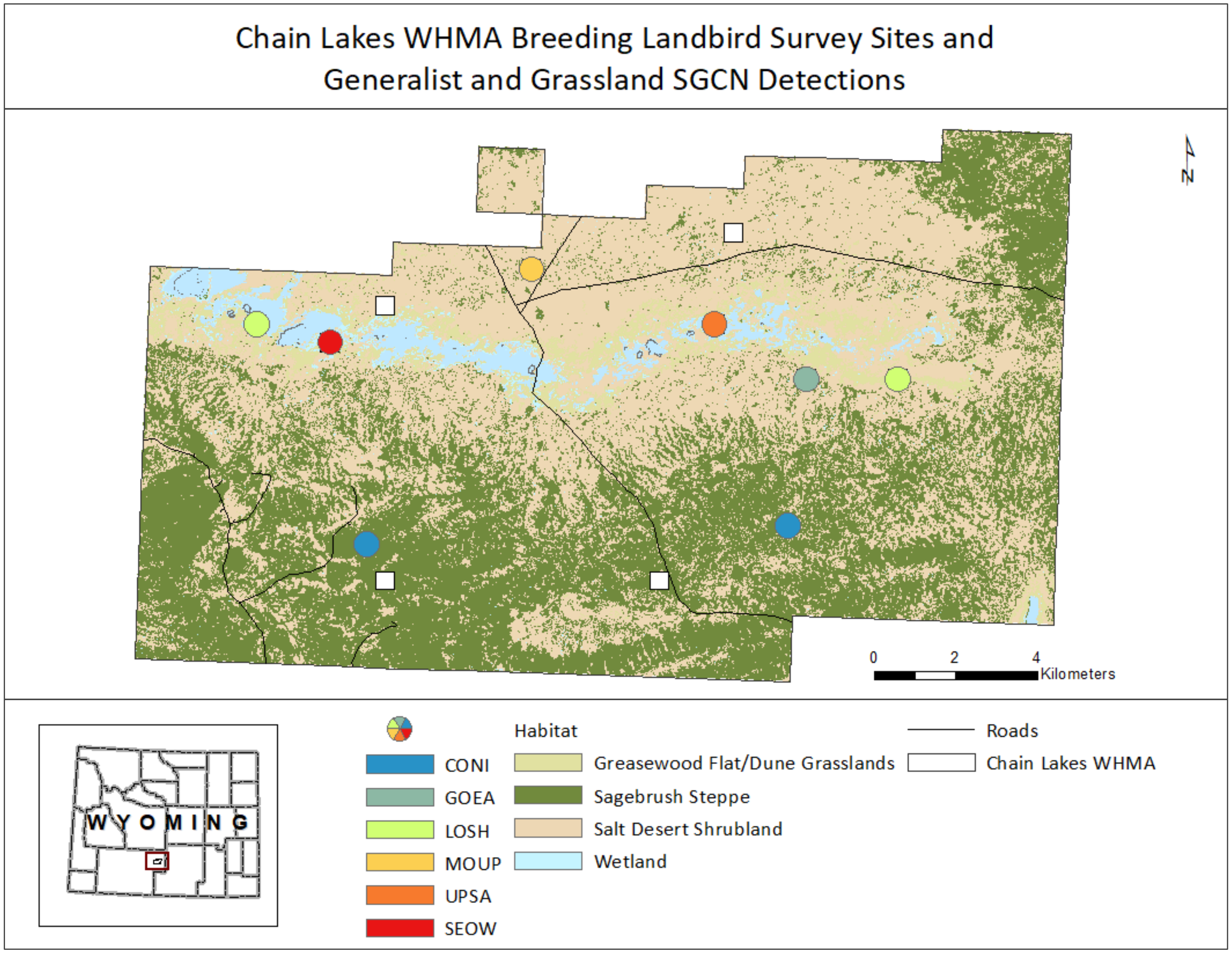

Figure 24. Occupancy by habitat generalists and grassland-associated Species of Greatest Conservation Need (SGCN), Common Nighthawk (CONI), Golden Eagle (GOEA), Loggerhead Shrike (LOSH), Mountain Plover (MOUP), Upland Sandpiper (UPSA), and Short-eared Owl (SEOW) at breeding landbird point count survey locations (*n* = 12) in Chain Lakes Wildlife Habitat Management Area (WHMA) in 2018. Survey sites with no detections of these species are represented by white squares.

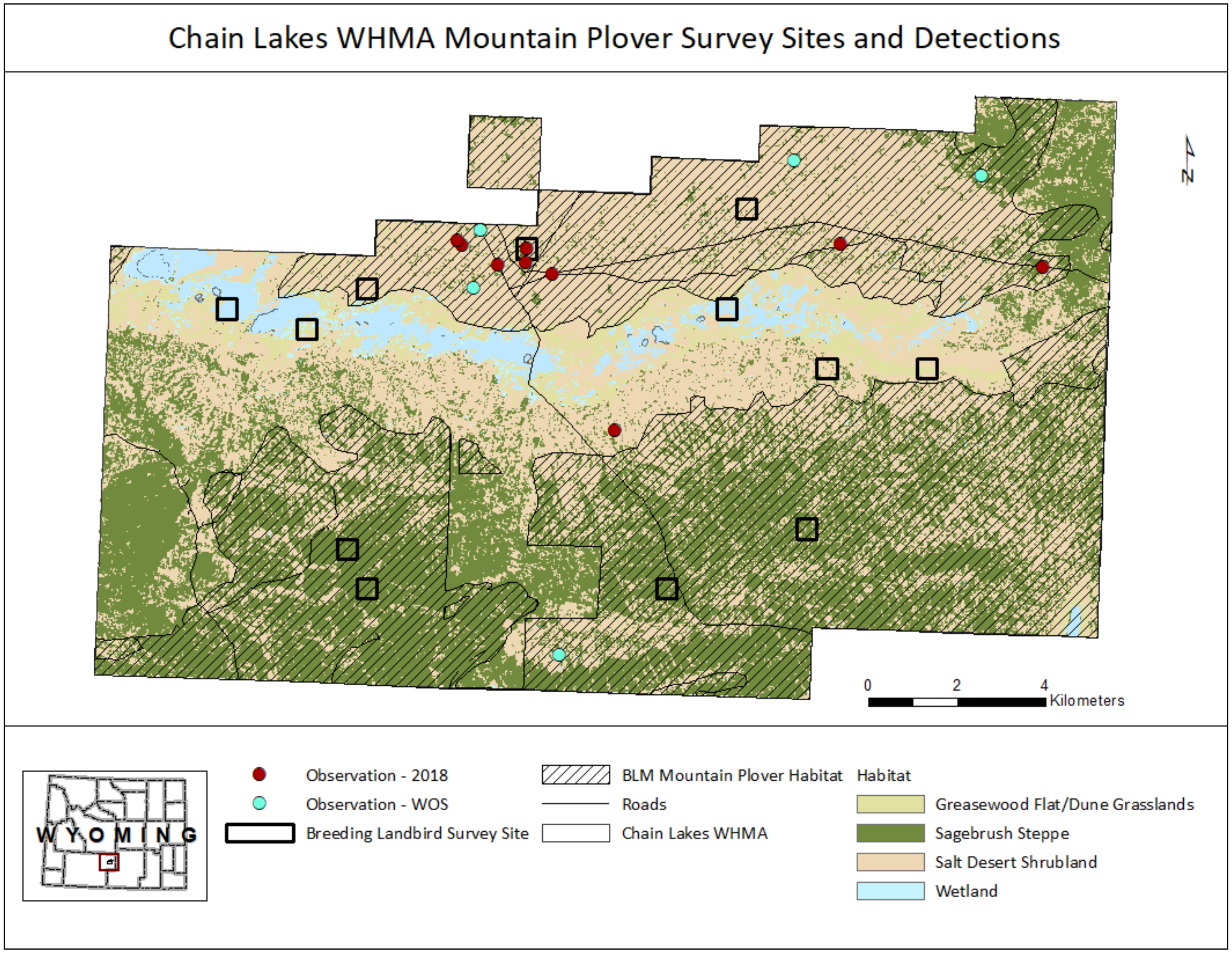

Figure 25. Breeding landbird point count survey locations (n = 12) and observations of Mountain Plover in Chain Lakes Wildlife Habitat Management Area (WHMA). We present observations collected incidentally and during breeding landbird surveys in 2018, in addition to prior observations from the Department's Wildlife Observation System. Also shown is Mountain Plover habitat as delineated by the Bureau of Land Management Rawlins Field Office.

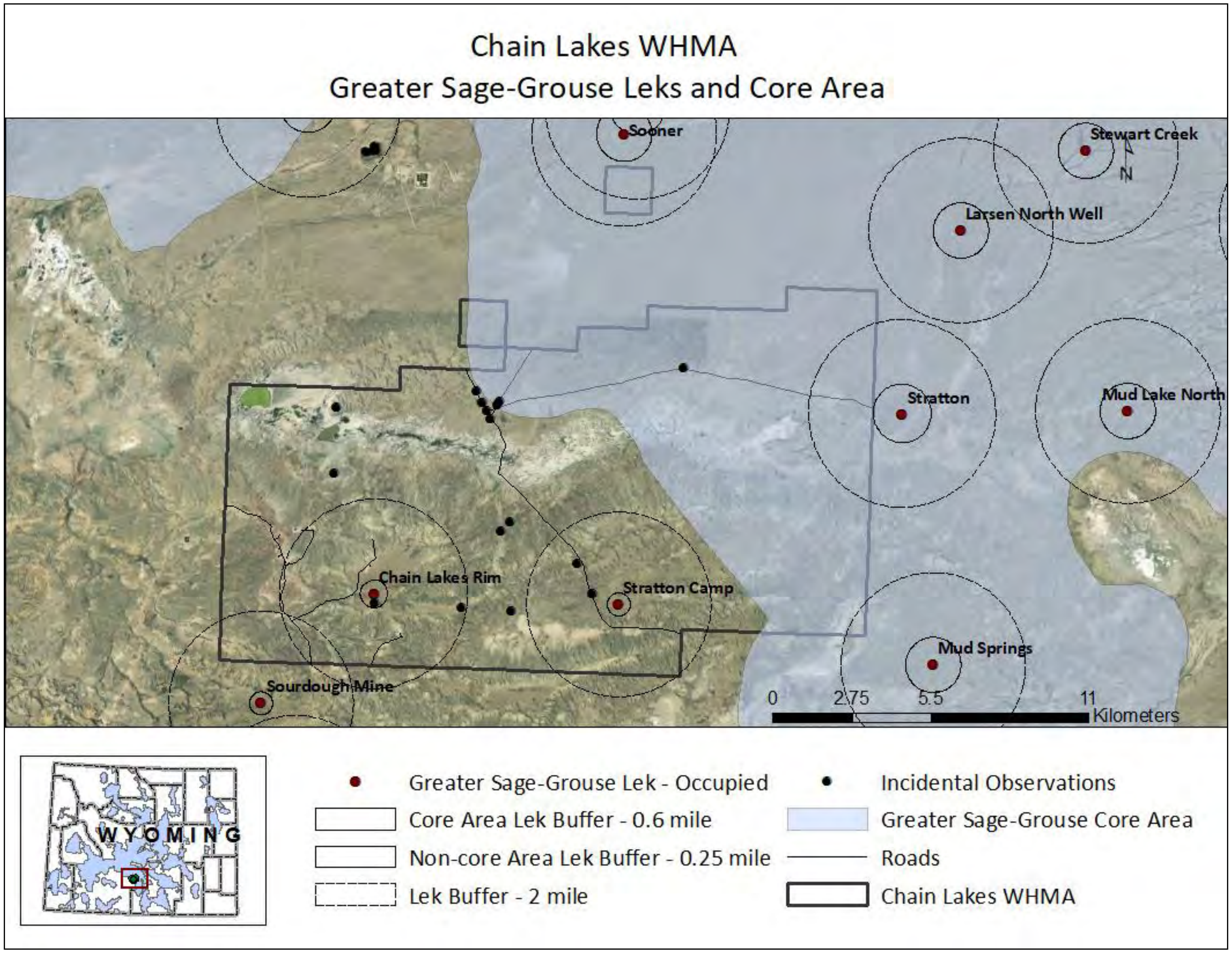

Figure 26. Greater Sage-Grouse leks, core area, and incidental observations in Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 April to 11 September 2018.

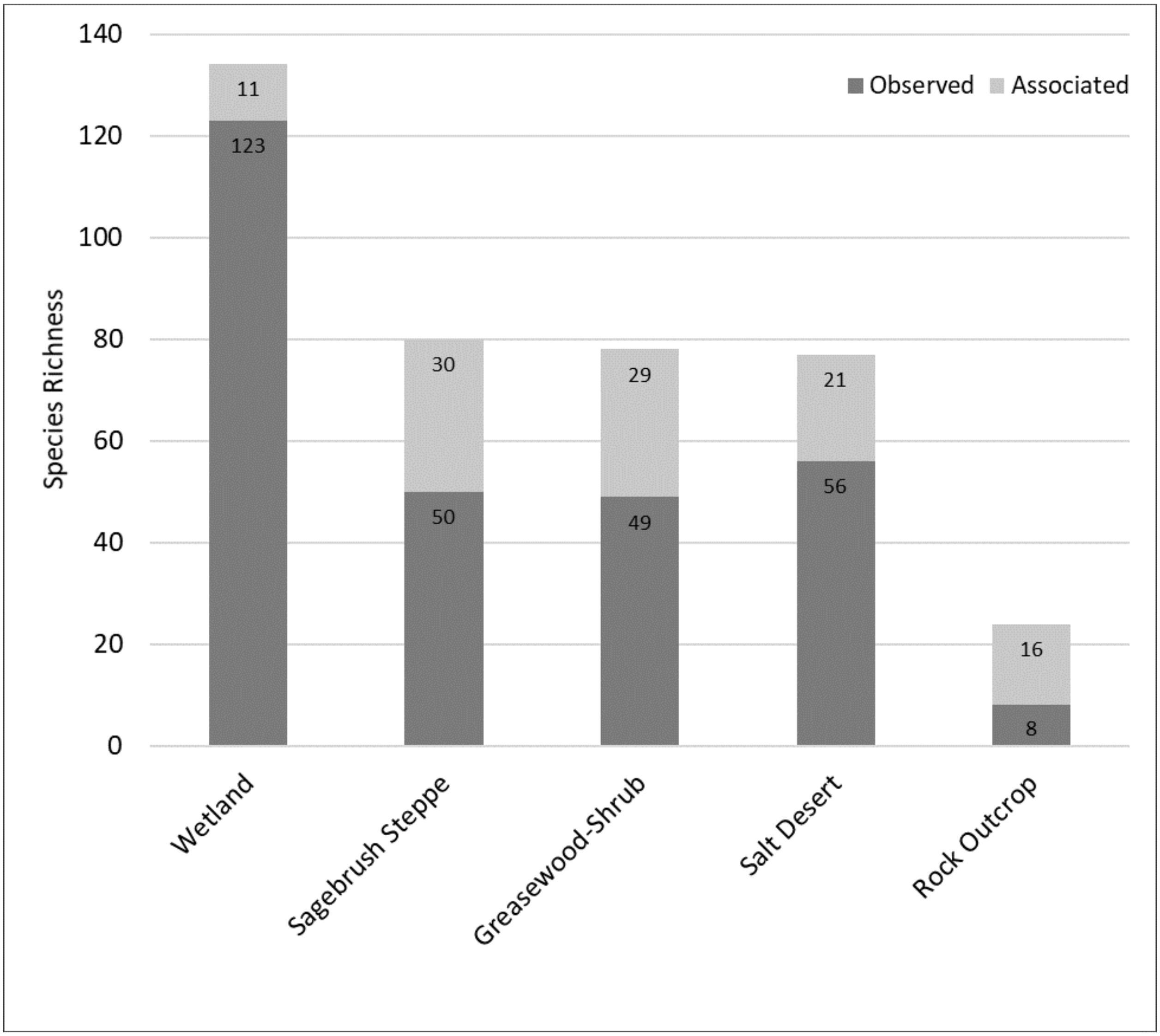

Figure 27. Species richness by habitat type in Chain Lakes Wildlife Habitat Management Area (WHMA) from 5 April to 11 September 2018. Many species were observed in multiple habitat types. Observed = the habitat(s) in which a species was detected during this study. Associated = the habitat(s) a species has been previously documented to use during the relevant life stage (e.g., migration, breeding) at which it was observed at Chain Lakes WHMA (MNHP and MFWP 2018, Poole 2018, Stapp 2018).

HARVEST REPORTS

HARVEST OF RAPTORS FOR FALCONRY

STATE OF WYOMING

NONGAME BIRDS: Raptors

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

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2018 – 31 December 2018

PREPARED BY: Courtney Rudd, Nongame Biologist
Bea Nicholas, Cheyenne Headquarters Management Assistant

SUMMARY

In 2018, the Wyoming Game and Fish Department issued 37 falconry capture licenses. The number of licenses issued represented 3 less than 2017 (n = 40 licenses). Licenses were issued to 32 residents (n = 35 licenses) and 2 nonresidents (n = 2 licenses). Residents filled 9 of 35 licenses; nonresidents filled 0 of 2 licenses (Table 1). Red-tailed Hawk (*Buteo jamaicensis*) was the most commonly captured species during 2018, with 3 captures (2 males, 1 female) by residents. Two Peregrine Falcons (*Falco peregrinus*) were captured, both by residents (1 male, 1 female). Both Prairie Falcons (*Falco mexicanus*) were captured by residents (1 female, 1 unknown). A resident captured a lone female American Kestrel (*Falco sparverius*). One Ferruginous Hawk (*Buteo regalis*) was captured by a resident (female); this species was last captured in 2016. The total number of birds captured in 2018 (n = 9) was significantly less than the mean (±SE) number of captures from 1981-2017 (21.51 ± 1.41 birds). Additionally, capture success for 2018 (24%) was almost less than half the mean (±SE) capture success from 1981-2017 (45.46% ± 2.06%, Table 2).

Table 1. Species and number of raptors captured by residents and nonresidents for falconry in Wyoming, 2018.

Species captured	Number of resident captures	Number of nonresident captures	Total captures
American Kestrel	1	0	1
Ferruginous Hawk	1	0	1
Peregrine Falcon	2	0	2
Prairie Falcon	2	0	2
Red-tailed Hawk	3	0	3
Total	9	0	9

Table 2. Number of individuals captured and yearly capture success rate (%) for raptors taken for falconry in Wyoming, 1981-2018.

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
2015	12	29
2016	16	39
2017	16	40
2018	9	24

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: 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
Wyoming Game and Fish Department Commission

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2017 – 14 April 2018

PREPARED BY: Courtney Rudd, Nongame Biologist
Andrea Orabona, Nongame Bird Biologist
United 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 2017, volunteers surveyed 74 Breeding Bird Survey routes across the state. Overall, the number of species detected per route has increased, while survey effort and the number of detections per survey have decreased. 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 populations of breeding birds along roadside surveys.

INTRODUCTION

A total of 80 avian species are classified as Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (Department; WGFD 2017). The Department utilizes data from various large-scale, multi-species survey efforts to monitor trends in avian populations, while implementing species-specific surveys for those species that are not adequately monitoring using the multi-species survey methods.

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 US 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 4,600 BBS routes are located across the continental US and Canada, including 108 active routes in Wyoming (Figure 1).

The BBS was designed to provide a continent-wide perspective of avian 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 2017 were to add additional data to the BBS database and interpret current large-scale trends of nongame breeding birds in Wyoming. Population trend estimates were not available in order to meet the Department's reporting deadline. Typically, they are completed for over 420 species of birds and, for the purposes of this report, are reviewed for SGCN only (Sauer et al. 2017). All raw data can be accessed on the BBS web site at http://www/pwrc.usgs.gov/bbs/ (Pardieck et al. 2018).

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 second week of July. Each route is 24.5 miles long and consists of 50 stops spaced at 0.5 mile intervals along the route. Beginning 0.5 hour before sunrise, observers record birds seen within a 0.25 mile radius and all birds heard at each stop during a 3-minute 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. All analyses on abundance of breeding birds in Wyoming were conducted by USGS-BRD.

RESULTS

In 2017, observers surveyed approximately 2,646 of 3,571 (74%) active routes in the US. In Wyoming, observers surveyed 74 of the 108 (69%) active routes. Results are reported in Table 1. Since 1990, the number of routes surveyed in Wyoming has decreased by 0.36 routes per year ($P < 0.001$; $R^2 = 0.1507$; Figure 2). Contrary to this trend, the number of routes surveyed in 2017 (i.e., 74 routes) was greater than the mean number of routes completed from 1990-2016 (65.0 ± 1.45 routes).

Observers detected a total of 35,261 individual birds representing 190 species in Wyoming (Table 2). Since 1990, the number of individuals detected has decreased by 4.1 individuals per route per year ($P < 0.001$; $R^2 = 0.55$; Figure 3), but the number of species detected has increased by 0.15 species per route per year ($P < 0.001$; $R^2 = 0.4812$; Figure 4). Consistent with these trends, the number of individuals detected per route in 2017 (i.e., 471.7 ± 37.1 individuals) was less than the mean number of individuals detected per route from 1990-2016 (i.e., 527.5 ± 8.7 individuals). However, the number of species detected per route in 2017 (i.e., 39.4 ± 1.5 species) was slightly greater than the mean number of species detected per route from 1990-2016 (i.e., 38.2 ± 0.3 species).

Of the 190 species detected in 2017, 44 are SGCN. As of the Department's publishing deadline, the USGS-BRD had not posted trend analysis for 1968-2017 to the BBS website. The Department will incorporate trend analysis in next year's report, if it is available, in order to determine whether there are notable trends in species' populations in Wyoming.

DISCUSSION

A complete history of BBS observers and routes surveyed in Wyoming from 1968-2017 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 for the BBS's ability to measure changes on the landscape that birds are experiencing.

Overall, survey effort has decreased in the last 28 years. However, 2017 recorded the 4th highest number of routes completed since 1990; at 74 routes, there were 2 additional routes completed from 2016, keeping Wyoming in the 51-75% completion bracket. While the number of individual birds detected per route has decreased, the number of species detected per route has slightly 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. The USFWS, Canadian Wildlife Service, and Partners in Flight use trend data 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. BBS data are used to help determine the need for SGCN status in State Wildlife Action Plans. 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

The Wyoming Game and Fish Department Commission provided funding for this project, for which we are 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 2017 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.

LITERATURE CITED

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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, 2017. Data are presented in numerical order by survey route. An asterisk indicates a deficiency is associated with a route (e.g., inclement weather, route conducted before or after the recommended survey window, private land access issues, lost data sheet, late start time).

Route number and name	Latilong	Observer	Species	Individuals
1 – NE Entrance, YNP	1	John Parker	51	573
2 – Cody	2	Grace Nutting	45	364
3 – Otto	3	Rex Myers	47	730
4 – Basin	4	N/A – discontinued		
5 – Wyarno	5	John Berry	46	1244
6 – Clarkelen	6	N/A – discontinued		
7 – Sundance	7	Jennifer Adams	53	584
8 – Colter Bay	8	N/A – discontinued		
9 – Dubois	9	Jazmyn McDonald	58	363
10 – Midvale	10	Matt Fraker	56	974
11 – Nowood	11	Donna Walgren	37	269
12 – Natrona	12	N/A – discontinued		
13 – Bill	13	Observer needed	Not conducted	Not conducted
14 – Redbird	14	N/A – discontinued		
15 – Fontenelle	15	Carol Deno	61	479
16 – Elk Horn	16	Zack Walker	Not conducted	Not conducted
17 – Bear Creek	17	Andrea Orabona	15	224
18 – Ervay	18	Jazmyn McDonald	34	236
19 – Brookhurst	19	Bruce Walgren	46	354
20 – Glenrock	20	N/A – discontinued		
21 – Dwyer	21	Martin Hicks	20	674
22 – Cumberland	22	Carol Deno	35	234
23 – McKinnon	23	N/A – discontinued		
24 – Patrick Draw	--	N/A – discontinued		
25 – Savery	25	Marie Adams	43	219
26 – Riverside	26	Steve Loose	48	517
27 – Buford	27	Grant Frost	54	385
28 – Yoder	28	Gloria Lawrence	Not conducted	Not conducted
29 – Canyon	--	N/A – discontinued		
30 – Mammoth, YNP	1	Katy Duffy	59	402
31 – West Thumb	--	N/A – discontinued		
32 – Hunter Peak	2	Jesse Boulerice	43	418
33 – Clark	2	Barb Pitman	46	426
34 – no route		N/A – no route		
35 – Frannie	3	Suzy Grimes	33	400
36 – Moose	8	Morgan Graham	53	417
37 – Lovell	3	Paul DuBowy	32	158
38 – Meeteetse	3	Jazmyn McDonald	54	407
39 – Ten Sleep	4	C.J. Grimes	Not conducted	Not conducted

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
40 – Dayton	4	Tracey Ostheimer	56	562
41 – Bald Mountain	4	Neil Miller	16	86
42 – Crazy Woman	5	Grace Nutting	Not conducted	Not conducted
43 – Schoonover	5	Donald Brewer	Not conducted	Not conducted
44 – Arvada	5	Donald Brewer	Not conducted	Not conducted
45 – Recluse	6	Donald Brewer	Not conducted	Not conducted
46 – Soda Well	6	Sandra Johnson	42	494
47 – Piney	--	N/A – discontinued		
48 – Seely	--	N/A – discontinued		
49 – Upton	7	Observer needed	Not conducted	Not conducted
50 – Moskee	--	N/A – discontinued		
51 – Alpine	8	Susan Patla	52	462
52 – Wilson	8	Matt Fraker	65	539
53 – Horse Creek	9	Eva Crane	52	383
54 – no route		N/A – no route		
55 – Crowheart	9	Matt Fraker	Not conducted	Not conducted
56 – Ethete	10	Joe Austin	50	555
57 – Anchor	10	Matt Fraker	Not conducted	Not conducted
58 – Gebo	10	Jazmyn McDonald	42	376
59 – Arminto	11	Heather O’Brien	Not conducted	Not conducted
60 – Lysite	11	Leah Yandow	31	320
61 – Worland	11	C.J. Grimes	Not conducted	Not conducted
62 – Teapot Dome	--	N/A – discontinued		
63 – Mayoworth	12	Observer needed	Not conducted	Not conducted
64 – Sussex	12	Bill Ostheimer	42	420
65 – Harland Flats	13	Matt Fraker	28	687
66 – Pine Tree	13	Observer needed	Not conducted	Not conducted
67 – Highlight	--	N/A – discontinued		
68 – Riverview	14	Nathan Darnall	28	356
69 – Newcastle	14	Observer needed	Not conducted	Not conducted
70 – Raven	14	Nichole Cudworth	Not conducted	Not conducted
71 – Soda Lake	15	Theresa Gulbrandson	31	258
72 – Buckskin Mountain	15	Don Delong	47	480
73 – Daniel	--	N/A – discontinued		
74 – Boulder	16	Susan Patla	57	354
75 – Big Sandy	16	Susan Patla	40	403
76 – Farson	16	Observer needed	Not conducted	Not conducted
77 – Fiddler Lake	17	Eva Crane	42	356
78 – Sand Draw	17	Jazmyn McDonald	37	376
79 – Sweetwater	17	Leah Yandow	24	327
80 – Gas Hills	18	N/A – discontinued		
81 – Bairoil	18	Greg Hiatt	Not conducted	Not conducted
82 – Lamont	18	Greg Hiatt	Not conducted	Not conducted

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
83 – Pathfinder	19	Laura Schwieger	30	335
84 – Leo	19	Donna Walgren	29	177
85 – Shirley	19	Linda Drury	Not conducted	Not conducted
86 – Warbonnet	20	Nathan Darnall	39	226
87 – Fletcher Peak	20	Jesse Boulerice	48	388
88 – Shawnee	20	Irene Fortune	33	718
89 – Meadowdale	21	Martin Hicks	12	308
90 – Lusk	21	Grant Frost	30	550
91 – Lingle	21	Nathan Darnall	30	669
92 – Diamondville	--	N/A – discontinued		
93 – Mountain View	22	Matt Fraker	Not conducted	Not conducted
94 – no route	--	N/A – discontinued		
95 – Green River	--	N/A – discontinued		
96 – Reliance	23	Observer needed	Not conducted	Not conducted
97 – Rock Springs	23	Fern Linton	38	235
98 – Black Rock	--	N/A – discontinued		
99 – Kaycee	12	Charlotte Snoberger	Not conducted	Not conducted
100 – no route	--	N/A – no route		
101 – Wamsutter	25	Tony Mong	Not conducted	Not conducted
102 – Rawlins	25	N/A – discontinued		
103 – Baggs	25	Tony Mong	Not conducted	Not conducted
104 – Walcott	26	Frank Blomquist	45	439
105 – Fox Park	26	Wendy Estes-Zumpf	29	318
106 – Ryan Park	26	Debbie Wagner	29	240
107 – Sybille Canyon	27	Ian Abernethy	Not conducted	Not conducted
108 – Rock River	27	Sandra Taylor	44	1484
109 – Harmony	27	Julie Polasik	60	720
110 – Cheyenne	28	Chuck Seniawski	24	434
111 – Chugwater	28	Chuck Seniawski	22	418
112 – Pine Bluff	28	Chuck Seniawski	24	402
120 – Welch	20	Chris Michelson	32	494
123 – Flaming Gorge	23	Matt Fraker	23	276
147 – Rozet	6	Observer needed	Not conducted	Not conducted
148 – Seely 2	7	Mary Yemington	43	565
150 – Government Valley	7	Jennifer Adams	37	568
167 – Thunder Basin	13	Nichole Cudworth	Not conducted	Not conducted
173 – Rye Grass	15	Theresa Gulbrandson	26	369
180 – Gas Hills 2	18	Courtney Rudd	18	431
192 – Carter	23	N/A – discontinued		
195 – Seedskadee	23	Tom Koerner	Not conducted	Not conducted
198 – Black Rock 2	24	Andrea Orabona	Not conducted	Not conducted
202 – Rawlins 2	25	Sandra Taylor	35	245
204 – Basin 2	4	Matt Fraker	61	867

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
206 – Caballa Creek	6	Observer needed	Not conducted	Not conducted
208 – Moran	8	John Stephenson	Not conducted	Not conducted
212 – Bucknum	12	Observer needed	Not conducted	Not conducted
214 – Hampshire	14	Nathan Darnall	23	307
224 – Patrick Draw III		N/A – discontinued		
250 – Moskee 2	7	Jennifer Adams	59	607
292 – Carter 2	22	Katie Theule	32	289
524 – Patrick Draw VI	24	Observer needed	Not conducted	Not conducted
900 – Hayden Valley		N/A – discontinued		
901 – Yellowstone, YNP*	1	John Parker	62	2355
902 – Pryor Flats*	1	Sandra Taylor	28	156

Table 2. Number of individuals and relative abundance of each species detected on Breeding Bird Survey routes in Wyoming, 2017. Data are presented in alphabetical order. The 30 most abundant species detected on BBS routes in 2017 are denoted by an asterisk.

Species name	Number detected	Relative abundance (%)	Total routes
American Avocet	30	0.09	4
American Coot	41	0.12	7
American Crow	232	0.66	33
American Dipper	1	<0.01	1
American Goldfinch	109	0.31	26
American Kestrel	79	0.22	37
American Pipit	15	0.04	1
American Redstart	51	0.14	2
American Robin*	1411	4.00	68
American Three-toed Woodpecker	1	<0.01	1
American White Pelican	117	0.33	14
American Wigeon	34	0.10	8
Audubon's Warbler*	292	0.83	23
Bald Eagle	15	0.04	8
Bank Swallow	75	0.21	6
Barn Swallow*	297	0.84	48
Barrow's Goldeneye	22	0.06	4
Belted Kingfisher	6	0.02	6
Black-billed Cuckoo	3	<0.01	2
Black-billed Magpie*	403	0.01	46
Black-capped Chickadee	45	1.14	20
Black-headed Grosbeak	43	0.13	12
Blue Grosbeak	5	0.12	2
Blue Jay	3	0.01	2
Blue-gray Gnatcatcher	4	0.01	4
Blue-winged Teal	10	0.03	3
Bobolink	23	0.07	4
Brewer's Blackbird*	945	2.68	55
Brewer's Sparrow*	911	2.58	54
Broad-tailed Hummingbird	51	0.14	14
Brown Thrasher	2	0.01	1
Brown-headed Cowbird	233	0.66	36
Bufflehead	10	0.03	2
Bullock's Oriole	81	0.23	19
Burrowing Owl	6	0.02	6
California Gull	73	0.21	6
Calliope Hummingbird	2	0.01	2

Table 2. Continued.

Species name	Number detected	Relative abundance (%)	Total routes
Canada Goose*	2789	7.91	21
Canada Jay	5	0.01	3
Canvasback	28	0.08	3
Canyon Wren	1	<0.01	1
Cassin’s Finch	51	0.14	13
Cassin’s Kingbird	1	<0.01	1
Cedar Waxwing	24	0.07	7
Chestnut-collared Longspur	10	0.03	3
Chipping Sparrow*	262	0.74	28
Chukar	2	0.01	1
Cinnamon Teal	14	0.04	6
Clark’s Nutcracker	88	0.25	21
Clay-colored Sparrow	14	0.04	5
Cliff Swallow*	1403	3.98	46
Common Goldeneye	1	<0.01	1
Common Grackle*	395	1.12	30
Common Merganser	26	0.07	12
Common Nighthawk	144	0.41	46
Common Poorwill	2	0.01	2
Common Raven*	342	0.97	50
Common Yellowthroat	87	0.25	22
Cooper’s Hawk	2	0.01	1
Cordilleran Flycatcher	26	0.07	5
Dark-eyed Junco*	362	1.03	20
Dickcissel	11	0.03	5
Double-crested Cormorant	9	0.03	4
Downy Woodpecker	6	0.02	5
Dusky Flycatcher	69	0.20	17
Eared Grebe	13	0.04	1
Eastern Kingbird	83	0.24	21
Eurasian Collared-Dove	136	0.39	18
European Starling*	1291	3.66	38
Evening Grosbeak	3	0.01	1
Ferruginous Hawk	16	0.05	10
Field Sparrow	2	0.01	1
Forster’s Tern	1	<0.01	1
Fox Sparrow	27	0.08	4
Gadwall*	277	0.79	15
Golden Eagle	49	0.14	26

Table 2. Continued.

Species name	Number detected	Relative abundance (%)	Total routes
Golden-crowned Kinglet	2	0.01	1
Grasshopper Sparrow	181	0.51	17
Gray Catbird	48	0.14	17
Gray Flycatcher	2	0.01	1
Great Blue Heron	52	0.15	20
Great Horned Owl	10	0.03	8
Greater Sage-Grouse	58	0.16	6
Green-tailed Towhee*	258	0.73	31
Green-winged Teal	2	0.01	2
Hairy Woodpecker	21	0.06	8
Hammond’s Flycatcher	22	0.06	6
Hermit Thrush	131	0.37	14
Hooded Merganser	1	<0.01	1
Horned Lark*	1637	4.64	52
House Finch	31	0.09	9
House Sparrow	210	0.60	21
House Wren*	212	0.60	40
Indio Bunting	1	<0.01	1
Juniper Titmouse	2	0.01	1
Killdeer*	252	0.71	52
Lark Bunting*	2569	7.29	36
Lark Sparrow	195	0.55	31
Lazuli Bunting	85	0.24	17
Least Flycatcher	10	0.03	5
Lesser Goldfinch	1	<0.01	1
Lesser Scaup	62	0.18	8
Lincoln’s Sparrow	122	0.35	17
Loggerhead Shrike	54	0.15	23
Long-billed Curlew	34	0.10	5
MacGillivray’s Warbler	44	0.12	8
Mallard*	186	0.53	40
Marsh Wren	7	0.02	2
McCown’s Longspur	115	0.33	4
Mountain Bluebird*	212	0.60	42
Mountain Chickadee	127	0.36	19
Mountain Plover	5	0.01	1
Mourning Dove*	795	2.25	62
Northern Goshawk	1	<0.01	1
Northern Harrier	33	0.09	20

Table 2. Continued.

Species name	Number detected	Relative abundance (%)	Total routes
Northern Mockingbird	2	0.01	2
Northern Pintail	13	0.04	6
Northern Rough-winged Swallow	259	0.73	16
Northern Shoveler	9	0.03	5
Olive-sided Flycatcher	15	0.04	8
Orange-crowned Warbler	10	0.03	3
Orchard Oriole	1	<0.01	1
Osprey	15	0.04	9
Ovenbird	75	0.21	2
Peregrine Falcon	2	0.01	2
Pied-billed Grebe	7	0.02	2
Pine Grosbeak	16	0.05	2
Pine Siskin	300	0.85	17
Pinyon Jay	13	0.04	4
Plumbeous Vireo	13	0.04	3
Prairie Falcon	17	0.05	13
Purple Martin	1	<0.01	1
Red Crossbill	85	0.24	11
Red-breasted Nuthatch	77	0.22	16
Red-eyed Vireo	6	0.02	1
Redhead	64	0.02	2
Red-headed Woodpecker	6	0.05	4
Red-naped Sapsucker	19	0.69	9
Red-shafted Flicker*	245	0.37	49
Red-tailed Hawk	132	4.63	51
Red-winged Blackbird*	1634	0.18	62
Ring-billed Gull	18	0.05	3
Ring-necked Duck	18	0.05	3
Ring-necked Pheasant	173	0.49	16
Rock Pigeon	131	0.37	13
Rock Wren	169	0.48	43
Ruby-crowned Kinglet*	295	0.84	22
Ruddy Duck	5	0.01	2
Rufous Hummingbird	1	<0.01	1
Sage Thrasher*	586	1.66	44
Sagebrush Sparrow	198	0.56	17
Sandhill Crane	172	0.49	25
Savannah Sparrow	200	0.57	28
Say's Phoebe	49	0.12	25

Table 2. Continued.

Species name	Number detected	Relative abundance (%)	Total routes
Song Sparrow	277	0.79	35
Sora	19	0.05	10
Spotted Sandpiper	57	0.16	12
Spotted Towhee	105	0.30	21
Steller's Jay	1	<0.01	1
Swainson's Hawk	37	0.11	8
Swainson's Thrush	37	0.10	8
Townsend's Solitaire	18	0.05	9
Tree Swallow*	267	0.76	29
Trumpeter Swan	15	0.04	3
Turkey Vulture	59	0.17	20
Unidentified Buteo hawk	2	<0.01	2
Unidentified Empid. flycatcher	1	<0.01	1
Unidentified flicker	13	0.04	3
Unidentified gull	1	0.01	1
Unidentified. woodpecker	2	0.01	1
Upland Sandpiper	73	0.21	11
Veery	18	0.05	4
Vesper Sparrow*	906	2.57	60
Violet-Green Swallow	144	0.41	27
Virginia's Warbler	1	<0.01	1
Warbling Vireo*	291	0.83	30
Western Bluebird	1	0.00	1
Western Grebe	13	0.04	5
Western Kingbird	131	0.37	20
Western Meadowlark*	4633	13.14	68
Western Tanager	115	0.33	17
Western Wood-Pewee	205	0.58	37
White-breasted Nuthatch	8	0.87	5
White-crowned Sparrow	307	0.02	21
White-throated Swift	36	0.10	3
Wild Turkey	59	0.17	7
Willet	30	0.09	6
Williamson Sapsucker	3	0.01	2
Willow Flycatcher	27	0.08	8
Wilson's Phalarope	29	0.08	8
Wilson's Snipe	184	0.52	39
Wilson's Warbler	5	0.01	4
Wood Duck	2	0.01	1

Table 2. Continued.

Species name	Number detected	Relative abundance (%)	Total routes
Yellow Warbler*	431	1.22	45
Yellow-breasted Chat	18	0.05	6
Yellow-headed Blackbird	87	0.25	21
Total individuals	*35,261*		
Total species	*190*		

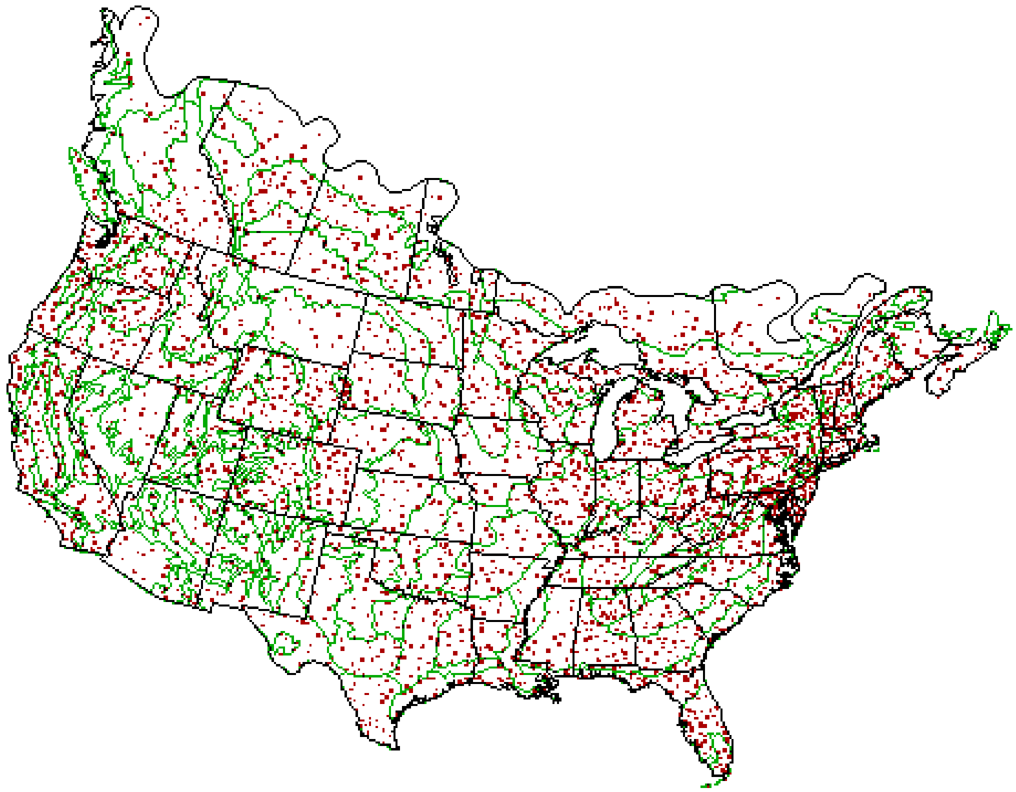

Figure 1. Location (red dots) of all Breeding Bird Survey routes in the United States and Canada (Sauer et al. 1997).

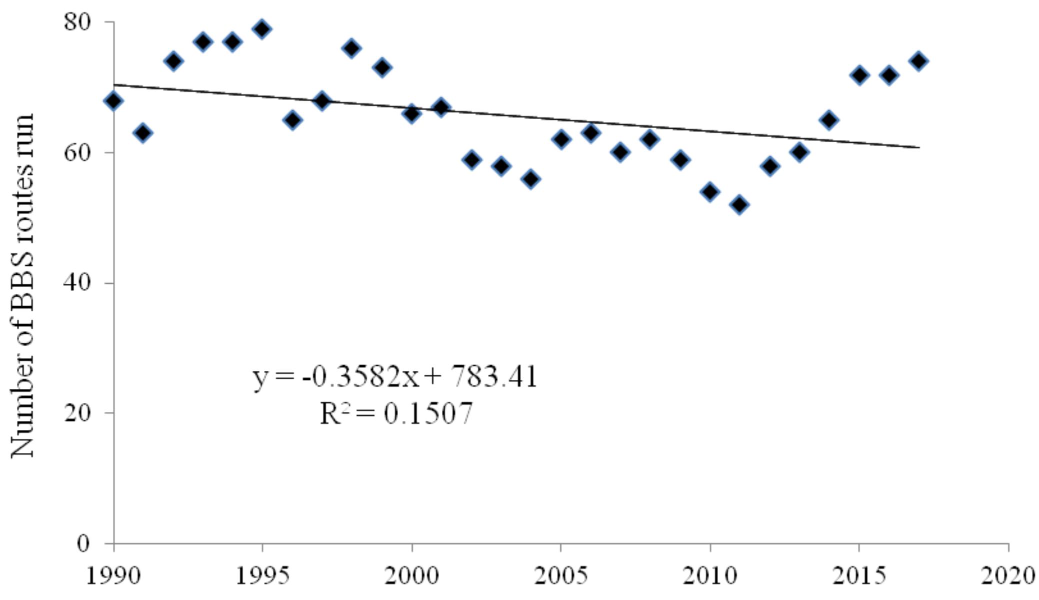

Figure 2. Number of Breeding Bird Survey routes completed in Wyoming, 1990-2017. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

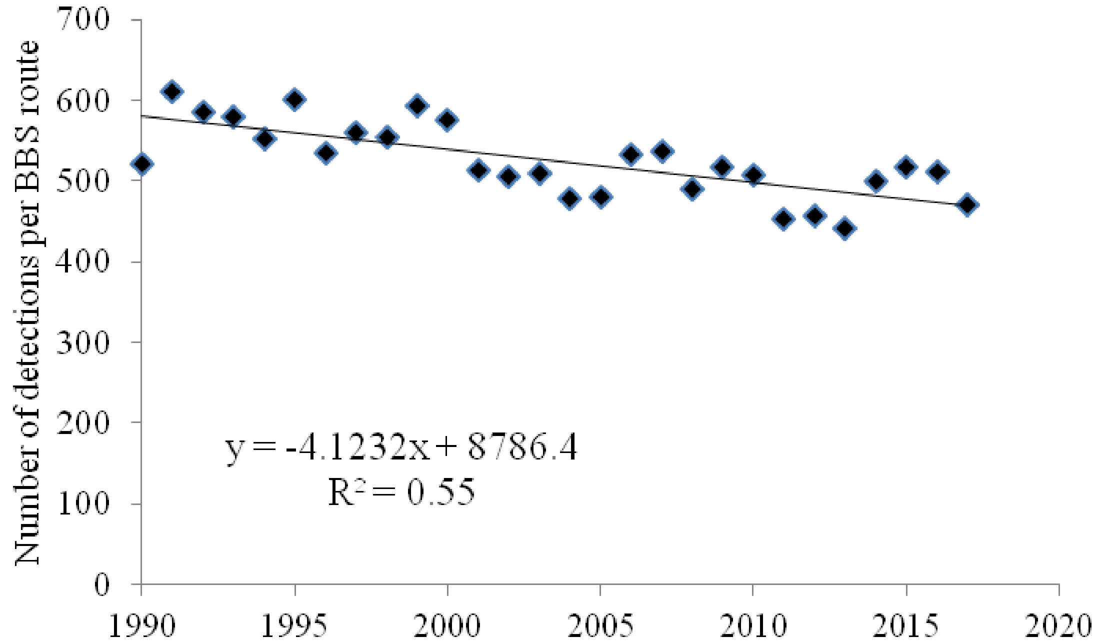

Figure 3. Average number of individual detections of birds per Breeding Bird Survey route in Wyoming, 1990-2017. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

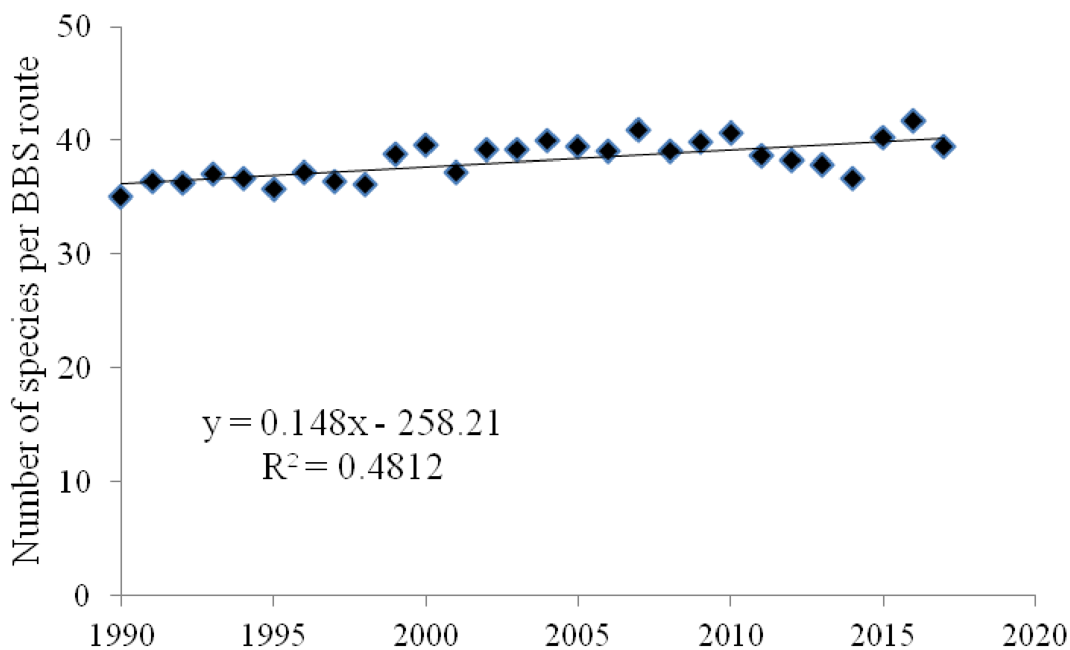

Figure 4. Average number of species detected per Breeding Bird Survey route in Wyoming, 1990-2017. Only currently active routes with data submitted to the Breeding Bird Survey are included in the analysis. The trend line is shown for reference.

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 Game and Fish Department

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Jim Dubovsky, US Fish and Wildlife Service
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 3 Canadian provinces (Saskatchewan, Alberta, and the Northwest Territories) that occur within the flyway. The function of the CFC 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 bird issues.

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 TC 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. 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 representative on the Central Flyway Nongame Migratory Bird Technical Committee (CFNMBTC). All current and ex-officio members of the CFNMBTC are presented in Table 1.

Since the its inception, the CFNMBTC has submitted 15 recommendations to the CFC for signing and submission, and 38 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 in Tables 2 and 3, respectively.

Table 1. Members of the Central Flyway Nongame Migratory Bird Technical Committee.

State/ Province/ Agency	Name	Representing
CO	Liza Rossi	Colorado Parks and Wildlife
KS	Daren Riedle	Kansas Department of Wildlife, Parks, and Tourism
MT	Allison Begley	Montana Fish, Wildlife, and Parks
ND	Sandy Johnson	North Dakota Game and Fish Department
NE	Joel Jorgensen	Nebraska Game and Parks Commission
NM	Erin Duvuvuei	New Mexico Department of Game and Fish
OK	Mark Howery	Oklahoma Department of Wildlife Conservation
SD	Eileen Dowd-Stukel	South Dakota Department of Game, Fish, and Parks
TX	Clifford Shackelford	Texas Parks and Wildlife Department
WY	Andrea Orabona	Wyoming Game and Fish Department
AB	Jason Caswell	Alberta Environment and Parks
NT	Suzanne Carriere	Northwest Territories Department of Environment and Natural Resources
SK	Katherine Conkin	Saskatchewan Ministry of Environment
CWS*	Jeff Ball	Canadian Wildlife Service
CWS*	Blake Bartzen	Canadian Wildlife Service
USFWS*	Jim Dubovsky	United States Fish and Wildlife Service
USFWS*	Kammie Kruse	United States Fish and Wildlife Service
USFWS*	Scott Somershoe	United States Fish and Wildlife Service

* Ex-officio members

Table 2. Summary of recommendations submitted by the Central Flyway Nongame Migratory Bird Technical Committee since 2007. Atlantic Flyway (AF); Central Flyway (CF); Central Flyway Council (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 TCs.
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 permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends an equitable distribution of 36 1st 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 1st year migrant peregrine falcons for Texas and 2 1st year migrant Peregrine Falcons for Oklahoma for the 20 September to 20 October 2009 trapping season only.

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
March 17, 2009	15	Allocation of permits for the nestling/post-fledgling 1st year take of Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends allocating 5 nestling/post-fledgling 1st 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 permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends that 12 of the 36 1st year migrant Peregrine Falcon take permits be allocated to the CF for the fall of the 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 Team.	The CFC recommends that a Central Flyway Nongame Migratory Bird TC representative is included on the USFWS's Eagle Technical Assessment Team.
March 15, 2011	15	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	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 13, 2012	14	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	The CFC recommends a continuation of the alternative outlined above (Recommendation #15).

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
July 25, 2013	12	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude.	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.
July 24, 2014	8	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude and south of 31° N latitude.	The CFC supports continuing equal distribution of the 36 permits for passage take Peregrine Falcons for falconry in 2014. For the 20 September to 20 October 2014 trapping season, 12 permits each would be allocated to the Central, Mississippi, and Atlantic Flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.
July 24, 2015	12	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	The CFC supports continuing the equal distribution of the 36 permits for passage take of Peregrine Falcons for falconry in 2016. For the 20 September to 20 October trapping season, 12 permits each would be allocated to the Central, Mississippi, and Atlantic flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.
March 15, 2016	6	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry purposes in the US east of 100° W longitude and south of 31° N latitude.	The CFC supports continuing the equal distribution of the 36 permits for passage take of Peregrine Falcons for falconry in 2016. For the 20 September to 20 October trapping season, 12 permits each would be allocated to the Central, Mississippi, and Atlantic flyways. The Central Flyway's 12 permits would be allocated as such: 10 to Texas, 2 to Oklahoma.

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
September 23, 2016	19	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	The CFC supports continuing the equal distribution of the 36 permits for passage take of Peregrine Falcons for the 20 September to 20 October 2017 trapping season. Twelve permits each would be allocated to the Central, Mississippi, and Atlantic Flyways.
September 23, 2016	21	Limit the precision of banding data for the public.	The CFC recommends that the USGS Bird Banding Lab limit public reporting of banding data to the 1-degree block level (60 x 60 minutes) for bandings and encounters for game birds and federally listed species.
March 7, 2017	6	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	The CFC requests the US Fish and Wildlife Service increase the maximum allowable take from 36 to 144 passage Peregrine Falcons, with an equal allocation of 48 permits to the Central, Mississippi, and Atlantic Flyways, beginning in 2017.
August 31, 2017	6	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	This is a provisional recommendation in response to the pending increase in the number of Peregrine Falcon passage take permits for the flyways east of 100° W longitude and south of 31° N latitude from 36 to 144, with an equal allocation of 48 permits to the Central, Mississippi, and Atlantic Flyways. Within the Central Flyway, we recommend that the 48 permits be allocated as follows: 30 permits to Texas (with 40% reserved for out-of-state falconers), 6 permits to Oklahoma, 6 permits to Kansas, and 6 permits to Nebraska.
August 31, 2017	8	Procurement of a 5-year supply of M6 rocket net propellant and testing of PAP 7993 for state and federal use.	The CFC recommends funding the procurement of a 5-year supply of M6 rocket charge propellant and testing of PAP 7993 propellant as a potential replacement. Funding for the Central Flyway portion will be $19,500.

Table 2. Continued.

Date	Recommendation #	Pertaining to	Recommendation
August 31, 2018	13	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	The CFC recommends the 48 permits available to the Central Flyway for the September 20, 2019 to October 20, 2019 trapping season be allocated among states as follows: 30 permits to the state of Texas with the understanding that 40% of the permits will be reserved for nonresident falconers, 6 permits to the state of Oklahoma, 6 permits to the state of Kansas, and 6 permits to the state of Nebraska.
March 5, 2019	3	Allocation of permits for the passage take of 1st year Peregrine Falcons for falconry in the US east of 100° W longitude and south of 31° N latitude.	The CFC recommends the 48 permits available to the Central Flyway for the September 20, 2019 to October 20, 2019 trapping season be allocated among states as follows: 30 permits to the state of Texas with the understanding that 40% of the permits will be reserved for nonresident falconers, 6 permits to the state of Oklahoma, 6 permits to the state of Kansas, and 6 permits to the state of Nebraska.
March 5, 2019	4	Golden Eagle Allocation Procedure.	The CFC recommends the process detailed in the March 2019 document, *Golden Eagle Allocation Procedure*, prepared for the National Flyway Council be used to allocate take of golden eagles for falconry.

Table 3. 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 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
January 11, 2007	Robert Blohm, Acting Chief, Division of Migratory Bird Management, USFWS	• Reopening of comment period: Protection of Bald Eagles; Definition of ''Disturb''	• Reinforced our June 9th and 12th 2006 comments. • Suggested this definition, with our additions in italics: "Disturb means to agitate or bother a bald or golden eagle to the degree that causes *or is likely or predicted to cause* (i) *repeated displacement*, injury, or death to an eagle (including chicks and eggs) due to interference with breeding, feeding, or sheltering behavior, or (ii) nest *site or communal roost* abandonment or *likely or predictable abandonment of nest site or communal roost*."
March 6, 2007	Central Flyway Council	• Participation of Canadian provinces in 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.
August 31, 2007	Jody Millar, Bald Eagle Monitoring Coordinator, USFWS	• Draft Post-delisting Monitoring Plan for Bald Eagles	• Plan is generally well developed, but we are disappointed that the sampling plan was not completed, approved, and ready for implementation prior to Bald Eagle delisting. • "Troubled at the apparent lack of dedicated funding to support the monitoring effort." • Unclear as to what exactly is expected of the states.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
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 Eagle Management Guidelines be developed. • Recommend the Service consider development of monitoring strategy for Golden Eagles. Lacking "defensible information on the status and trends of Golden Eagle populations".
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 US 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.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
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.
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.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
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	US Senators Feinstein and Alexander, -and- US Representatives Dicks and Simpson	• State Wildlife Grants program appropriation	• Requests funding for the State Wildlife Grants program at a level of $90 million during FY2011 and retention of the 65:35 cost-share ratio, which Congress enacted during FY2010.
March 23, 2010	George Allen, Chief Branch of Permits and Regulations, USFWS	• Bird Banding Lab letter	• The CFC requested that each of the four flyways be allowed a 120-day review period in order to evaluate and prepare a coordinated response among our TC.
March 4, 2011 (original) August 10, 2011 (signed)	USFWS	• Double-crested Cormorant letter	• The CFC had several questions about the USFWS's long-term vision to manage Double-crested Cormorants before we develop a flyway management plan.
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.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 13, 2012	USFWS	• Double-crested Cormorant management	• Comments to Federal Register Notice of Intent regarding Double-crested Cormorant management.
October 5, 2012	George Allen, USFWS	• Blackbird depredation	• Informal comments regarding a Pre-publication Draft Proposed Rule Regarding Amendments to the Migratory Bird Treaty Act.
October 9, 2012	Central Flyway Webless and Waterfowl Technical Committees	• Technical Committees' species responsibility	• Request for dialogue to improve how the different TCs address issues related to species based current Flyway structure. Non-hunted species currently fall under the responsibility of the TCs that traditionally 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.
April 8, 2013	George Allen, USFWS	• Raptor rehabilitation and falconry regulations	• Courtesy response expressing gratitude for the opportunity to comment on pre-publication draft Proposed Rule regarding revisions to rehabilitation and falconry regulations.
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 the best available information.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
July 22, 2014 (email sent)	Dave Morrison (TX)	• Double-crested Cormorant management	• Management Plan that the CFNMBTC compiled, as requested by the CFC.
March 6, 2015	Central Flyway Council	• Southern Wings Program	• Increased awareness of the Southern Wings Program, and support from the CFNMBTC.
March 6, 2015	Central Flyway Council	• CFNMBTC activities	• A brief update to the CFC on CFNMBTC activities to-date. Included correspondence and recommendations logs.
March 10, 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.
July 23, 2015	Central Flyway Council	• CFNMBTC activities	• A brief presentation to the CFC on CFNMBTC activities to-date. Included general activities, 2012 NTC review, CFNMBTC thoughts, CFNMBTC recent activities, and MBTA Take Notice of Intent.
July 24, 2015	USFWS	• PEIS for evaluating the potential to authorize incidental take of migratory birds under the MBTA	• Comments were provided on 13 of the 15 various points of consideration, as well as in the "other comments" section.
February 24, 2016	Brian Millsap	• Peregrine Falcon isotope analysis	• Formal request from the CFNMBTC for a complete isotope analysis report prior to the September 2016 CFNMBTC meeting.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
February 24, 2016	Scott McNuff	• Comments on increasing the take quota for Peregrine Falcons	• CFNMBTC will review the newly released "Population Estimates for Northern Juvenile Peregrine Falcons with Implications for Harvest Levels in North America". • Requested a final isotope analysis report from USFWS prior to the annual CFNMBTC meeting in September 2016. • Will recommend to the CFC to continue the same level of take.
May 27, 2016	USFWS	• Request a 30-day extension to the comment period for the proposed rule "Revisions to Regulations for Eagle Incidental Take and Take of Eagle Nests"	• Proposed rule will have widespread and long-term implication to Bald and Golden Eagle management in the US. • Close scrutiny of the large amount of information in the rule and supporting documents is necessary and coordination of review within and among states requires time to thoughtfully complete. • Current 60-day comment period is insufficient.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
July 5, 2016	USFWS	• Comments on revisions to regulations for eagle incidental take and take of eagle nests	• Makes biological sense to define Eagle Management Units (EMUs) along flyway boundaries with the condition that local-area population thresholds are analyzed and enforced. However, management under EMUs could negatively impact states with small populations of breeding Bald Eagles. USFWS should adequately address issues of highly variable populations and massive ecological gradients within the large EMUs. • Agree with the proposed language changes to simplify and standardize the permitting process. • Agree with the decision to authorize Golden Eagle take only in instances where the take is at least equally offset by compensatory mitigation. • Support the USFWS proposal for long-term Bald and Golden Eagle population monitoring, and request that necessary funding is provided by the USFWS. • CFC has identified several areas where the proposed rule is not beneficial to eagles or where further clarification is needed (e.g., in-lieu fee programs, clarification on if the proposed rule is retroactive, proposed Bald Eagle take, 30-year permit for industry is not biologically sound, funding and staffing are needed to implement the proposed rule).

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
September 23, 2016	Robert Ford, National PIF Coordinator	• Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental US	• Concerned that none of the Plan's project leads or authors represented either state wildlife agencies or NTCs. • Concerned that none of the CF states had the opportunity to review or provide any input, which does not foster Plan ownership.
September 23, 2016	US Congress	• Recovering America's Wildlife Act	• Support passing H.R. 5650, Recovering America's Wildlife Act.
September 23, 2016	Brad Bortner, USFWS	• Failure of falconry permitting turned over to the states	• Electronic system stopped working in June 2016 so database was inaccessible to states and falconers. • Duration of the database outage has been problematic and burdensome for state wildlife agencies. • Suggested that the USFWS provide adequate resources to ensure a similar outage does not occur in the future, improve communication and coordinate with states, provide a technical point-of-contact, and provide backup database copies during an outage.
March 7, 2017	Jerome Ford, USFWS	• Comments on increasing the take quota for Peregrine Falcons	• Take can be increased based on recent population estimate. • Stable isotope analyses show that ~75% of hatch-year peregrines originate from the Northern Management Population. • Split increased take between the 3 flyways at 48 each. • Use adaptive management for setting the population estimate.

Table 3. Continued.

Date	Recipient	Issue(s)	CF Key Remark(s)
March 7, 2017	Brad Bortner, USFWS	• Joint administration of falconry between the USFWS and state wildlife agencies	• Electronic falconry database initial outage was June 2016; database is still inaccessible to falconers and state wildlife agencies. • Broader concerns from 9/23/2016 letter were not addressed.
August 30, 2018	Jerome Ford, USFWS	• Decline of Black-billed Magpies	• CFC recommends that the USFWS remove OK, KS, NE, SD, and ND from the existing depredation order allowing take of Black-billed Magpies unless justification can be provided for retaining the depredation order in these states.
December 7, 2018	USFWS Public Comments Processing	• 12-month petition finding and proposed Threatened status for Eastern Black Rail with Section 4(d) rule.	• CFC has concerns regarding proposed 4(d) rules for wetland management restrictions. • Recommend the application of the final 4(d) rule be limited to locations where Eastern Black Rails are known to occur and breed regularly.

WYOMING BIRD RECORDS COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Rare and Unusual Birds

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

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2018 – 31 December 2018

PREPARED BY: Courtney Rudd, Nongame Biologist
Andrea Orabona, Nongame Bird Biologist

SUMMARY

The Wyoming Bird Records Committee (WBRC) was established by the Wyoming Game and Fish Department (Department) Nongame Program in 1989 to accomplish the following goals:

1) To solicit, organize, and maintain records, documentation, photographs, audio recordings, and any other material relative to the birds of Wyoming.
2) To review records of new or rare species or species difficult to identify and offer an intelligent, unbiased opinion of the validity or thoroughness of these reports. From these reviews, the WBRC will develop and maintain an Official State List of Birds in Wyoming.
3) To disseminate useful and pertinent material concerning the field identification of Wyoming birds in order to assist Wyoming birders and ornithologists with increasing their knowledge and skill.

The WBRC is interested in promoting and maintaining quality and integrity in the reporting of Wyoming bird observations, and it treats all bird records as significant historical documents. The WBRC operates under a set of bylaws approved in 1991 and updated in 1992, 1998, and 2015.

As of 31 December 2018, the WBRC has reviewed 1,428 reports of rare and unusual birds in Wyoming. A total of 1,164 (82%) have been accepted and 264 (18%) have not been accepted. A total of 15 reports were submitted in 2018. Of those, 11 were accepted, 3 were not accepted, and 1 record is out for further review based on the initial vote count.

The WBRC Database is a dynamic document, typically updated once or twice a year following the WBRC meetings. A full report of all sightings submitted to the WBRC through 2018,

species for which the WBRC requests documentation, rare and unusual bird sighting forms, information on how to document rare and unusual birds, and the WBRC bylaws are available from the Nongame Bird Biologist in the Department's Lander Regional Office or on the Department's website: https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Nongame-Birds.

ACKNOWLEDGEMENTS

Partial funding was provided through a Cooperative Agreement with the Bureau of Land Management, for which we are extremely grateful. We wish to thank all observers for taking the time to submit their sightings to the WBRC. We are also indebted to the following Wyoming Bird Records Committee members for their invaluable efforts during the 2018 reporting year: S. Billerman, M. Fraker, G. Johnson, D. Jones, J. Maley, and F. Stetler.

WYOMING BAT WORKING GROUP ANNUAL SUMMARY

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

FUNDING SOURCE: Unites States Fish and Wildlife Service State Wildlife Grant

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 30 March 2019

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist
Laura Beard, Nongame Biologist

SUMMARY

The Wyoming Bat Working Group (WYBWG) is a subgroup of the larger Western Bat Working Group, which coordinates management and conservation of bats in the western US. Both groups were formed in the mid-1990s to address growing concern over the status of the Townsend's big-eared bat (*Corynorhinus townsendii*; COTO). After the development of the COTO Conservation Assessment and Strategy (Pierson et al. 1999), emphasis broadened to include all bat species. The WYBWG is comprised of representatives from several federal and state agencies, local conservation districts, and non-governmental organizations.

The WYBWG has focused considerable resources on addressing potential threats to populations of bats in Wyoming. Perhaps the largest concern for bats in the US currently is white-nose syndrome (WNS), caused by the fungus *Pseudogymnoascus destructans*. Severe declines in abundance have been reported at many hibernacula in the eastern US. Since its introduction, *P. destructans* has been slowly progressing westward, and, in the spring of 2018, the fungus was detected for the first time in Wyoming in Goshen County (USFWS 2018). In an effort to prepare for the potential arrival of WNS in Wyoming, the WYBWG drafted a strategic plan to guide and coordinate management response to this potential threat in Wyoming (Abel and Grenier 2010). The plan provides guidance on addressing the threat of WNS and standardizes management actions to facilitate detection of the fungus. The WYBWG and Wyoming Game and Fish Department (Department) continue to implement strategies in the plan, the most recent of which was the development of a WNS risk assessment to prioritize roosts in need of monitoring or management activities (Bjornlie et al. 2018). However, because our knowledge of WNS is rapidly growing, the plan is already out of date. Consequently, the WYBWG has developed a subcommittee that is in the process of updating this plan in light of new research and protocols. In addition, partners within the WYBWG continue to coordinate on cave and mine surveys to locate and monitor hibernacula for bat use. These surveys contribute to routine

population monitoring and help address closure needs for both bat and human safety. Finally, the WYBWG continues to collaborate on surveillance for the presence of *P. destructans* and WNS in an effort to detect the disease early and implement appropriate management actions.

With assistance from the WYBWG, the Department, along with other partners, began implementing the North American Bat Monitoring Program (Loeb et al. 2015) in 2016 at sites throughout Wyoming, with statewide implementation in 2018. This program, similar to the Breeding Bird Survey for avian species, is a North America-wide effort to conduct annual monitoring of bats, including hibernacula and maternity counts and acoustic surveys. Through the Department, the WYBWG will coordinate on surveys to ensure state- and agency-level needs are addressed.

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WYOMING BLACK-FOOTED FERRET WORKING GROUP ANNUAL SUMMARY

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Black-footed ferret

FUNDING SOURCE: United States Fish and Wildlife Service Section 6 Funding
Unites States Fish and Wildlife Service State Wildlife Grants
Wyoming Game and Fish Department Commission Funds

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2018 – 14 April 2019

PREPARED BY: Nichole Bjornlie, Nongame Mammal Biologist
Dana Nelson, Nongame Biologist

SUMMARY

In October 2015, the US Fish and Wildlife Service (Service), in collaboration with the Wyoming Game and Fish Department (Department), established a statewide 10(j) designation for black-footed ferrets (*Mustela nigripes*; ferrets) in Wyoming (USFWS 2015). The 10(j) rule, a designation under the Endangered Species Act, allows a listed species to be considered a nonessential experimental population within a specific area. This designation removes the penalties associated with accidental take (e.g., harming or killing) while conducting an otherwise legal activity, thereby providing assurances for landowners to voluntarily accept listed species onto their property while continuing ongoing land management practices without repercussions for accidental take. The rule was an expansion of a pre-existing 10(j) designation in Shirley Basin (USFWS 1991) that allowed the Department to establish the first ferret reintroduction site near Medicine Bow in 1991. This new rule allowed the Department and the Service, in collaboration with private landowners, to establish the first new ferret reintroduction site in the state in 25 years. On 26 July 2016, 36 ferrets were successfully reintroduced to the Pitchfork and Lazy BV Ranches outside of Meeteetse (Boulerice 2017).

In the initial stages of the development of the expanded 10(j) designation, the Department and the Service, in partnership with APHIS – Wildlife Services, Bureau of Land Management (BLM), US Forest Service, Natural Resources Conservation Service, and Wyoming Department of Agriculture, developed a Memorandum of Understanding (MOU) in order to ensure that all parties would maintain open dialogue about all ferret management efforts in the state. In light of this MOU, and because the statewide 10(j) designation expands the potential for ferret reintroduction efforts statewide, the need to establish a formal, collaborative, multi-agency group to develop support for current and future management efforts for ferrets became apparent.

Consequently, in 2016 we reinstituted the Wyoming Black-footed Ferret Working Group (Working Group). Comprised of representatives from several federal, state, and local agencies and non-governmental organizations, including the signatories to the MOU, the objective of the Working Group is to complement and assist the Department and the Service with on-going ferret recovery efforts in Wyoming. To that end, the Working Group will advise and assist the Department and the Service by:

1. Providing general input on ferret and prairie dog (*Cynomys* spp.) management,
2. Providing input on prairie dog towns identified as biologically suitable ferret reintroduction sites,
3. Assisting with development and revision of a Wyoming-specific ferret recovery plan,
4. Communicating openly to avoid resource conflicts and working collaboratively towards ferret recovery, and
5. Providing agency-specific assistance (e.g., assistance with plague management efforts, ferret and prairie dog monitoring, predator control, and prairie dog boundary control).

In 2018, the Working Group, with the support of multiple collaborators, was able to acquire funding to dust approximately 3,000 acres and apply sylvatic plague vaccine on approximately 1,000 acres of prairie dog colonies in Meeteetse in an on-going effort to manage and minimize the impacts of a sylvatic plague outbreak. All plague management efforts were coordinated and conducted by Wildlife Services. The BLM has secured funding to fully cover plague management efforts at the Meeteetse reintroduction site through 2021. Additionally, the Working Group provided assistance for ferret monitoring efforts in both Shirley Basin and Meeteetse. Finally, the subcommittee tasked with developing a Wyoming ferret management plan completed this effort, and the plan was approved by the Wyoming Game and Fish Commission on 14 November 2018 (WGFC 2018). The management plan addresses 3 primary objectives:

1. Establish recovery and management goals for ferrets in Wyoming,
2. Define a process by which ferret reintroduction sites are initiated and maintained throughout Wyoming in a manner that achieves recovery and management goals, and
3. Outline a framework for ferret management that allows for adaptive changes to species recovery throughout the state.

In conjunction with the management plan, the subcommittee also finalized a matrix to help identify and prioritize new reintroduction sites for ferrets in Wyoming. The matrix will be maintained as a living document, and will be used for the first time once the Department and the Service are in the position to move forward with another new reintroduction site in Wyoming.

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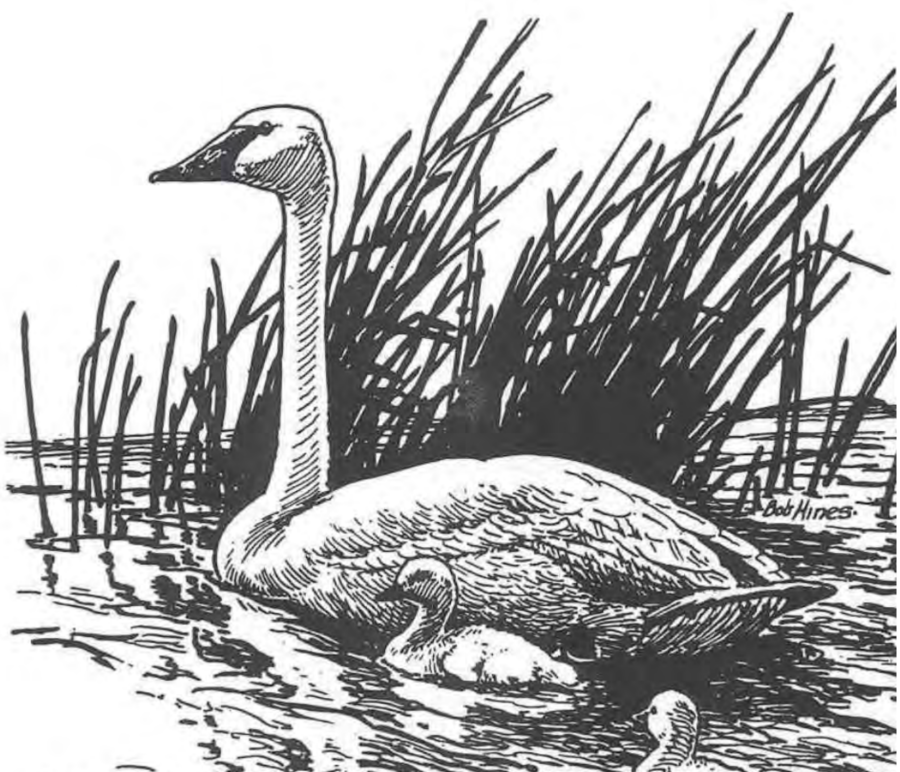
APPENDIX I
OTHER REPORTS

U.S. Fish and Wildlife Service

Trumpeter Swan Survey of the Rocky Mountain Population, U.S. Breeding Segment

Fall 2018



ACKNOWLEDGMENTS

We would like to especially thank the personnel who conducted the surveys, a list of whom is provided in Appendix B. The survey was a collaborative effort among Red Rock Lakes NWR, Migratory Birds and State Programs -- Mountain-Prairie Region of the U.S. Fish and Wildlife Service, the Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Southeast Idaho National Wildlife Refuge Complex, National Elk Refuge, Harriman State Park, Idaho Department of Fish and Game, Grand Teton National Park, Yellowstone National Park, Montana Fish, Wildlife and Parks, Wyoming Game and Fish Department, Ruby Lake NWR, Oregon Department of Fish and Wildlife, Malheur NWR, Confederated Salish and Kootenai Tribes - Flathead Indian Reservation , and the Shoshone-Bannock Tribes.

TRUMPETER SWAN SURVEY
of the
ROCKY MOUNTAIN POPULATION,
U.S. BREEDING SEGMENT

FALL 2018

U.S. Fish and Wildlife Service
Migratory Birds and State Programs
Mountain-Prairie Region
Lakewood, Colorado

January 30, 2019

Prepared by: ______________________
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Abstract –Observers counted 1,043 swans (white birds and cygnets) in the U.S. Breeding Segment of the Rocky Mountain Population of trumpeter swans during fall of 2018, which was a 8.1% increase from last year's count (965). The number of white birds in the Greater Yellowstone Area (600) was similar to last year's count of 595. The total number of cygnets increased 27.8%, from 115 in 2017 to 147 in 2018. Cygnet counts increased from 2017 by 148.3% for Montana but decreased by 15.5% and 7.14% for Wyoming and Idaho respectively. Twenty-eight white birds were observed at the Summer Lake Wildlife Management Area (WMA), which was an increase of 33.3% from last year's count of 21, and 4 white birds were observed at Malheur National Wildlife Refuge (NWR). Nevada did not do a survey this year. Precipitation throughout most of the Greater Yellowstone Area was 100% – 150% of normal during winter 2017 - 2018. During the summer months, temperatures were average while precipitation was 75% – 100% of normal, especially during June - August. Palmer Drought Indices for areas within the Greater Yellowstone area increased slightly during 2018 compared to last year and was near normal for the area for 2017.

The Fall Trumpeter Swan Survey is conducted annually in September. The survey is conducted cooperatively by several administrative entities and is intended to provide a good index to abundance of the Rocky Mountain Population (RMP) trumpeter swans that summer in the U.S. The history of the survey dates back to the 1930s, although methods and survey coverage have changed over time as the number of swans increased and new technologies became available. To be consistent with previous reports, only data from 1967 to present were analyzed for this report. The data are used by managers to assess the annual status of the Greater Yellowstone Flocks and Restoration Flocks.

This report contains information only from the Greater Yellowstone Flocks [formerly Tri-state Area Flocks] and Restoration Flocks, collectively referred to as the RMP U.S. Breeding Segment. These terms for the groups of swans are consistent with the newly revised terminology of the Pacific Flyway Management Plan for the RMP of Trumpeter Swans (Pacific Flyway Council 2017).

NEW RMP TERMINOLOGY

The Pacific Flyway in August 2017 approved a new management plan for the RMP of trumpeter swans (Pacific Flyway Council 2017). This plan revised the terminology used to describe various breeding segments, flocks and geographic areas (Appendix A). Use of the term "Tri-state Area" was discontinued. To help facilitate this transition and maintain consistency with data contained in previous RMP U.S. Breeding Segment Fall Survey reports, this report will use the new terminology followed by the previous terminology in brackets to increase clarity.

The RMP of trumpeter swans consists of birds nesting primarily from Western Canada southward to Nevada and Wyoming and is comprised of two primary breeding segments: the RMP U.S. breeding segment and the RMP Canadian breeding segment (Fig. 1). The RMP U.S.

breeding segment is comprised of Greater Yellowstone flocks and restoration flocks in Montana, Idaho, Wyoming, Nevada, Oregon and Washington. Greater Yellowstone flocks summer in Yellowstone National Park and the portions of Idaho, Montana, and Wyoming within the Greater Yellowstone Area (Fig. 2). Most swans in the Greater Yellowstone flocks remain within this area in winter, where they intermingle with the much larger numbers of migrant trumpeter swans from Canada. The RMP Canadian breeding segment summers in southeastern Yukon Territory, southwestern Northwest Territories, northeastern British Columbia, and Alberta. The Greater Yellowstone Area is their primary wintering area, although evidence of dispersal to other wintering areas has increased in recent years.

The Greater Yellowstone Core Area represents that portion of the Greater Yellowstone Area within which almost all trumpeter swans in Idaho, Montana, and Wyoming summered and wintered during much of the 20th century, prior to the range expansion efforts that began in the late 1930s and which intensified during the 1980s (Cornely et al. 1985, Shea et al. 1993, Shea and Drewien 1999, Shea et al. 2013). It includes the entire Island Park region, Teton River drainage, Teton Basin, Henrys and South Forks of the Snake River south to Idaho Falls, and Camas NWR/Mud Lake area of Idaho; Red Rock Lakes NWR, Centennial Valley, Hebgen Lake, and upper Madison River drainage of Montana; and Yellowstone National Park, Grand Teton National Park, and the Snake River drainage in Wyoming (including the Jackson Hole area) south to Alpine (Fig. 3). The Greater Yellowstone Expansion Area includes the remainder of the Greater Yellowstone Area outside of the Greater Yellowstone Core Area.

Restoration flocks refer to groups of swans established outside of the Greater Yellowstone Area, which includes those flocks at Ruby Lake NWR, Nevada; Malheur NWR and Summer Lake WMA, Oregon; Turnbull NWR, Washington; and the Flathead and Blackfoot valleys of western Montana (Fig. 2). While some restoration flocks primarily winter near their breeding areas, others disperse widely.

Tri-state region refers to the entire state of Idaho, and portions of Montana and Wyoming within the Pacific Flyway (Fig. 2).

METHODS

The survey is conducted within a relatively short time frame to reduce the possibility of counting swans more than once due to movements of birds among areas. Aerial cruise surveys and ground surveys are used to count numbers of swans in the Greater Yellowstone Area [Tri-state Area], and sometimes are used in Nevada, Malheur NWR, and Summer Lake WMA and vicinity; ground surveys are used to count the number of swans in areas not covered by aerial surveys. During aerial surveys, data are collected by observers seated in a single-engine, fixed-winged aircraft. Flying altitude varies with changes in terrain and surface winds, but generally averages 30-60 m above ground level, and flight speed is between 135-155 kph. One to two observers and the pilot count white (i.e., adults and subadults) and gray (i.e., cygnets) swans in known or suspected summer habitats. Counts are not adjusted for birds present but not seen by aerial crews, and have an unknown and unmeasured sampling variance associated with them.

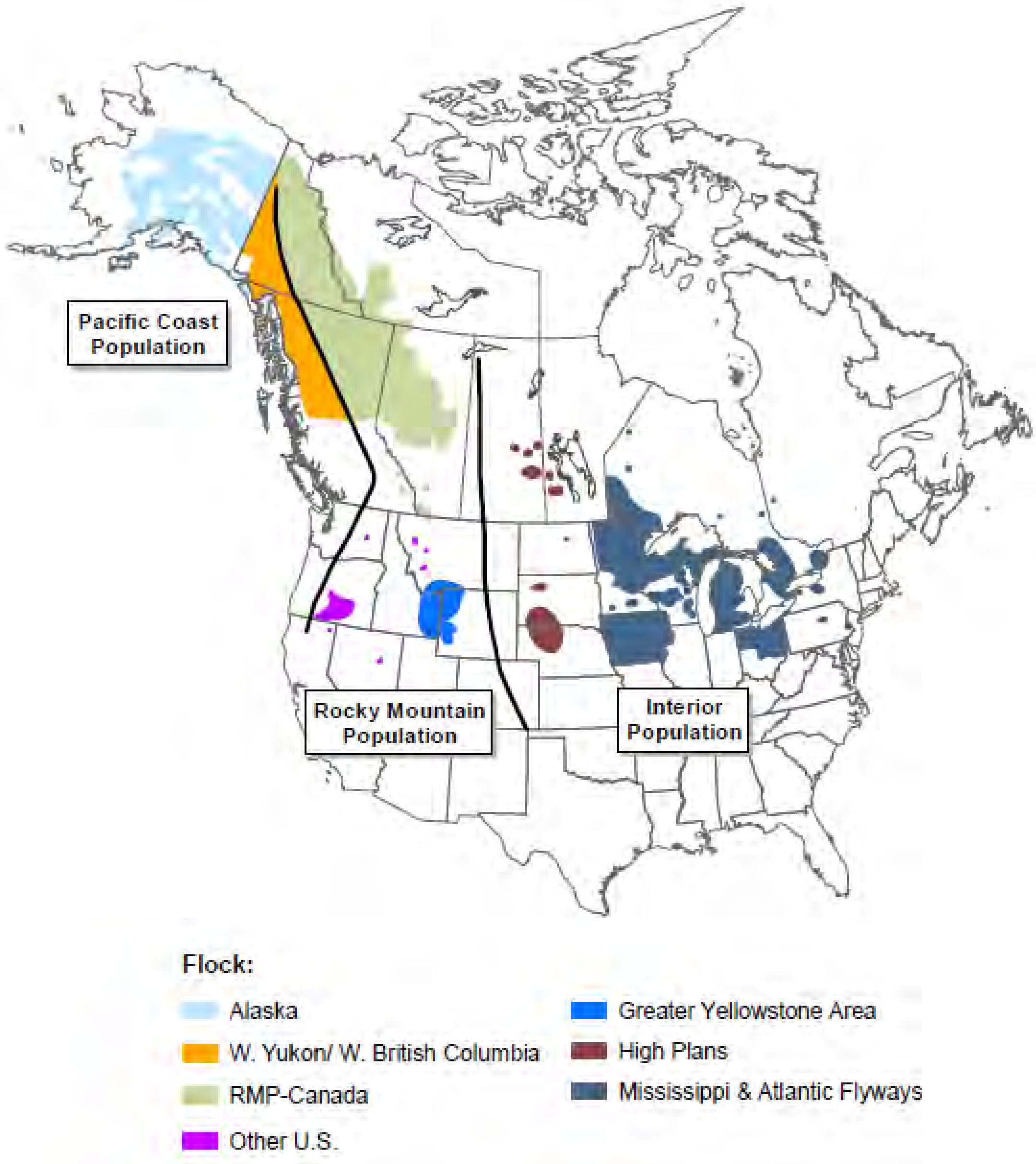

Fig. 1. Approximate summer range of the Pacific Coast, Rocky Mountain, and Interior Populations of trumpeter swans, as reported by North American Trumpeter Swan Survey cooperators (from Groves 2017).

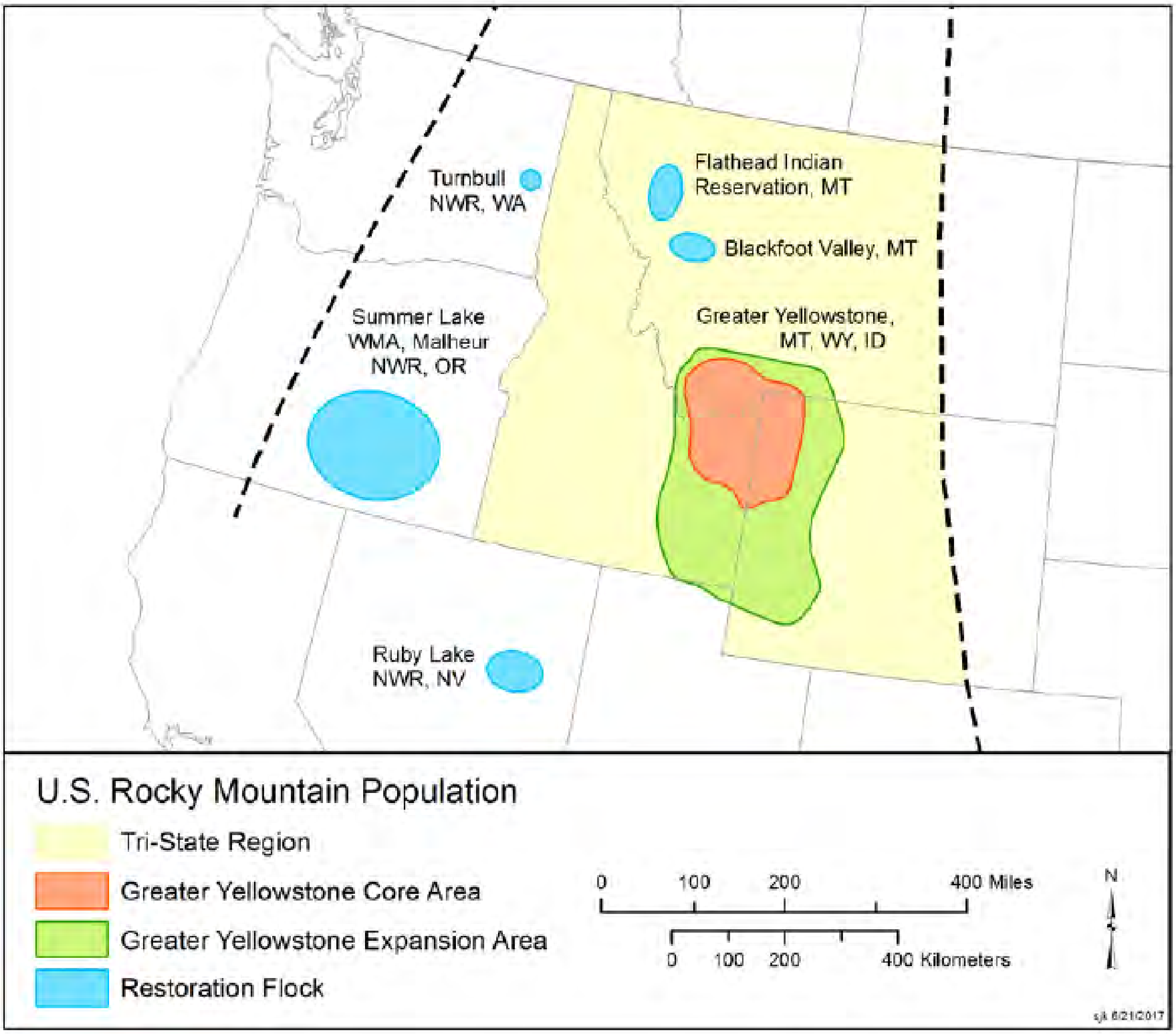

Fig. 2. High-concentration areas and Restoration flock areas of Rocky Mountain Population U.S. Breeding Segment trumpeter swans. Map courtesy of Sonya Knetter, Idaho Department of Fish and Game 2017.

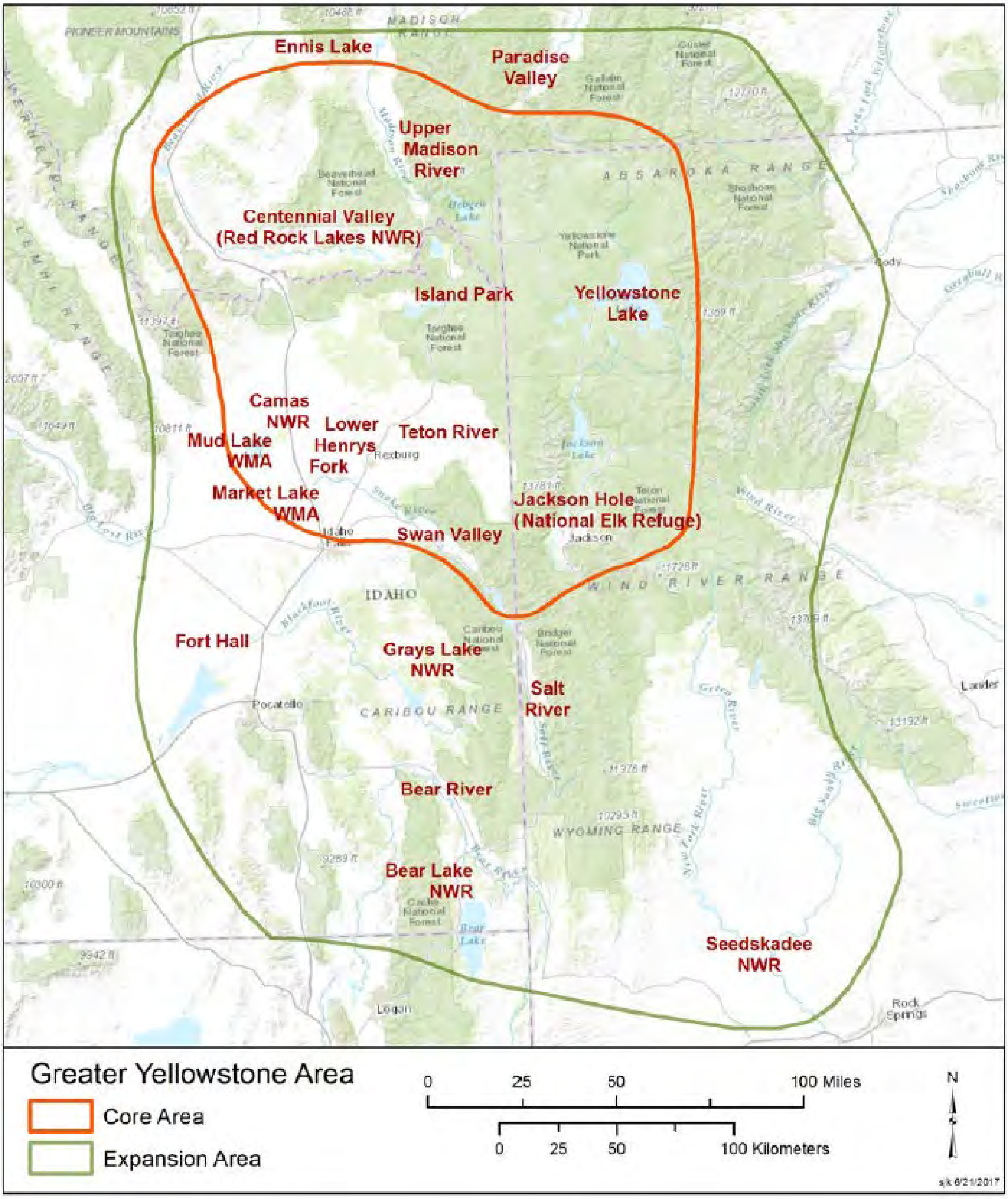

Fig. 3. Greater Yellowstone Area including both the Core and Expansion areas. Map courtesy of Sonya Knetter, Idaho Department of Fish and Game 2017.

During fall 2018, areas within the Greater Yellowstone Area were surveyed between 5 September and 21 September. This year in Idaho the swan flight was again combined with the September sandhill crane survey which led to a longer flight time, but otherwise did not detract from counting swans. Camas NWR, Idaho and Mud Lake and Market Lake WMA, Idaho were surveyed from the ground. The Paradise Valley and Hebgen Lake areas in Montana were not surveyed this year. Approximately 24 h of flight time and additional ground survey time were required to complete the survey. Weather conditions during surveys included sunny skies and calm winds in the morning changing to gusty winds and high overcast skies during the afternoon. Temperatures ranged from 45 degrees Fahrenheit in the morning to 60 degrees during the day.

We used least-squares regression on log-transformed counts to assess changes in growth rates for each of the swan flocks comprising the RMP U.S. Breeding Segment. The regression analysis included only data collected within the traditional surveyed areas. Counts from the current fall survey (2018) were compared to results from the earlier time frames, a practice used in U.S. Fish and Wildlife Service survey reports for other waterfowl (e.g., U.S. Fish and Wildlife Service 2018).

Core and Expansion Areas within the Greater Yellowstone Area

The Pacific Flyway Management Plan for RMP Trumpeter Swans has as a management objective to expand both the breeding and wintering range outside of the Greater Yellowstone Core Area (Core Area) (Pacific Flyway Council 2017). The Core Area was important in the early stages of trumpeter swan management due to the protection afforded to the swans by all the federal and state lands in that area. Those areas assisted in increasing the number of swans in the RMP U.S. Breeding Segment. However, while the number of swans increased, the amount of habitat available to support them did not. Expansion areas were identified and used to assist in redistributing swans and growing their numbers across the Greater Yellowstone Ecosystem.

In 2006, the Mountain-Prairie Region Migratory Bird Program of the U.S. Fish and Wildlife Service (USFWS) requested information from biologists that manage swans in the RMP to identify areas that have been surveyed since 1930's as either within or outside the Core Area. The Core Area is designated as the entire Island Park region, Teton River Drainage, Teton Basin, Henrys and South Forks of the Snake River, and Camas NWR of Idaho; Red Rock Lakes NWR, Centennial Valley, Hebgen Lake, and Madison River and tributaries of Montana; and Yellowstone National Park, Grand Teton National Park and the Snake River drainage in Wyoming, including the Jackson Hole area south to Alpine (Fig. 3) The Greater Yellowstone Expansion Area refers to portions of Montana, Idaho and Wyoming within the Pacific Flyway with suitable habitat for trumpeter swans, but outside of the Core Area. A list of these locations is provided in Table 3.

RESULTS AND DISCUSSION

Overall during winter 2017-18, areas within the summer range of the Greater Yellowstone Flocks received above-average precipitation (100 – 150% of normal). For the winter period, the temperature for much of the survey region was at the long-term average (Joint Agricultural Weather Facility 2017*a*). Average temperatures occurred throughout the region during spring. Spring precipitation was 150% to 200% of normal for the Greater Yellowstone Area (Joint Agricultural Weather Facility 2017*b*). By mid-summer, precipitation for the entire region was near normal (75% to 100%), while temperatures were average (Joint Agricultural Weather Facility 2017*c*). During mid-June, no drought conditions existed across the survey area (Fig. 4). The Palmer Drought Index for southwestern Montana (near the north-central portion of the core Greater Yellowstone Area) in June suggested slightly wetter conditions for 2018 compared to 2017 (Fig. 5).

Historical Trends

Historical (i.e., 1967 to the early 1990s) trends in abundance for the RMP U.S. Breeding Segment were described in a previous report (U.S. Fish and Wildlife Service 2003), and the details, including the dates used in those analyses, will not be reiterated here. Briefly, regression analyses suggested that the growth rate for total swans of the entire U.S. Breeding Segment did not change ($P = 0.27$) during 1967-88 (Table 1, Fig. 6). The rate for white birds appeared to decline slightly (-0.8% per year, $P [\beta<0] = 0.16$), while that for cygnets showed no trend ($P = 0.50$). Patterns for regression statistics for the Greater Yellowstone Flocks were similar to those for the RMP U.S. Breeding Segment (Fig. 7), because the vast majority of birds comprising the RMP U.S. Breeding Segment summer in the Greater Yellowstone Area (Table 1). However, the counts of white swans appeared to decline at a somewhat greater rate (-1.0% per year, $P = 0.09$) during 1967-88, compared to those for white birds in the entire RMP U.S. Breeding Segment.

Birds summering in Montana (Table 2) had patterns of change relatively similar to that of the Greater Yellowstone Flocks as a whole, because historically the swans in Montana comprised the majority of birds in the Greater Yellowstone Flocks. Total swans in Montana appeared to decline slightly (-1.2% per year) during 1967-88 (Fig. 8), although the value for the slope parameter was only marginally significant ($P = 0.16$). The decline existed only for white birds; counts for cygnets suggested no trend ($P = 0.95$). In Idaho, no trends in total or white swan counts were evident, but the counts for cygnets increased ($P = 0.03$) (Fig. 9). No trends in swan counts were evident in Wyoming (Fig. 10).

For Restoration Flocks, we analyzed historical data only for Malheur NWR (Oregon Flock) and Ruby Lake NWR. Swans were translocated to Summer Lake WMA (Oregon Flock) beginning in winter 1991, so there were no historical (i.e., pre-1988) data to analyze similar to the other areas. Plots of the swan counts for total birds and white birds at Malheur NWR suggested that a piecewise regression with a breakpoint at 1983 would fit the data better than a simple linear regression. For the period 1967-1983, no trend was evident in counts of total swans or white birds ($P \geq 0.17$) (Fig. 11). During 1984-1991, rates for total birds and white birds were negative but not statistically significant ($P \geq 0.15$). No trend in the rate for cygnets was evident for either time period ($P \geq 0.45$). Counts for the Nevada Flock ranged between 6 and 42 birds (Table 2), with no apparent long-term trends (Fig. 12).

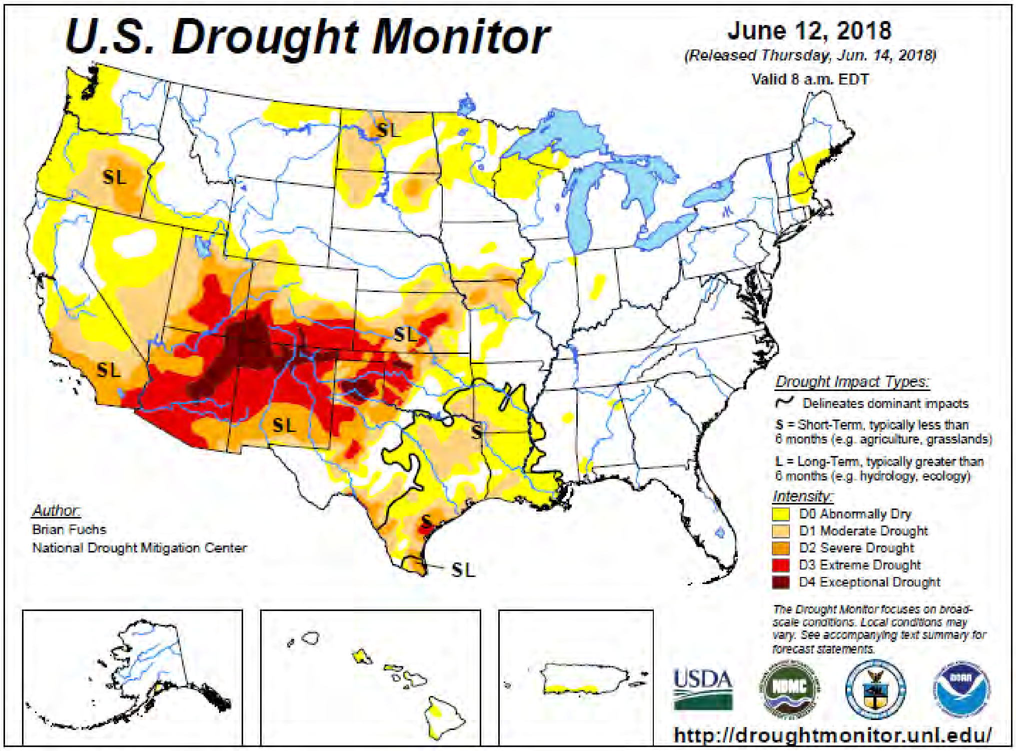

Fig. 4. Palmer Drought Index map for June 12, 2018 (Joint Agricultural Weather Facility 2018*d*).

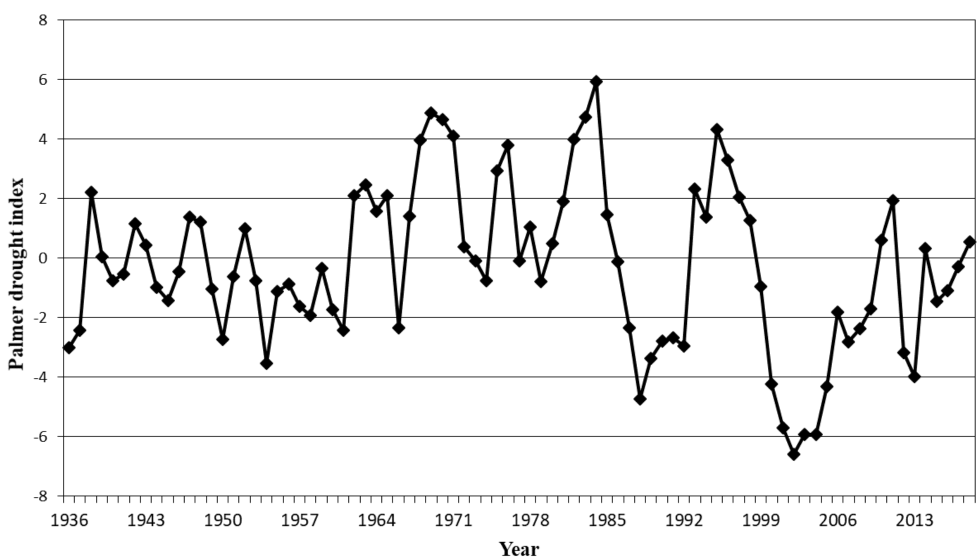

Fig. 5. Monthly Palmer Drought Indices for climate division 2 in southwest Montana (data from the National Climatic Data Center [http://www1.ncdc.noaa.gov/pub/data/cirs/climdiv/climdiv-pdsidv-v1.0.0-20181204]).

During 1988-92, several significant management actions affecting the RMP U.S. Breeding Segment occurred concurrently (e.g., termination of winter feeding, experimental translocations of swans [U.S. Fish and Wildlife Service 2003]), and may collectively have influenced the demographics of these birds. The number of swans in the RMP U.S. Breeding Segment (excluding counts for Summer Lake WMA) declined markedly (-51%) between the falls of 1988 and 1993, and the 1993 count was 44% below the 1967-88 average (Fig. 6). No marked changes in abundance were apparent for Restoration Flocks (Figs. 11, 12).

Recent Trends

Due to the inclusion of the birds from the successful restoration of the Confederated Salish Kootenai Tribes (CSKT) swans from Northwest Montana into the long term data set of swans for the RMP U.S. Breeding segment, there was a large increase in the total number of swans counted in the RMP beginning in 2015 (Fig. 6), and simply including those new birds in the existing regression was not appropriate. Therefore, a new trend starting with 2015 has been initiated. During 2015 - 2017, the growth rate for total swans in the RMP U.S. Breeding Segment remained stable ($P = 0.70$) while the number of white birds increased by 4.1 % ($P = 0.22$) (Fig. 5). Cygnet growth rate over this 3-year period decreased by 17.8 % ($P = 0.07$). Growth rates for swans in the Greater Yellowstone Flocks (1993 – 2017) increased by 3.0% ($P \leq 0.01$). White birds and cygnets also increased 2.8% and 3.9% respectively ($P < 0.01$) (Fig. 7).

The rate of growth for total swans in Montana increased 4.0% ($P \leq 0.01$ Fig. 8) per year since 1993 and the rate for white birds increased 4.2% per year ($P \leq 0.01$); the data for cygnets suggested an increase of 3.4% and was statistically significant ($P = 0.05$). In Idaho, no trend ($P = 0.81$) was evident for total swans. Similarly there was no trend for white birds ($P = 0.62$) nor a trend for cygnets ($P = 0.58$) (Fig. 9). For Wyoming during 1993-2017, total swans (+4.1% per year, $P < 0.01$), white birds (+3.5% per year, $P < 0.01$), and cygnets (+7.4 % per year, $P < 0.01$) increased (Fig. 10).

Because complete surveys of the Summer Lake WMA were not conducted during 2002-2004, we analyzed data for the Oregon Flock by region (i.e., Malheur NWR, Summer Lake WMA). As mentioned above, the data for total birds and white birds at Malheur NWR suggested a piecewise regression with a breakpoint at 1983 would fit the data better than a simple linear regression. The decline that occurred from 1984-91, (see above) continued during 1992-2015 (no survey was conducted in 2016) for both total swans (-9.1% per year, $P < 0.01$) and white birds (-8.3% per year, $P < 0.01$) (Fig. 11). The rate for cygnets also declined at -7.9% ($P < 0.01$). At Summer Lake WMA, swans were translocated to the area beginning in winter 1991, so data from fall 1992-2001 were analyzed. Regression analyses indicated large negative rates of growth for total birds (-15.7% per year, $P = 0.03$) and white birds (-19.9% per year, $P = 0.03$) (Fig. 13). No trend in the rate of cygnets produced was evident ($P = 0.62$), but few cygnets ever have been produced at this location (0-6 per year, $\bar{x} = 2.4$). However, during this timeframe, most birds were translocated to Summer Lake WMA during winter, primarily to alleviate potential negative impacts of high swan concentrations on habitats in the Harriman State Park area of eastern Idaho.

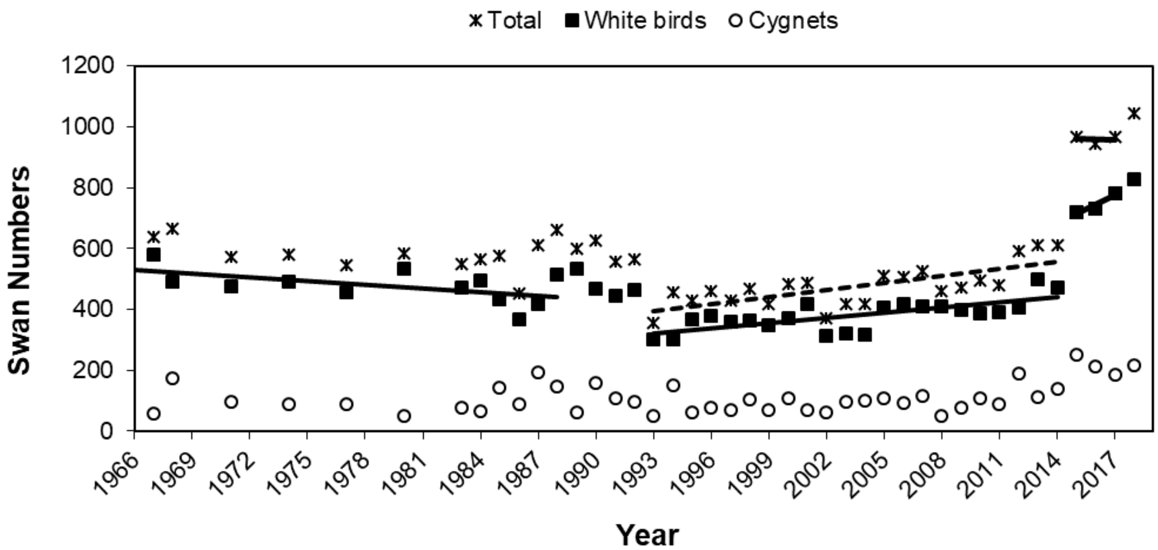

Fig. 6. Counts of swans in the RMP U.S. Breeding Segment during the Fall Trumpeter Swan Survey, 1967-2018 (dotted and solid lines depict trends for total swans and white birds, respectively up until 2014). A new trend line will begin for 2015 and beyond to account for the inclusion of birds from the Flathead Flock.

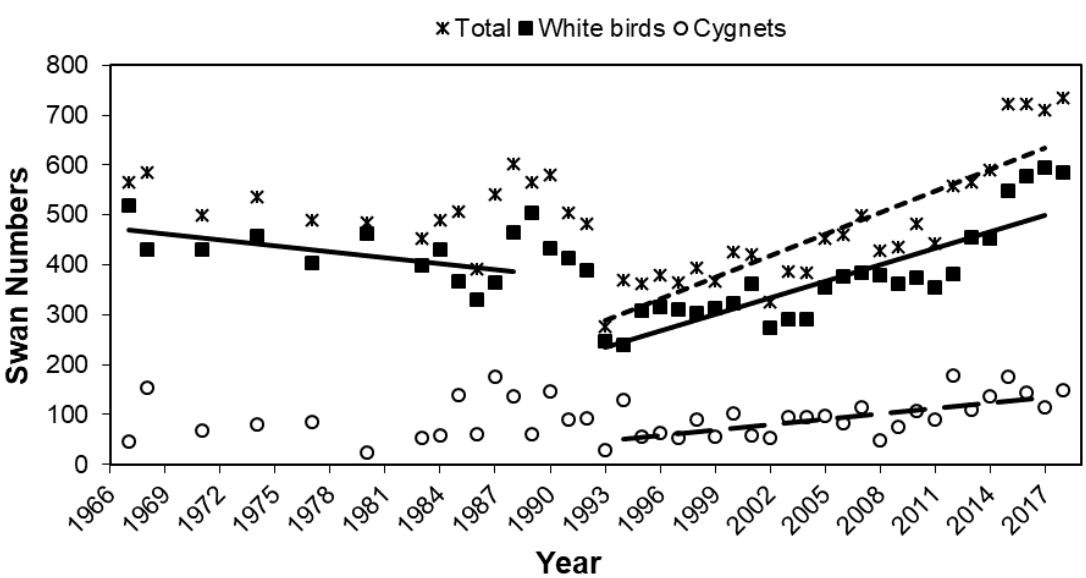

Fig. 7. Counts of swans in the Greater Yellowstone Flocks during the Fall Trumpeter Swan Survey, 1967-2018 (dotted, solid and dashed lines depict trends for total swans, white birds, and cygnets, respectively).

Most swans remained in the area for only a few months after being translocated (M. St. Louis, personal communication). Thus, the steep decrease in the number of swans at Summer Lake WMA does not reflect the decline of an established nesting flock, but rather suggests only that few of the >600 swans translocated to this area during the early 1990s (Shea and Drewien 1999) survived, or that most moved elsewhere over time. A new set of reintroductions began in 2009 for Summer Lake WMA. Those reintroductions are focusing on the establishment of a breeding flock.

The CSKT started a trumpeter swan restoration program on the Flathead Indian Reservation (FIR) in 1996 (Becker and Lichtenberg 2007). The first birds successfully released were put on the FIR in 2002 (34 adults). Since 2002 a total of 239 captive-reared birds have been released, and 2014 marked the fifth consecutive year there were more than 8 nesting pairs. The tribe considers this reintroduction program to be a success and swans have dispersed well beyond the Reservation. The rate of growth for the entire Flathead Flock increased 18.1% ($P \leq 0.01$) per year during 2002-2017. Similar rates of growth per year occurred for white birds (17.8%, $P \leq 0.01$) and cygnets (19.6%, $P \leq 0.01$) (Fig. 14).

Results from the 2018 survey

During fall 2018, observers counted 1,043 total swans in the RMP U.S. Breeding Segment, which was an increase of 8.1% from last year's survey (965) (Table 1, Fig. 6). The total count of swans in the Greater Yellowstone Flocks (747) was an increase of 5.2% from last year's count (710) (Table 1). These counts may be low due to the Paradise Valley and Hebgen Lake areas not being surveyed this year. In previous years, the Paradise Valley had around 20 birds and Hebgen Lake had 1 or 2 birds over a 5 year period. Idaho's total swan count (166) was a 16.9% increase from last year (142). Montana (329) had a 13.8 % increase from last year's count of 289. The count of total swans in Wyoming (252) was a 9.7% decrease from the count of 279 last year. The number of white birds in the Greater Yellowstone Area (600) was similar from last year's count of 595.

There were 4 adult white birds counted at Malheur NWR this year. Twenty white swans and 5 cygnets, were counted at Summer Lake WMA this year. Six swans (5 white and 1 cygnets) were counted at three other areas in south central Oregon. Ruby Lake NWR did not conduct a survey this year. This was the fourth year that the FIR Flock counts were officially added to the fall survey. Aerial observers and ground crews from the FIR counted 194 white birds and 64 cygnets.

The number of cygnets in the Greater Yellowstone Area (147) increased by 27.8% from last year's count of 115. The Palmer Drought Index in southwestern Montana has continued to increase for the past 3 years, suggesting slightly wetter conditions have been occurring which may be conducive to swan production. The cygnet counts increased from 2017 by 148.3% for Montana, but decreased by 15.5% for Wyoming and 7.1% for Idaho. An index to production rate (i.e., cygnets/white birds) for Wyoming (0.241) was slightly lower than last year, but similar to its long-term (i.e., 1967-2018) average (0.242). The index for Montana (0.293) was 10.0%

higher than its long-term average (0.266), while Idaho's index (0.203) was 6.5% lower than its long-term average of 0.217. The production index for the Greater Yellowstone Flocks (0.244) was similar to the long-term average (0.246).

Table 1. Counts of trumpeter swans of the Rocky Mountain Population U.S. Breeding Segment during fall, 1967-2018.

	Greater Yellowstone Flocks			Restoration Flocks			RMP U.S. Breeding Segment		
Year	White birds	Cygnets	Total	White birds	Cygnets	Total	White birds	Cygnets	Total
1967	520	45	565	60	13	73	580	58	638
1968	431	154	585	58	20	78	489	174	663
1969	a			69	23	92			
1970				45	16	61			
1971	431	68	499	46	27	73	477	95	572
1972				42	16	58			
1973				42	7	49			
1974	457	80	537	35	9	44	492	89	581
1975				41	9	50			
1976				31	9	40			
1977	403	86	489	51	4	55	454	90	544
1978				39	15	54			
1979				41	42	83			
1980	462	23	485	71	26	97	533	49	582
1981				77	14	91			
1982				56	20	76			
1983	398	54	452	73	22	95	471	76	547
1984	431	58	489	65	9	74	496	67	563
1985	368	139	507	63	5	68	431	144	575
1986	331	61	392	34	26	60	365	87	452
1987	365	175	540	52	19	71	417	194	611
1988	464	137	601	49	9	58	513	146	659
1989	505	60	565	30	3	33	535	63	598
1990	432	147	579	36	11	47	468	158	626
1991	414	91	505	32	18	50	446	109	555
1992	390	92	482	75	6	81	465	98	563
1993	248	29	277	55	22	77	303	51	354
1994	239	130	369	63	22	85	302	152	454

Table 1. (cont.)

	Greater Yellowstone Flocks			Restoration Flocks			RMP U.S. Breeding Segment		
Year	White birds	Cygnets	Total	White birds	Cygnets	Total	White birds	Cygnets	Total
1995	307	55	362	58	7	65	365	62	427
1996	316	63	379	64	15	79	380	78	458
1997	310	54	364	48	15	63	358	69	427
1998	304	90	394	60	15	75	364	105	469
1999	312	56	368	35	14	49	347	70	417
2000	324	102	426	48	7	55	372	109	481
2001	362	59	421	54	12	66	416	71	487
2002	273	53	326	38[b]	7[b]	45[b]	311[b]	60[b]	371[b]
2003	291	95	386	30[b]	1[b]	31[b]	321[b]	96[b]	417[b]
2004	291	94	385	27[b]	5[b]	32[b]	318[b]	99[b]	417[b]
2005	355	98	453	49	8	57	404	106	510
2006	377	82	459	39[c]	9[c]	48[c]	416[c]	91[c]	507[c]
2007	383	115	498	28	1	29	411	116	527
2008	379	48	427	29	3	32	408	51	459
2009	361	75	436	35	2	37	396	77	473
2010	375	107	482	2[c, d]	0	2[c, d]	377	107	484
2011	354	89	443	37	0	37	391	89	480
2012	381	178	559	24	10	34	405	188	593
2013	455	110	565	44[e]	1[e]	45[e]	499	111	610
2014	452	137	589	20[d]	2[d]	22[d]	472	139	611
2015[f]	548	175	723	170	75	245	718	250	968
2016	578	143	721	153	70	223	731	213	944
2017	595	115	710	186	69	255	781	184	965
2018	600	147	747	226[d]	70[d]	296[d]	826	217	1043

[a] Blank denotes value not calculated because of incomplete survey.
[b] Data for only Malheur NWR and the Nevada Flock included; Summer Lake WMA survey not completed.
[c] Count biased low; only a portion of Summer Lake WMA surveyed.
[d] Ruby Lake NWR did not provide data.
[e] Malheur NWR did not conduct survey.
[f] Flathead Flock Restoration Program in northwest Montana was added to the annual surveys, Restoration Flock, due to the success of the program, which is now considered self-sustaining.

Table 2. Counts of trumpeter swans of the Rocky Mountain Population U.S. Breeding Segment during fall, 1967-2018.

	Montana			Idaho			Wyoming			Flathead Indian Reservation			Malheur NWR			Summer Lake WMA			Nevada		
Year	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnets	Total	White birds	Cygnet	Total	White birds	Cygnet	Total
1967	334	25	359	87	8	95	99	12	111				33	12	45	a			27	1	28
1968	242	123	365	88	6	94	101	25	126				34	11	45				24	9	33
1969	b												36	14	50				33	9	42
1970													37	13	50				8	3	11
1971	297	49	346	60	6	66	74	13	87				38	22	60				8	5	13
1972													32	13	45				10	3	13
1973													36	4	40				6	3	9
1974	296	49	345	71	17	88	90	14	104				29	9	38				6	0	6
1975													33	7	40				8	2	10
1976													23	8	31				8	1	9
1977	267	64	331	60	7	67	76	15	91				33	0	33				18	4	22
1978													24	13	37				15	2	17
1979	324	63	387										31	33	64				10	9	19
1980	315	6	321	73	11	84	74	6	80				53	15	68				18	11	29
1981													53	9	62				24	5	29
1982													38	17	55				18	3	21
1983	228	32	260	92	6	98	78	16	94				55	17	72				18	5	23
1984	268	22	290	80	21	101	83	15	98				40	6	46				25	3	28
1985	212	87	299	83	27	110	73	25	98				38	2	40				25	3	28

Table 2. (cont.)

	Montana			Idaho			Wyoming			Flathead Indian Reservation			Malheur NWR			Summer Lake WMA			Nevada		
Year	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total	White birds	Cygnet	Total
1986	174	28	202	83	14	97	74	19	93				19	24	43				15	2	17
1987	210	133	343	63	15	78	92	27	119				38	14	52				14	5	19
1988	268	77	345	87	28	115	109	32	141				33	8	41				16	1	17
1989	294	23	317	101	16	117	110	21	131				20	3	23				10	0	10
1990	245	108	353	92	28	120	95	11	106				27	7	34				9	4	13
1991	176	60	236	138	26	164	100	5	105				22	14	36	2	0	2	8	4	12
1992	156	74	230	109	8	117	125	10	135				28	6	34	34	0	34	13	0	13
1993	60	16	76	94	6	100	94	7	101				22	12	34	25	5	30	8	5	13
1994	70	48	118	79	49	128	90	33	123				15	7	22	33	6	39	15	9	24
1995	84	17	101	118	21	139	105	17	122				11	3	14	34	3	37	13	1	14
1996	95	36	131	127	20	147	94	7	101				17	5	22	32	5	37	15	5	20
1997	88	18	106	112	19	131	110	17	127				16	7	23	15	2	17	17	6	23
1998	105	35	140	110	37	147	89	18	107				22	5	27	17	3	20	21	7	28
1999	120	21	141	103	23	126	89	12	101				11	3	14	8	6	14	16	5	21
2000	127	24	151	102	40	142	95	38	133				10	5	15	12	0	12	26	2	28
2001	140	9	149	124	23	147	98	27	125				11	12	23	12	0	12	31	0	31
2002	76	18	94	103	14	117	94	21	115	34		34	14	7	21	2[c]	0[c]	2[c]	24	0	24
2003	89	29	118	100	27	127	102	39	141	34		34	11	1	12	2[c]	0[c]	2[c]	19	0	19
2004	89	32	121	112	23	135	90	39	129	0	7	7	10	5	15	b			17	0	17
2005	112	40	152	136	22	158	107	36	143	26	5	31	20	5	25	12	3	15	17	0	17

Table 2. (cont.)

Year	Montana White birds	Montana Cygnet	Montana Total	Idaho White birds	Idaho Cygnet	Idaho Total	Wyoming White birds	Wyoming Cygnet	Wyoming Total	Flathead Indian Reservation White birds	Flathead Indian Reservation Cygnet	Flathead Indian Reservation Total	Malheur NWR White birds	Malheur NWR Cygnet	Malheur NWR Total	Summer Lake WMA White birds	Summer Lake WMA Cygnet	Summer Lake WMA Total	Nevada White birds	Nevada Cygnet	Nevada Total
2006	117	17	134	132	39	171	128	26	154	20	8	28	17	5	22	6	0	6	16	4	20
2007	157	41	198	113	15	128	113	59	172	32	17	49	11	0	11	0	0	0	17	1	18
2008	140	7	147	112	5	117	127	36	163	38	19	57	9	3	12	0	0	0	20	0	20
2009	138	21	159	122	21	143	101	33	134	74	13	87	4[c]	2[c]	6[c]	9	0	9	22	0	22
2010	129	30	159	101	29	130	145	48	193	59	20	79	2[c]	0[c]	2[c]	11[a]	0	11[a]			
2011	123	40	163	98	12	110	133	37	170	94	37	131	5	0	5	17	0	17	15	0	15
2012	129	96	225	97	30	127	155	52	207	124	20	144	7	0	7	17	10	27	5	0	5
2013	208	26	234	80	28	108	167	52	219	164	34	198				24	1	25	20	0	20
2014	198	57	255	74	23	97	180	57	237	123	42	165	2	1	3	18	1	19			
2015	212	60	272	104	47	151	232	68	300	144	72	216	4	1	5	20	2	22	2	0	2
2016	215	48	263	127	28	155	236	67	303	138	60	198				13	10	23	2	0	2
2017	260	29	289	114	28	142	221	58	279	158	67	225	2	0	2	21	2	23	5	0	5
2018	257	72	329	140	26	166	203	49	252	194	64	258	4	0	4	28	6	34			

[a] Swans translocated to Summer Lake WMA beginning in winter 1991; count from 1991and 2010 not used in analyses.
[b] Blank denotes survey was not conducted.
[c] Incomplete count; data not used in analyses.

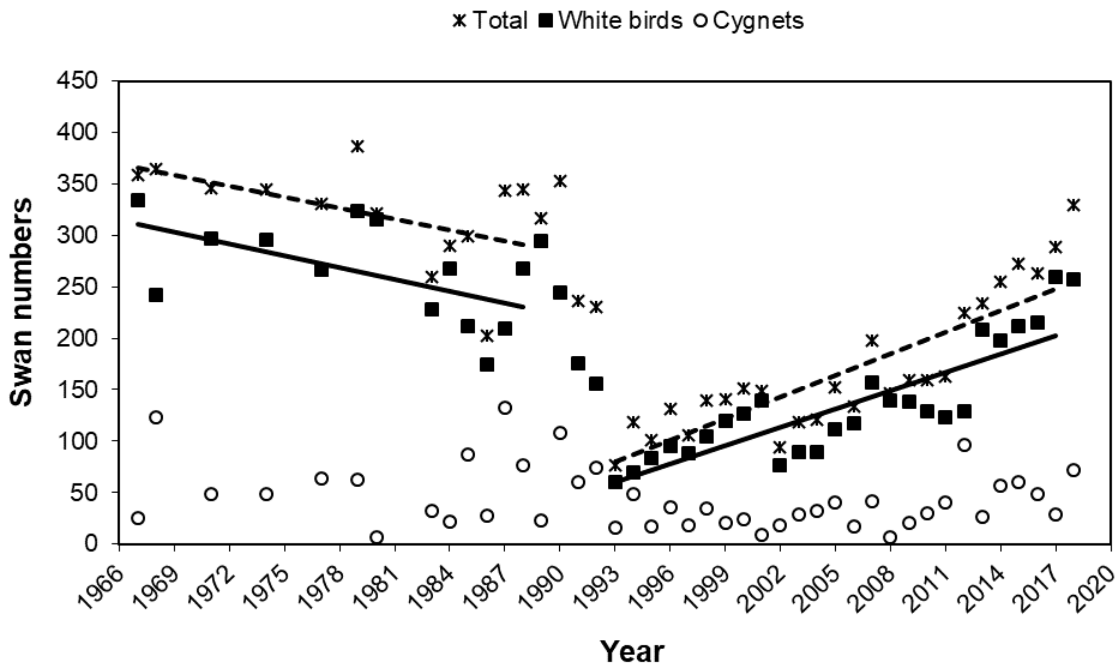

Fig. 8. Numbers of swans counted in Montana during the Fall Trumpeter Swan Survey, 1967-2018 (dotted and solid lines depict trends for total swans and white birds, respectively).

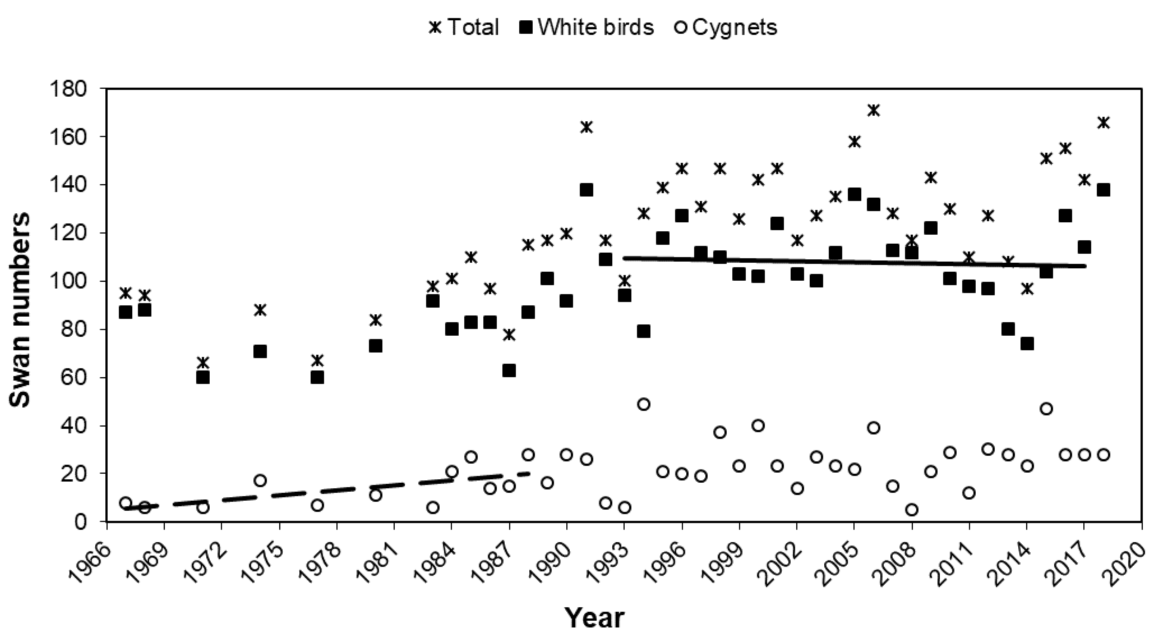

Fig. 9. Numbers of swans counted in Idaho during the Fall Trumpeter Swan Survey, 1967-2018 (solid and dashed lines depict trend for white birds and cygnets, respectively).

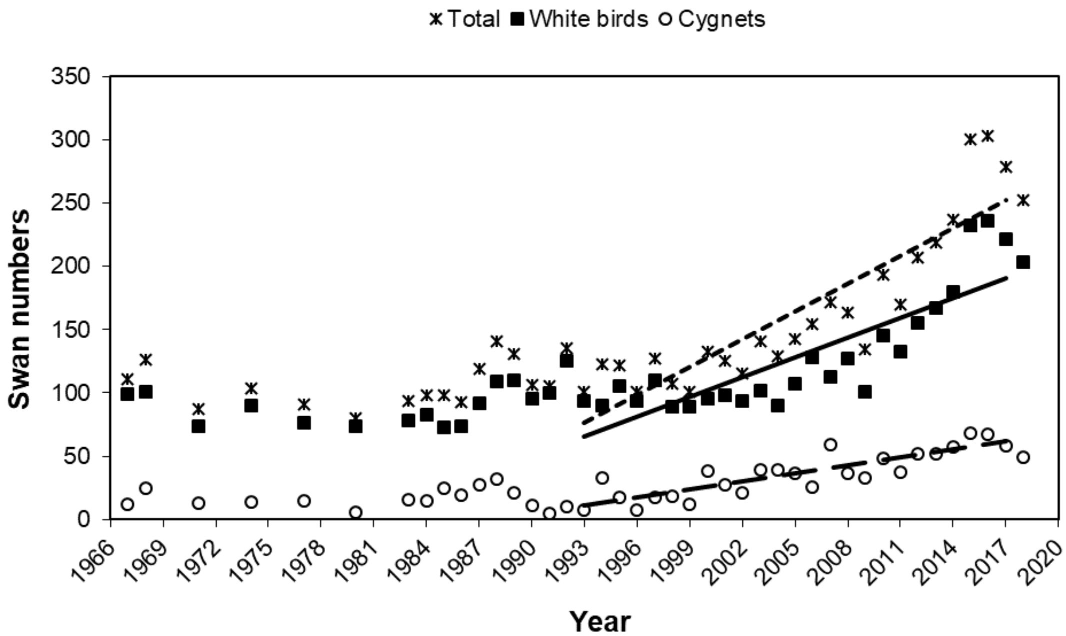

Fig. 10. Numbers of swans counted in Wyoming during the Fall Trumpeter Swan Survey, 1967-2018 (dotted, solid, and dashed lines depict trends for total swans, white birds, and cygnets, respectively).

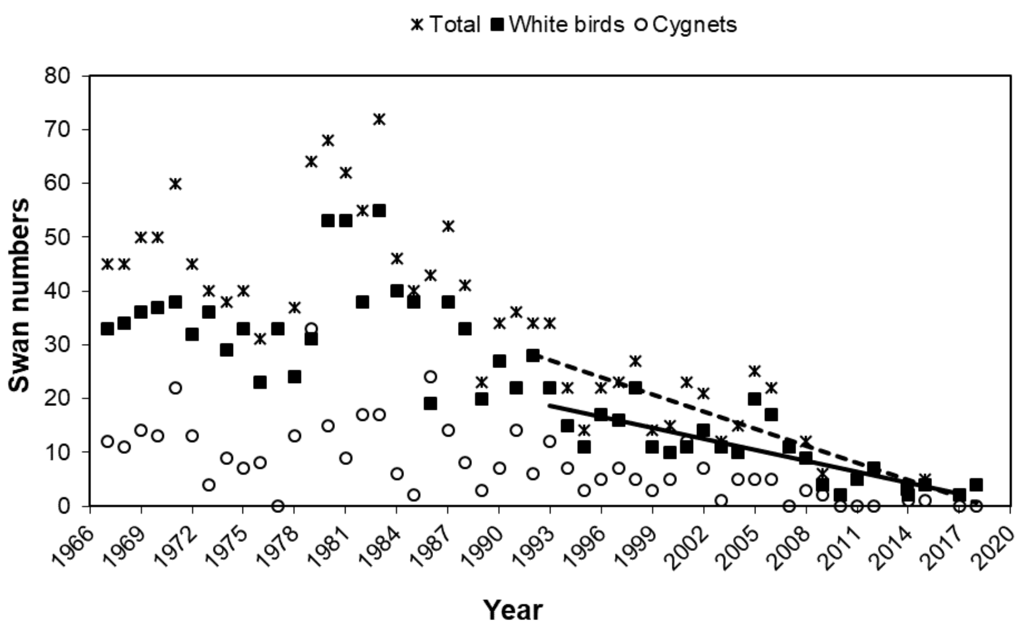

Fig. 11. Numbers of swans counted at Malheur NWR during the Fall Trumpeter Swan Survey, 1967-2018 (dotted and solid lines depict trends for total swans and white birds, respectively. No survey for 2013 or 2016).

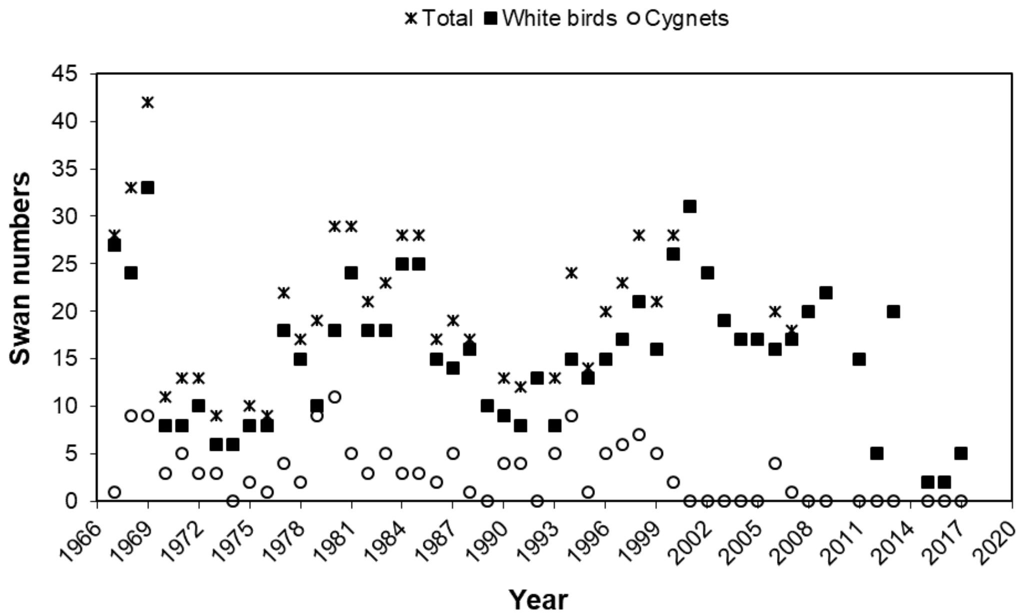

Fig. 12. Numbers of swans counted in the Nevada Flock during the Fall Trumpeter Swan Survey, 1967-2018. (No data for 2014 and 2018). Ground counts were performed for 2015 through 2017 which might underrepresent the number of swans in Nevada.

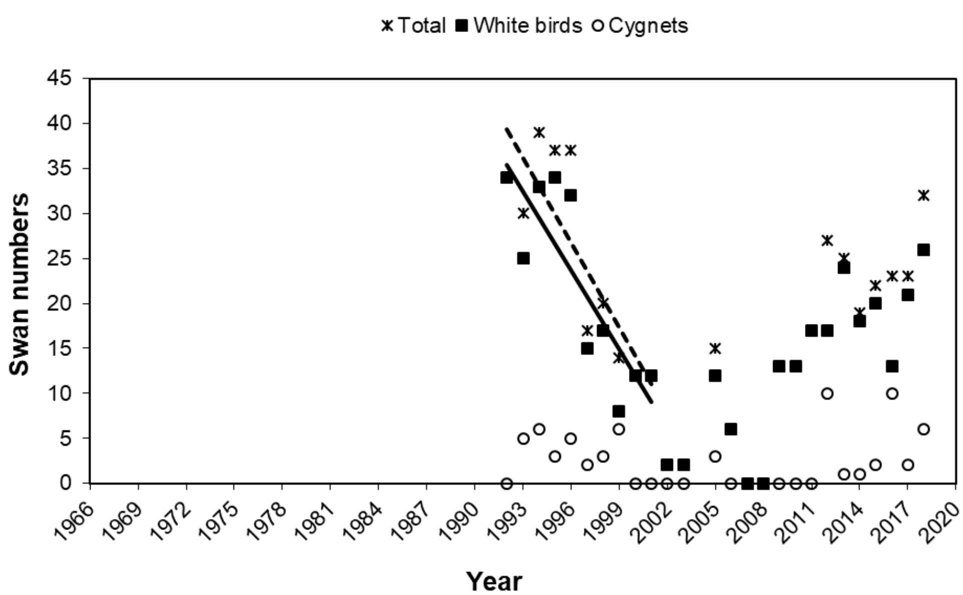

Fig. 13. Numbers of swans counted at Summer Lake WMA during the Fall Trumpeter Swan Survey, 1992-2018 (dotted and solid lines depict trends for total swans and white birds, respectively).

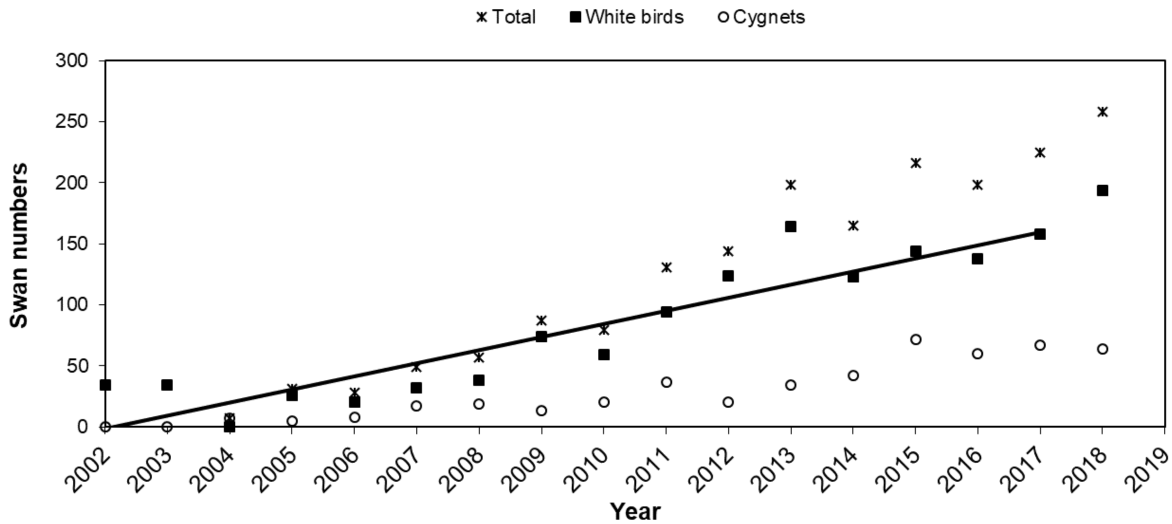

Fig. 14. Numbers of swans counted at Flathead Indian Reservation during the Fall Trumpeter Swan Survey, 2002 – 2018 (solid line depicts trend for white birds).

Swan Counts in Core and Expansion Areas

Total swans counted were taken from the Appendix in the Fall Reports from 1999 – 2018. Data were categorized as being from either a state's Core Area or its Expansion Area. Natural logarithms were calculated from the count data and were plotted over time for each state. Swans in Montana's Core and Expansion ($P \leq 0.01$) areas have both increased overall for the last 18 years (5.5% and 13.6% respectively) (Fig. 15) and Montana is the only state that has a positive trend for both areas. The significant increase in the growth of birds in the Expansion Area likely is largely due to the expansion of FIR Flock, now considered self-sustaining. Idaho's Core and Expansion areas showed no trends ($P \geq 0.73$) (Fig. 16). Wyoming's Core Area showed no trend ($P = 0.39$), while its Expansion Area had a significant ($P \leq 0.01$) increase of 9.7% over the past 18 years (Fig. 17), although the number of white birds has declined the past two years from a high in 2016.

Additional Reintroduction Efforts in Montana

Blackfoot Flock

In 2004, the USFWS, Montana Fish, Wildlife and Parks, and the University of Montana completed a trumpeter swan habitat suitability study of the Blackfoot Watershed and determined 29 sites were suitable for nesting territories, 9 wetlands of which were suitable for the release of trumpeter swans. An implementation plan was developed in 2005 with a goal of 7 breeding pairs that fledged young at least twice from nests in the Blackfoot. Reintroduction of trumpeter swans in the Blackfoot Valley of Montana began in 2005 with the release of 10 birds.

All birds are marked with USGS aluminum leg bands and a red plastic leg band with white number/letter/number sequence (e.g., 3P1). All after-hatch-year birds are also fitted with red and white neck collars bearing codes that match the red plastic leg bands.

Results

Since 2005 there have been a total of 185 swans released in the Blackfoot Valley (Table 4). The first nesting occurred in 2011 with 2 nesting pairs producing a total of 6 cygnets. This year there were 6 nesting pairs producing 11 cygnets to fledging. Once implementation plan goals have been met, the swans will be included in Montana's portion of this report.

Table 3. Sites (public and private) classified as either Core Area or Expansion Area for each state in the Rocky Mountain Population U.S. Breeding Segment, 1999 – 2018.

State	Core Area	Expansion Area
Montana	Red Rock Lakes NWR	Paradise Valley
	Centennial Valley	Flathead Indian Reservation
	Madison Valley	
Idaho	Island Park	Grays Lake NWR
	Shotgun Valley	Soda Springs Area
	Harriman State Park	Bear Lake NWR
	Upper Henry's Fork	Ft. Hall Bottoms
	Lower Henry's Fork	Lower Snake River
	Camas NWR	Minidoka NWR
	Teton Basin	
Wyoming	Yellowstone National Park	Upper Green River
	Upper Snake River drainage	New Fork & Big Sandy Rivers
	Caribou-Targhee NF/WY	Bridger-Teton NF/Pinedale
	Bridger-Teton NF/Jackson	Seedskadee NWR
	Grand Teton National Park	BOR Fontenelle Reservoir
	National Elk Refuge	Hamm's Fork
	Jackson Area	Salt River Drainage

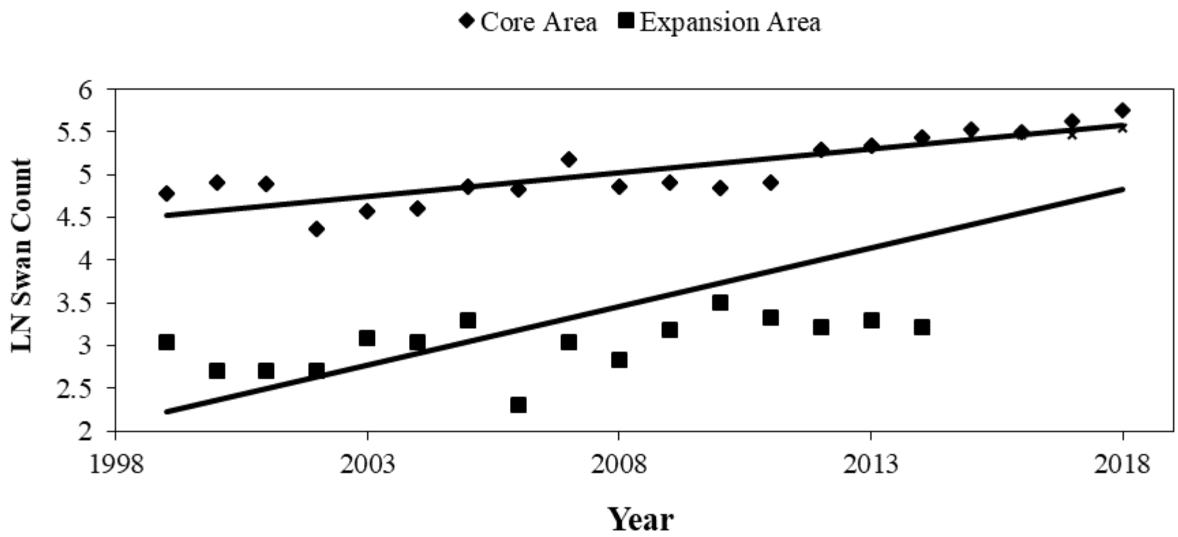

Fig.15. Growth rate of swans in Montana Core and Expansion Areas, 1999 - 2018. Data points for Expansion Areas from 2015 - 2017 are coincident with Core Area points and hidden.

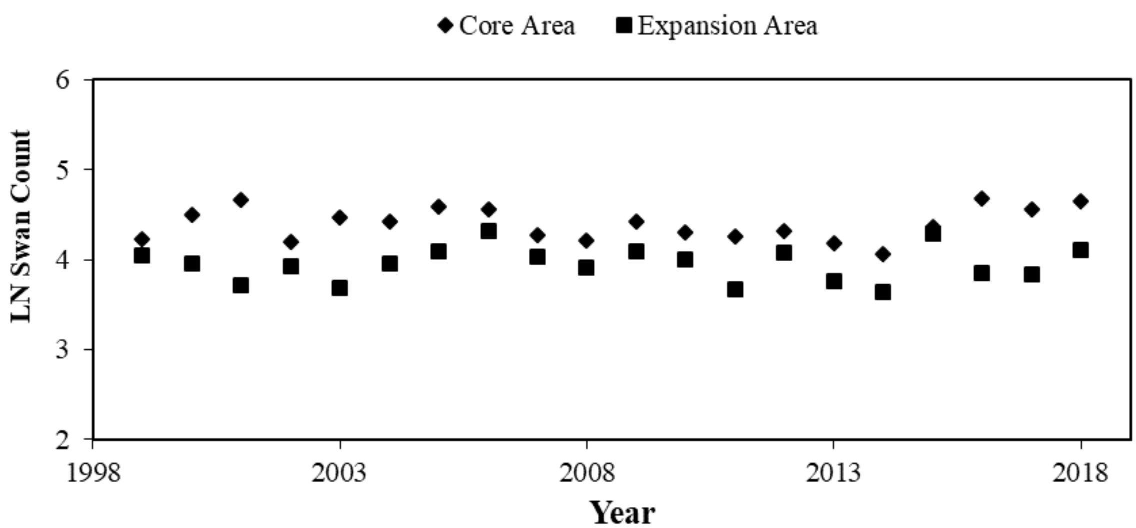

Fig. 16. Growth rate of swans in Idaho Core and Expansion Areas, 1999 - 2018.

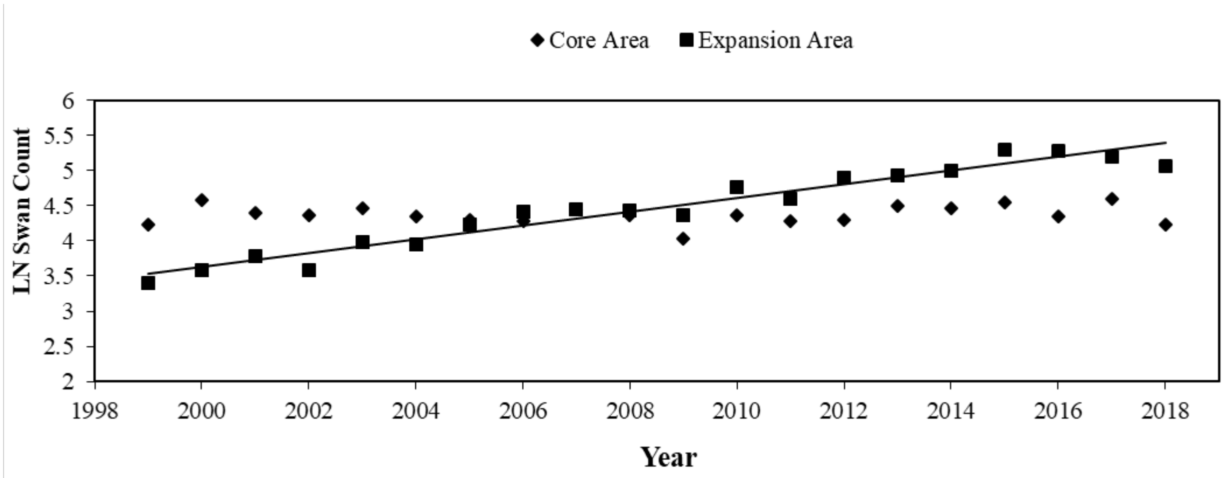

Fig. 17. Growth rate of swans in Wyoming Core and Expansion Areas, 1999 – 2018.

Table 4. Blackfoot Flock trumpeter swan reintroduction program 2005 – 2018.

Year	Captive Releases	Adults	Cygnets	Total	Nests
2005	10			10	
2006	17	2		19	
2007	13	6		19	
2008	43	4		47	
2009	29	12		41	
2010	30	18		48	
2011	10	12	6	28	2
2012	15	20	9	44	3
2013	10	21	3	34	4
2014	7	12	5	24	4
2015	12	24	3	39	4
2016	8	27	24	51	8
2017	0[a]	42	20	62	5
2018	5	26	11	63	6

[a] No releases in 2017 due to severe forest fires in the area

Conclusions

Changes in point counts of animals can be influenced by several factors (i.e., mortality, animal movements, survey problems). As a result, attributing annual changes in abundance to a specific factor or even a suite of factors is inherently difficult.

The Fall Trumpeter Swan Survey provides a good index to abundance, because managers and biologists have strived over the years to maintain consistency in areas surveyed and personnel who conduct the survey. Nonetheless, issues inherent in monitoring migratory birds can potentially affect the accuracy of a count. Also, no systematic surveys to detect swan mortality are conducted, nor are operational programs (e.g., banding, neck collaring) in place to estimate annual survival. Therefore, unless monitoring of these birds is increased, or well-designed research is conducted to examine their demographics, isolating causes for changes in annual counts will remain elusive.

The total number of swans in the RMP U.S. Breeding Segment increased by 7.9% from that observed in 2017. The count for the Greater Yellowstone Flocks was 747 total birds which is a 5.2% increase from 2017. Winter precipitation for the Greater Yellowstone Area was much above average, and Palmer Drought Indices suggest that June 2018 moisture conditions within the range of the RMP U.S. Breeding Segment were slightly wetter than the previous year and near normal. Production was 27.8% higher than last year for the Greater Yellowstone Flock and 17.9% higher than last year for the entire RMP. The number of white birds that were recorded during this fall's survey (824) exceeded the objective of 718 white birds specified in the RMP Trumpeter Swan Management Plan (Pacific Flyway Council 2017) for the fourth consecutive year. For the first time, the total number of swans exceeded 1,000 birds, with a total of 1,043.

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Appendix A. Revised RMP terminology from 2017 Pacific Flyway management plan for the Rocky Mountain Population of Trumpeter Swans (Pacific Flyway Council 2017).

RMP Trumpeter swan population segments, flocks, and geographic reference areas.

Population segments and flocks

Canadian breeding segment

- Alberta flock
- British Columbia flock
- Yukon flock
- Northwest Territories flock

U.S. breeding segment

- Greater Yellowstone flocks
  - Idaho Flock
  - Montana Flock
  - Wyoming Flock
- Restoration flocks
  - Flathead flock (MT)
  - Blackfoot flock (MT)
  - Malheur flock (OR)
  - Summer Lake flock (OR)
  - Turnbull flock (WA)
  - Ruby Lake flock (NV)

Geographic reference areas

Tri-State Region: Pacific Flyway portions of Montana, Wyoming, and Idaho

Greater Yellowstone core area: Area within which almost all Tri-state trumpeter swans summered and wintered during much of the 20th century prior to expansion efforts that began in the late 1980s

Greater Yellowstone expansion area: Portions of Greater Yellowstone outside of the core area where trumpeter swans have been recently established.

Appendix B. Site-specific counts of trumpeter swans of the Rocky Mountain Population U.S. Breeding Segment during the Fall Trumpeter Swan Survey, 2018.

Montana	White birds	Cygnets	Total	Pilot/observer/notes
Red Rock Lakes NWR				P: L. Bladder O: B. West, 9/18/2018
Upper Red Rock Lake	56	0	56	
Upper Lake Outlet to River Marsh	0	0	0	
Swan Lake	8	7	15	
Shambo Pond	0	0	0	
River Marsh	16	9	25	
Lower Red Rock Lake	32	49	81	
West Pintail Ditch	0	0	0	
Widgeon Pond	2	1	3	
Sparrow Slough	0	0	0	
Sparrow Pond	2	0	2	
Shoveler Pond	0	0	0	
Culver Pond	2	0	2	
MacDonald Pond	0	0	0	
Elk Springs Creek	0	0	0	
Tucks Slough	0	0	0	
Red Rock Creek	0	0	0	
Antelope Pond	0	0	0	
Sora Pond	0	0	0	
Subtotal	**118**	**66**	**184**	
Centennial Valley (CV)				
Red Rock River	8	1	9	
Lima Reservoir	111	0	111	
Blake Slough	2	1	3	
Elk Lake	2	0	2	
7L Wetland	2	4	6	
Mud Lake	0	0	0	
Conklin Lake	0	0	0	
Stibal Pond	2	0	2	
Huntsman Pond	0	0	0	
Scheid Stock Pond	0	0	0	
Jones Pond	0	0	0	
Winslow Pond	0	0	0	
Winslow Creek	0	0	0	
Bean Creek Pond (tooth pond)	0	0	0	
Pond, T16 R39 S28 "Peet Creek"	0	0	0	
Sand Creek Wetland	0	0	0	
Subtotal	**127**	**6**	**133**	
Madison Valley				
Ennis Lake	0	0	0	
Walsh Ponds	0	0	0	
Madison River	12	0	12	P: P. Thorpe , O: D. Collins, P. Donnelly; 9/18/18
Hidden Lake				**NOT SURVEYED THIS YEAR**
Otter & Goose Lake				**NOT SURVEYED THIS YEAR**
Cliff Lake				**NOT SURVEYED THIS YEAR**
Wade Lake				**NOT SURVEYED THIS YEAR**

Conklin Lake				**NOT SURVEYED THIS YEAR**
Tributary to Odell Creek				**NOT SURVEYED THIS YEAR**
Quake Lake				**NOT SURVEYED THIS YEAR**
Hebgen Lake (Madison Arm)				**NOT SURVEYED THIS YEAR**
Grayling Arm				**NOT SURVEYED THIS YEAR**
Denny Creek (just south of Hebgen)				**NOT SURVEYED THIS YEAR**
Subtotal	**12**	**0**	**12**	
Paradise Valley				**NOT SURVEYED THIS YEAR**
Sacagawea Park				
DePuy's-South				
Beaver Creek				
DePuy's-Main Lake				
DePuy's-North				
Armstrong's				
Bailey's				
Brandis'				
Brandis' North Fish Ponds Slough				
Diamond B				
Dana's				
Deep Creek				
North of Chico on Yellowstone River				
Nelson's				
Paradise Valley Airport				
Pray				
Yellowstone River (south of Emigrant)				
Emigrant Ditch				
Emigrant Creek				
Emigrant Pond				
Subtotal				
Montana Total	**257**	**72**	**329**	
Idaho				
Island Park/Upper Henry's Fork				P: P Thorpe; O: D. Collins, P. Donnelly (9/17-9/18)
Henry's Lake	4	0	4	
Henry's Lake Flat	0	0	0	
Big Springs to Mack's Inn	0	0	0	
Henry's Fork	**0**	**0**	**0**	
Subtotal	**4**	**0**	**4**	
Shotgun Valley				
South Shore Island Park Reservoir	9	0	9	
Sheep Creek Reservoir	0	0	0	
Icehouse Reservoir	2	0	2	
Shotgun Reservoir	1	0	1	
North shoreline Island Park Reservoir	0	0	0	
Sheridan Reservoir	2	0	2	
Sheridan Creek (cabin with pond)	0	0	0	
Twin ponds on Icehouse creek	8	0	8	Coordinates 44.4274; 111.588
Subtotal	**22**	**0**	**22**	
Harriman State Park				
Henry's Fork above Osbourne Bridge	0	0	0	
Henry's Fork below Osbourne Bridge	0	0	0	
Silver Lake	11	4	15	

Golden Lake	25	0	25	
Pond east-northeast of Golden Lake	2	0	2	
Thurman Creek	0	0	0	
Fish Pond	0	0	0	
Subtotal	**38**	**4**	**42**	
Upper Henry's Fork Area				
Buffalo River	0	0	0	
Henrys Fork-Box Canyon to Harriman State Park	0	0	0	
Trude Siding-Pond/Elk Creek complex	0	0	0	
Tom's Creek	0	0	0	
Blue Spring	0	0	0	
Last Chance Pond-north	0	0	0	
Last Chance Pond-south	0	0	0	
Henry's Fork below Pine Haven	0	0	0	
Boy Scout (Boundary) Pond	0	0	0	
Boy Scout swimming lake	0	0	0	
Eccles Butte Northeast	0	0	0	
Eccles wetland #1	0	0	0	
Eccles wetland #2	0	0	0	
Eccles wetland #4	0	0	0	
Eccles wetland #5	0	0	0	
Swan Lake (west)	1	4	5	
Hatchery Butte Road ponds	0	0	0	
Lilypad Lake (Pineview)	0	0	0	
Hatchery Butte	0	0	0	
North of Hatchery Butte	0	0	0	
Beaver Pond (Gerrit)	2	1	3	
Railroad Pond	0	0	0	
Pond northeast of Gerrit	0	0	0	
Mesa Marsh	0	0	0	
Northwest of Mesa Marsh	2	0	2	
Bear Lake and Cub Lake	0	0	0	
Twin Lakes	0	0	0	
Porcupine Lake	0	0	0	
Beaver Lake	0	0	0	
Rock Creek and adjacent pond	0	0	0	
Lower Goose Lake	0	0	0	
Upper Goose Lake	2	0	2	
Long Meadows	0	0	0	
Swan Lake (east-Falls River)	0	0	0	
Steele Lake	0	0	0	
Putney Meadows	0	0	0	
Falls River Ridge complex-4 ponds	0	0	0	
Thompson's Hole	0	0	0	
Pond west of Thompson's Hole	0	0	0	
Chain Lakes	0	0	0	
Fall River Canyon	0	0	0	
Pond between Beaver and Swan Lake (east)	0	0	0	
Horseshoe Lake	2	0	2	
Tule Lake and adjacent ponds	0	0	0	
Subtotal	**9**	**5**	**14**	
Teton Basin				
McReynolds Reservoir	0	0	0	

Teton Basin	2	0	2	
Subtotal	**2**	**0**	**2**	
Lower Henry's Fork				
Upper Arcadia Reservoir	0	0	0	
Lower Arcadia Reservoir	0	0	0	
Marsh northwest of Upper Arcadia Reservoir	0	0	0	
Mikesell Reservoir 1	0	0	0	
Mikesell Reservoir 2	0	0	0	
Sand Creek Wildlife Management Area and springs	2	2	4	
Sand Creek below Wildlife Management Area	0	0	0	
Wetlands west of Ashton	0	0	0	
Willow Creek ponds	0	0	0	
Chester Reservoir	0	0	0	
West of Chester Dam	0	0	0	
Singleton Ponds	0	0	0	
Lemon Lake	0	0	0	
Mackerts Pond	0	0	0	
Chester Wetlands WMA (IDFG)	2	0	2	
Deer Park Wildlife Management Area	0	0	0	
Cartier Slough Wildlife Management Area	0	0	0	
Davis Lake	0	0	0	
Egin Lakes	0	0	0	
Quayle's Lake	0	0	0	
Henry's Fork above Menan Butte	0	0	0	
Lower Henry's Fork to east of Market Lake	0	0	0	
Roberts Slough	0	0	0	
Subtotal	**4**	**2**	**6**	
Camas NWR				
Toomey Pond	7	0	7	
2-Way Pond	0	0	0	
Rays Lake	0	0	0	
Center Pond	0	0	0	
Big Pond	2	2	4	
First pond north of Sandhole Lake	0	0	0	
Sandhole Lake	0	0	0	
Mallard Slough	0	0	0	
Redhead Pond	0	0	0	
Camas Creek	0	0	0	
Mud Lake Wildlife Management Area	2	2	4	
Market Lake Wildlife Management Area	0	0	0	
Pond southeast of Market Lake	0	0	0	
Spring Pond	0	0	0	
Subtotal	**11**	**4**	**15**	
Grays Lake NWR	28	1	29	Report from final flight in Sept. There
Shorty's Cabin				Was no separation into management
Buck Lake (west of Bear Island)				Units for Grays Lake NWR
Big Springs Area				
Bishop Island				
B Riley Point (northwest of Bear Island)				
Outlet (main)				
Big Bend Marsh				
Brockman Creek				

Outlet Creek (north of road)				
North Canal				
South Canal				
Lakefront ponds (west of Headquarters)				
Kackley/Gravel Creek				
Beavertail				
Crane Reservoir (Little Valley)				
Chubb Springs				
Reservoir south of Wayan				
Crane Creek				
Subtotal	**28**	**1**	**29**	
Soda Springs Area				
5-Mile Meadow	0	0	0	
Miller Pond	0	0	0	
Soda Creek - Miller > Cellan Reservoir	0	0	0	
Cellan Reservoir	0	0	0	
Soda Creek-spring creek west of Soda Springs	0	0	0	
Chester Basin	0	0	0	
Alexander Reservoir	0	0	0	
Alexander Siding	0	0	0	
Woodall Springs	0	0	0	
Blackfoot Reservoir	0	0	0	
Chesterfield Reservoir	0	0	0	
Chicken Creek wetlands	0	0	0	
Subtotal	**0**	**0**	**0**	
Bear Lake NWR	22	10	32	Phil Thorpe air survey count; not
Rainbow Unit				Divided into management units
Rainbow Subunit				
Alder Unit				
Mud Lake Unit				
Salt Meadow Unit				
Dingle Unit				
West Canal Unit				
Bunn				
Red Slough				
Thomas Fork Unit				
Northeast of Refuge				
Bloomington Unit				
Subtotal	**22**	**10**	**32**	
Fort Hall Bottoms				
Head of Clear Creek	0	0	0	
American Falls Reservoir-northwest corner	0	0	0	
Kinney Creek	0	0	0	
Clear Creek above Sheepskin Road	0	0	0	
Cabin Creek	0	0	0	
Mouth of Portneuf River	0	0	0	
Flying Y	0	0	0	
Fisher Creek	0	0	0	
Sloughs along Broncho Road	0	0	0	
Diggie Creek	0	0	0	
Big Jimmy Creek	0	0	0	
Springfield Reservoir	0	0	0	

Sterling Wildlife Management Area	0	0	0	
Subtotal	0	0	0	
Lower Snake River				
American Falls Reservoir - Minidoka NWR	0	0	0	
C. J. Strike Reservoir	0	0	0	
Subtotal	**0**	**0**	**0**	
Minidoka NWR	**0**	**0**	**0**	
Other Idaho				
Pond near Bear River southwest of Grace	0	0	0	
Chesterfield Reservoir	0	0	0	
Wetland on Toponce Creek	0	0	0	
Wetlands east of Blackfoot	0	0	0	
Subtotal	**0**	**0**	**0**	
Central and Western Idaho				
White Arrow Ponds (Bliss)				Not Surveyed
Fairfield Gravel Pit				Not Surveyed
Clear Springs Pond				Not Surveyed
Mormon Reservoir				Not Surveyed
Silver Creek (Picabo)				Not Surveyed
Kanaka Rapids				Not Surveyed
Owsley Bridge - Upper Salmon Falls Dam				Not Surveyed
Oxford Slough Waterfowl Production Area				
Swan Lake (Bannock County)				
Marsh Valley				
Subtotal				
Idaho Total	**140**	**26**	**166**	
Wyoming				
Yellowstone National Park				P:Mike Packila; O:D. Smith 9/5/17
Geode Lake	0	0	0	
Crescent Pond	0	0	0	
Slough Creek	0	0	0	
Tern Lake	0	0	0	
Yellowstone Lake west-northwest of Molly Island	0	0	0	
Yellowstone Lake south arm	5	0	5	Grouse Creek
Yellowstone Lake - Yellowstone River delta (se arm)	3	0	3	
Beach Springs	0	0	0	
Heart Lake	0	0	0	
Yellowstone River, Alum-Grizzly Overlook	7	0	7	
Yellowstone River, north of Fishing Bridge	0	0	0	
Yellowstone River, Otter Creek	0	0	0	
Yellowstone River, Hayden Valley	0	0	0	
Boundary Creek	0	0	0	
Boundary Creek Pond	0	0	0	
Beula Meadow (Lake)	0	0	0	
Lillypad Lake	0	0	0	
Junco Lake	0	0	0	
Riddle Lake	2	0	2	
Falls River	0	0	0	
Upper Boundary Lake	0	0	0	
7-Mile Bridge	0	0	0	

Swan Lake	2	0	2	
Robinson Lake	0	0	0	
Richardson's Pond	0	0	0	
West Robinson Lake	0	0	0	
Bechler Meadow	0	0	0	
Lower Madison River	0	0	0	
Nymph Lake	0	0	0	
Grizzly Lake	2	0	2	
Obsidian Lake	0	0	0	
Floating Island Lake	0	0	0	
Trumpeter Lake	0	0	0	
Wolf Lake	0	0	0	
Grebe Lake	2	0	2	
Yellowstone Delta	0	0	0	
Winegar Lake	0	0	0	
South Arm - Grouse	0	0	0	
East end of Mary Bay	0	0	0	
Delusion Pond	0	0	0	
Northwest of Winegar Lake	0	0	0	
Fern Lake	0	0	0	
Cascade Lake	0	0	0	
Pelican Creek (mouth)	0	0	0	
Goose Lake	0	0	0	
Firehole River	1	0	1	
Tanager Lake	0	0	0	
Subtotal	**24**	**0**	**24**	
Upper Snake River/Targhee National Forest				P: M. Packila; O: S. Patla (9/19-20/2018)
Ernest Lake	0	0	0	dry
Bergman Reservoir	0	0	0	dry
Indian Lake	2	0	2	Occupied late
Squirrel Meadows	0	0	0	dry
Boone Creek	0	0	0	
Winegar Creek (new 2009)	1	0	1	
Widget Lake	0	0	0	
Junco Lake	0	0	0	
Moose Lake	0	0	0	
Loon Lake	2	0	2	Moved from Junco lake late
Rock Lake	0	0	0	
Fish Lake	0	0	0	
Grassy Lake Reservoir	0	0	0	
Subtotal	**5**	**0**	**5**	
Bridger-Teton National Forest-Jackson				
Arizona Lake	0	0	0	No swans this summer season
Blackrock Ranger Station pond/sloughs	0	0	0	Good water level fall
Enos Lake	0	0	0	1 dead swan outlet; pair here most of summer
Bridger Lake	0	0	0	
Atlantic Creek	0	0	0	
Gravel Lake (2016)	2	1	3	One cygnet lost
Gravel Lake wetland ponds (2018)	2	0	2	South of lake
Pinto Pond	2	0	2	On river near pond, nest failed early
Half Moon Lake	0	0	0	
Tracy Lake	2	0	2	

Hatchet Pond	0	0	0	Low water
Burnt Fork Potholes	0	0	0	
Buffalo F river	0	0	0	
Upper Slide Lake	0	0	0	River took dike out so lake is changing
Goose Lake	0	0	0	
Lower Slide Lake	0	0	0	
Grizzley Lake Trail wetland (new 2016)	0	0	0	
Bradley Lake (Snake River Canyon)	0	0	0	
Subtotal	**8**	**1**	**9**	
Grand Teton National Park				
Polecat Slough	0	0	0	
Flagg Ranch gravel pits	0	0	0	
Elk Ranch Reservoir	0	0	0	Water very low
Hedrick Pond	0	0	0	
Swan Lake	2	2	4	
Christian Pond	0	0	0	3 cygnets hatched; walked away July 1
Glade Creek north	0	0	0	
Glade Creek south (north of Tusker's Island)	0	0	0	
Glade Creek cliff slough	0	0	0	
Steamboat Mountain	0	0	0	
Jackson Lake north	3	0	3	
Jackson Lake Arizona island area	0	0	0	
Jackson Lake south	9	0	9	Mud flats north of dam
Two Ocean Lake	0	0	0	
Emma Matilda Lake	2	1	3	Pr from Christian Pond; lost 2 cygnets
Dam to Moran, Snake River	0	0	0	
Moran to Moose, Snake River	0	0	0	
Subtotal	**16**	**3**	**19**	
National Elk Refuge				
Visitor Center ponds	0	0	0	
Main Marsh Central	2	0	2	
Northwest Main Marsh (near overlook)	2	3	5	1 white cygnet
Southeast Main Marsh	0	0	0	
Northeast Main Marsh	2	3	5	Near Elk Jump nest pool
Miller/Wingar Springs	2	0	2	Near old bridge structure
Shop pond	0	0	0	
Pierre Pond east	0	0	0	Dike breached by river 2 yrs, water low
Pierre Pond west	2	0	2	Dike breached last year; water low
Romney Pond #2	2	0	2	
Nowlin Ponds	0	0	0	
Bill's Bayou	0	0	0	
Subtotal	**12**	**6**	**18**	
Jackson Area				
Bar B Ponds, west of airport (2016)	3	0	3	
Tucker Pits	0	0	0	
Wilson area wetland ponds, including golf course	0	0	0	
Skyline Pond (Puzzleface Ranch)	0	0	0	Pair here all summer, gone today
Teton Science School ponds	0	0	0	
Boyles Hill area	2	0	2	WWS Captive Flock here 4 Prs/5Cys
Valley Springs Hwy 89 captive facility	0	0	0	WWS Captive flock 9Ad/4Cyg

Valley Springs Ranch pond, private	2	0	2	
Healy Pond, Dairy Creek subdivision	3	0	3	
3 Creeks Golf Course Development (2013)	0	0	0	
South Park Loop Area	0	0	0	
South Park Unit, Wyoming Game & Fish Dept.	2	2	4	
Evans Gravel Pit Ponds	0	0	0	
Hillwood Pond, Bar BC (added 2010)	0	0	0	
Spring Gulch Spring Creek Pond (added 2014)	0	0	0	
Subtotal	**12**	**2**	**14**	
Upper Green River (north of Warren Bridge)				
Potholes north of Mosquito Lake	0	0	0	
Mosquito Lake	2	0	2	
Wagon Creek Lake	0	0	0	
Rock Crib Lake	0	0	0	
Mud Lake	0	0	0	
Roaring Fork Pond	0	0	0	
Dollar Lakes	0	0	0	
Upper Green River above Big Bend	2	0	2	North of Kendall's Warm spring
Circle S/Jensen Pond (added 2010)	2	1	3	On Jensen pond across river
Carney Slough/Cline Pond	2	0	2	
Carney Fish Pond	2	0	2	On new pond north of fish pond
Green River Big Bend to Black Butte	2	0	2	
O Bar Y Ranch Pond	2	5	7	Nest pond
O Bar Y cabin pond (2018)	2	0	2	
Green River Black Butte to Warren Bridge	0	0	0	
Hoback Rim pond GWJH LLC	0	0	0	
New Fork Potholes/Marsh Creek	0	0	0	
Kendal Wetland	2	0	2	Nest failed
Blatt Ranch Reservoir;Willow creek	2	2	4	First year nested successfully; lost 2 cyg
New Fork River (north of highway 191)	0	0	0	
Kitchen Reservoir north	0	0	0	
Kitchen Ranch Reservoir main	0	0	0	Pair and cyg missing from area
Lauzer Fish Pond reservoir	2	0	2	One bird up ditch north of reservoir
Soda Lake area	0	0	0	
Forty Rod Headwater Slough	0	0	0	
Pape Ranch pond (added 2010)	3	0	3	
Green River private ponds, south of Warren bridge	0	0	0	
Webb Draw, Horse Creek (added 2010)	0	0	0	Pair missing
Noble Pond west of Cora	1	0	1	
Fenn Duck Cr pond (added 2012)	2	1	3	First year fledge cygnet
Beaver Rim pond (added 2017)	0	0	0	Could not check; fire in area
Subtotal	**28**	**9**	**37**	
New Fork River & Big Sandy to Farson area				
Fayette Ranch ponds-complex NE of Pinedale	0	0	0	
Hagies Gravel Pit	0	0	0	
Pinedale ponds south of town (2014)	2	0	2	
New Fork River Pinedale to Boulder	0	0	0	
New Fork ponds-north of airport	2	3	5	Moved to New Fork Mocroft Ranch area
Fayette Ranch New Fork ponds-south of Airport	2	0	2	
Boulder Creek Ponds/pole creek ranch (2017)	2	1	3	
Boulder Sloughs	2	0	2	
Sloughs south of Boulder to East Park	0	0	0	

Swift Reservoir	2	0	2	
Jensen slough, Anticline (added 2010)	2	4	6	Large cygnets
New Fork to confluence with Green	5	0	5	Including sloughs and main river
Ross Butte ponds, New Fork River (2017)	0	0	0	
East Fork Gun Club Ponds (added 2010)	0	0	0	
East Fork Sloughs	2	0	2	Vossberg's ponds
Big Sandy/Big Bend	0	0	0	
Big Sandy/Eden reservoirs	0	0	0	
Farson area	4	0	4	Data from Phil Thorpe; 2 separate pairs
Subtotal	**25**	**8**	**33**	
Seedskadee NWR (SNWR) and lower Green River				
Green River, north of refuge HQ	0	0	0	
Main Marsh Hawley, Pool 1, SNWR	2	3	5	
Main Marsh Hawley, Pool 2, SNWR	2	1	3	
Main Marsh Hawley, Pool 3, SNWR	0	0	0	
Main Marsh Hawley, Pool 4, SNWR	2	4	6	On river, all gray cygnets
Main Marsh Hawley, Pool 5, SNWR	0	0	0	
Main Marsh Hawley Unit, Pool 6, SNWR	0	0	0	
Main Marsh Hawley, Pool 7, SNWR	0	0	0	
Main Marsh Hawley, channel, SNWR	0	0	0	
Headquarters Marsh, SNWR	0	0	0	
Hamp Unit, SNWR	2	0	2	
Sagebrush Wetland, SNWR	0	0	0	Move to river
Dunkle Wetland, SNWR	2	0	2	Swan on river, wetland dried up
Green River Dunkle to Big Island	2	5	7	1 white cygnet, 4 gray on river
Big Island area south to Stauffer Bridge	2	0	2	
Green River Telephone Island	0	0	0	
Green River south of Highway 28, SNWR	0	0	0	
Green River Highway 28 to dam, SNWR	0	0	0	
Killdeer Wetlands, Green River city	2	0	2	
OMC plant area (added 2012)	1	0	1	
Green river Mann's Flat Area	0	0	0	
Hofeldt Ranch pond (added 2012)	2	0	2	
Subtotal	**19**	**13**	**32**	
Green River Fontenelle Reservoir north to Daniel				
Fontenelle Reservoir	18	0	18	
Fontenelle Reservoir, Fontenelle Creek Area	12	0	12	
Big Piney cutoff, Green River	0	0	0	
Mc Nitch Reservoir	0	0	0	
67 Reservoir (2018)	2	0	2	
Green river North of HWY 353	0	0	0	
Muddy Creek Slough N of Big Piney (added 2012)	2	0	2	Did not nest this year
Tarten Island Slough, Green River	2	0	2	
Green River, 3 Bridges Area	0	0	0	
Voorhees Ranch Ponds north of LaBarge	0	0	0	
La Barge pond (private)	0	0	0	
Green River Long Island Area	4	0	4	2 separate pairs
Piney Cutoof Reservoir (added 2015)	2	0	2	
Green River, Figure Four Canyon	0	0	0	
Ferry Island Slough	2	2	4	
Grindstone cattle co, Green River	0	0	0	
Rimfire Ranch Ponds	2	1	3	First successful nest on Sophia Pond
Soapholes, BLM ponds (added 2013)	4	4	8	1 white Cyg, family on BLM nest pond

Subtotal	**50**	**7**	**57**	
Hamm's Fork				
McNaughton Reservoir, Hamm's Fork	nc	nc	nc	No reports of swans this summer
Hamm's Fork north of Kemmerer	nc	nc	nc	
Subtotal	**0**	**0**	**0**	
Salt River				
Palisades Reservoir, Alpine wetland	2	0	2	Lost cygnet
Swan Cove SD Marsh	0	0	0	
Salt River, Alpine to Freedom	2	0	2	Jacknike creek area
Salt River, Freedom to Afton	0	0	0	
Subtotal	**4**	**0**	**4**	
Other Wyoming				
Martins Pond, BLM, Wind River	2	0	2	FWS report
Alkali Lake, Wind River Reservation	0	0	0	
Ray Lake Marsh	0	0	0	
Goose Lake Complex (2018)	4	3	7	
Dinwoody Marsh (new 2017)	2	0	2	FWS report
Subtotal Wind River Area (Central Flyway)	**8**	**3**	**11**	Not included in Pacific Flyway Total
TOTAL WY outside YNP	**179**	**49**	**228**	
TOTAL WY including YNP	**203**	**49**	**252**	
Nevada				
Ruby Lake NWR				No Survey this Year
Franklin Lake				
Oregon				P:A Menlow, O: M St. Louis 9/13 & 15
Malheur NWR	4	0	4	
Summer Lake Wildlife Management Area	23	5	28	
Sycan Marsh	0	0	0	
Thompson Reservoir				No Survey, Low water levels
Saber Ridge Ranch, Crook County, OR	4	1	5	Includs Rabbit Valley Res, Crooked River Wetlands
NE Summer Lake Basin	0	0	0	
Colahan Ranch	0	0	0	
Sprague River Valley	1	0	1	
Subtotal for Oregon	**32**	**6**	**38**	
Flathead Indian Reservation	**158**	**67**	**225**	

[a] Blank denotes area not surveyed.
[b] Swans included in total counts, but not used in trend analyses.

Appendix C. Personnel who conducted the 2018 Fall Trumpeter Swan Survey.

Montana (Red Rock Lakes NWR, Centennial Valley, Madison Valley)
Observer: B. West (Red Rock Lakes NWR)
Pilot: L. Bladder (Choice Aviation)

Montana (Paradise Valley, Hebgen Lake area): No Survey This Year

Idaho
Observer: D. Collins (FWS), P. Donnelly (FWS, IWJV),
Pilot: P. Thorpe (U.S. Fish and Wildlife Service
Ground surveys by Camas NWR staff, Bear Lake NWR staff and IDFG WMA staff

Wyoming
Observer: S. Patla (Wyoming Game and Fish Department)
Pilot: M. Packila (Wildlife Air)

Wyoming (Yellowstone National Park)
Observer: D. Smith (Yellowstone National Park)
Pilot: L. Walker (Yellowstone National Park)

Ruby Lake NWR and vicinity: No Survey This Year

Oregon (Summer Lake WMA and Malheur NWR)
Observer: M. St. Louis (Oregon Department of Fish and Wildlife)
Pilot: Sr. Trooper A. Menlow, R. Gosse (Oregon State Police Pilot)

Montana (Flathead Indian Reservation, Confederated Salish Kootenai Tribe)
Observer: S. Clairmont (CSKT)
Pilot: R. Snyder (CSKT)
Ground: D. Becker and CSKT Management Staff

Montana (Blackfoot Valley)
Ground: G Neudecker (USFWS)

TRACKING WYOMING'S BREEDING HARLEQUIN DUCKS TO IDENTIFY IMPORTANT POST BREEDING HABITATS, MIGRATION ROUTES, STOP-OVER SITES AND MOLTING AND WINTERING AREAS

2018

Biodiversity Research Institute
innovative wildlife science

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BIODIVERSITY RESEARCH INSTITUTE
innovative wildlife science

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SUBMITTED ON:

29 March 2019

The mission of Biodiversity Research Institute is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers.

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FRONT PHOTO CAPTION:

Pair of Harlequin Ducks on a Wyoming breeding stream. Photo Credit: Ken Wright.

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

The Harlequin Duck (*Histrionicus histrionicus*) is a rare summer resident to the state of Wyoming, with small numbers of harlequin pairs which occupy the swift waters of remote mountain streams in northwest Wyoming. Due to the low densities of harlequins within the state, Wyoming has identified the Harlequin Duck as a species of conservation concern.

Supported by collaborative partnerships among Biodiversity Research Institute (BRI), the Wyoming Game and Fish Department, Grand Teton National Park, Yellowstone National Park, and Environment and Climate Change Canada, a Harlequin Duck satellite telemetry study was conducted in northwestern Wyoming during 2014, 2016-2018. Simultaneous efforts during 2016-2018 were also implemented through separate partnerships in the states of Montana and Washington, and Alberta, Canada. Combined, a comprehensive western North American Harlequin Duck movement study provides detailed information on the seasonal movements and connectivity between interior breeding areas and Pacific coast non-breeding locations. Movement data collected during this regional study will be provided to state and provincial wildlife managers with a goal of conveying important aspects of Harlequin Duck breeding and migration ecology and connectivity to the Pacific coast non-breeding areas.

In Wyoming during 2016-2018, we tracked the seasonal movements of nine male Harlequin Ducks captured and marked with satellite transmitters on breeding streams or spring staging locations within Grand Teton National Park and Yellowstone National Park. All nine harlequins successfully initiated molt migration toward the Pacific coast. Male harlequins departed their breeding areas during the early portions of June through early July (June 3 – July 8). The duration of molt migration from breeding sites to their Pacific coast molting areas ranged from ≤4 to 38 days. Male harlequins tended to utilize rivers as stopover locations during migration. Harlequins migrated through a wide variety of habitats, with a preference for temperate conifer forests. Three individuals also utilized grasslands, deserts, and shrublands during migration. We identified the molting locations of seven male harlequins, which included the western coastline of Vancouver Island (n=5), the Salish Sea/Puget Sound (n=1), and coastal Oregon (n=1). Male harlequins generally remained at or near their molting sites during the winter season. One male was successfully tracked for its complete annual cycle. The male was originally captured and equipped with a satellite transmitter in Yellowstone National Park and the following spring it migrated to a southern British Columbia breeding area, approximately 735 km from its Yellowstone breeding site.

While on their breeding areas, paired male harlequins tended to mostly utilize small sections of their breeding stream, ranging in distances of 1.6-11.1 km. Multiple individuals made occasional trips to neighboring streams. Male harlequins satellite marked in Grand Teton National Park utilized the northern end of Jackson Lake for night roosting. Similarly, males staging in the spring at the LeHardy Rapids utilized the northwestern section of Yellowstone Lake to roost. Male harlequins remained at their breeding sites for 18-48 days following the satellite transmitter tagging procedure performed during May 16-24.

Among the 10 harlequins that were color-banded during 2014-2017, only two individuals (20%) were re-observed on breeding areas in subsequent seasons. Both of these individuals were females and therefore, none of the five marked males returned.

2.0 INTRODUCTION

The Harlequin Duck (*Histrionicus histrionicus*) is one of the rarest breeding birds in the state of Wyoming. Its current breeding range in Wyoming is limited to the northwestern region including Grand Teton National Park, Yellowstone National Park and the Bridger-Teton Forest. Most harlequins in Wyoming are located in remote, uninhabited mountain streams, making them a difficult species to inventory (Patla and Oakleaf 2009; Oakleaf and Patla 2013). Currently, 70 breeding pairs are estimated to occupy Wyoming's rivers and streams. Wyoming represents the most southeastern breeding population of harlequins in western North America and they are currently designated as a "Species of Greatest Conservation Need" (Wyoming State Wildlife Action Plan 2010, 2017). The Wyoming State Wildlife Plan (2010) identified the need for enhancing Harlequin Duck breeding survey efforts, determining the movement patterns and habitat requirements for brooding and post-breeding harlequins, and a coordinated regional survey effort, to assess the current population of Wyoming's Harlequin Duck, as well as the other Rocky Mountain states supporting breeding harlequins.

Recording and mapping movements of waterfowl through remote sensing satellite telemetry technology has proven to be a safe and effective tool in evaluating regional and local movement patterns in certain sea duck species (SDJV 2015), including the Harlequin Duck (Brodeur et al. 2002; Chubbs et al. 2008; Robert et al. 2008).

During 2016-2018, wildlife research biologists from the US and Canada, collaborated on a western North American Harlequin Duck satellite telemetry study focused on ducks nesting inland from Pacific coastal wintering sites. The study involved the states of Montana, Washington, and Wyoming and the province of Alberta, Canada. In Wyoming, collaborators included Biodiversity Research Institute (BRI), Wyoming Game and Fish Department (WGFD), Grand Teton National Park (GTNP), Yellowstone National Park (YNP), and Environment and Climate Change Canada. During the study, pairs of harlequins were identified on their breeding streams or spring staging locations and captured pairs were equipped with tracking devices programed to record breeding site, migration, molting, and wintering movements. Male harlequins were equipped with an internal satellite transmitter and females received a geolocator tracking device attached to their leg band.

In Wyoming, satellite location data from each marked male was digitally downloaded, archived, and mapped to assess the extent of breeding stream usage, summer and spring migration corridors, timing and distance of migrations, migration habitat associations, and molting and wintering locations. Capture attempts were performed to recapture tagged females in subsequent breeding seasons to retrieve the geolocator device in order to download movement data.

3.0 STUDY OBJECTIVES

1. Utilize tracking technology to address the Wyoming State Wildlife Plan's recommendation to identify breeding Harlequin Duck annual movement patterns and identify pre and post-breeding habitat requirements.
2. Involve Wyoming in a recently implemented regional Harlequin Duck tracking study, involving western US states and western Canada.
3. Identify the timing and important migration routes and Pacific coast molting and wintering areas of Wyoming's breeding Harlequin Duck population.
4. Establish a public web-based project page highlighting project partners, provide project progress, and map the annual movements of Wyoming's Harlequin Ducks.

4.0 STUDY AREA

Harlequin Ducks breeding in Wyoming are primarily located in remote and inaccessible backcountry mountain streams. Grand Teton National Park (GTNP) and Yellowstone National Park (YNP) offer the only known harlequin breeding streams or spring staging locations conducive to conducting harlequin capture and breeding studies. Harlequin Duck pairs were identified on their breeding streams in GTNP and breeding streams or spring staging locations in YNP (Figure 1).

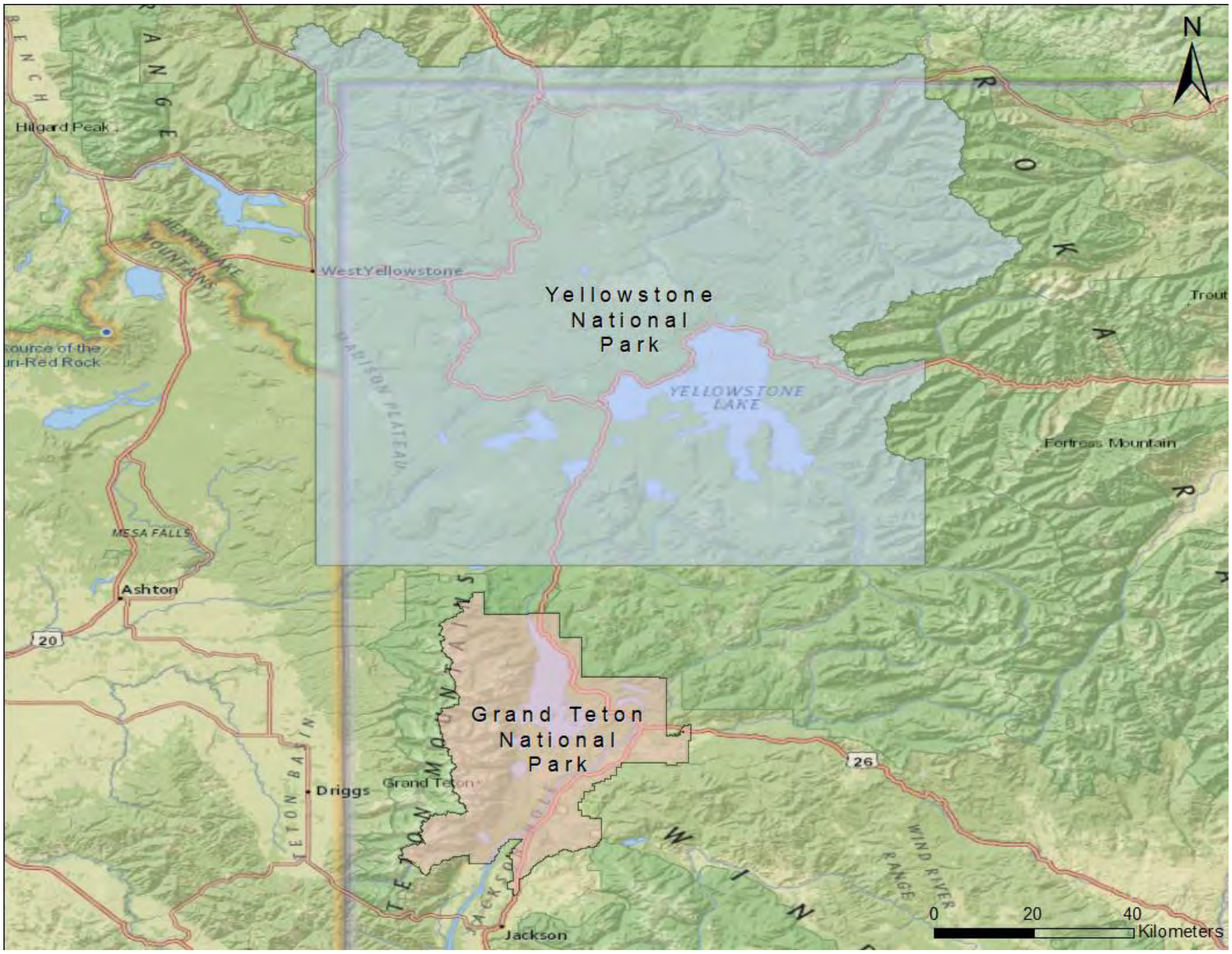

Figure 1. Harlequin Duck satellite telemetry study area within Grand Teton and Yellowstone National Parks.

5.0 METHODS

5.1 Harlequin capture, banding, and tracking device attachments

Capture of Breeding Pairs

Field crews located pairs of Harlequin Ducks by walking stretches of mountain streams known to support historical breeding pairs or river areas with congregations of spring staging harlequins. When pairs were identified on breeding streams, field teams would quickly position themselves downstream and out of sight of the pair. A 4-panel 12 or 18-meter (100mm mesh) mist net was strung across the stream between two upright poles and anchored on opposite stream banks (Figure 2). At least 1-2 people remained at each pole to monitor the net at all times, while additional personnel walked upstream to relocate the pair. The pair was then flushed downstream into the net; birds generally flushed into the net while flying and occasionally a harlequin was captured while swimming. Upon capture, personnel stationed at each pole immediately waded into the stream to extract the harlequins from the net. Each captured pair or individual was placed in a specially outfitted plastic pet carrier with an elevated mesh floor and a padded door designed to keep the harlequins dry from excrement and safe from abrasions.

Figure 2. A field crew setting a mist net across a stream for Harlequin Duck capture.

Spring staging locations were located on the Yellowstone River at the LeHardy Rapids. The river width and its swift currents required a modified net arrangement for captures. Pre-sunrise, we stretched an 18-meter mist net from the near shoreline pole out into the river, set the outer pole in the river, and secured it with anchors and thin rope guy-lines (Figure 3). Personnel remained near the shoreline pole to monitor the nets. In some instances, plastic harlequin decoys were used to attract flying ducks toward the net.

Figure 3. Mist net placed at the base of LeHardy Rapids, YNP for harlequin capture.

Handling and Processing

Each captured harlequin was immediately transferred to a stream-side processing area, usually consisting of a tent or nearby ranger cabin (Figure 6). Harlequins were weighed, measured, banded, and blood and feather tissue samples collected for contaminant (e.g., mercury and lead) screening. Each bird was banded with a U.S. Geological Survey stainless steel or incoloy metal band and a plastic orange band with black lettering (uniquely coded for each individual) was placed on the opposite leg (Figure 4).

Figure 4. Susan Patla of WGFD with a banded female harlequin.

Satellite Transmitter Preparation and Attachment

Platform Transmitter Terminal (PTT) satellite transmitters were manufactured by Telonics Inc., Mesa, Arizona (Model IMPTAV-2630) and each unit weighed approximately 41 g. Prior to implantation, veterinarians added a felt circular cuff at the antenna base to provide additional surface area for optimal adhesion to the skin at the antenna exit site (Figure 5). Transmitters were then sterilized with ethylene oxide and allowed to de-gas before implanting.

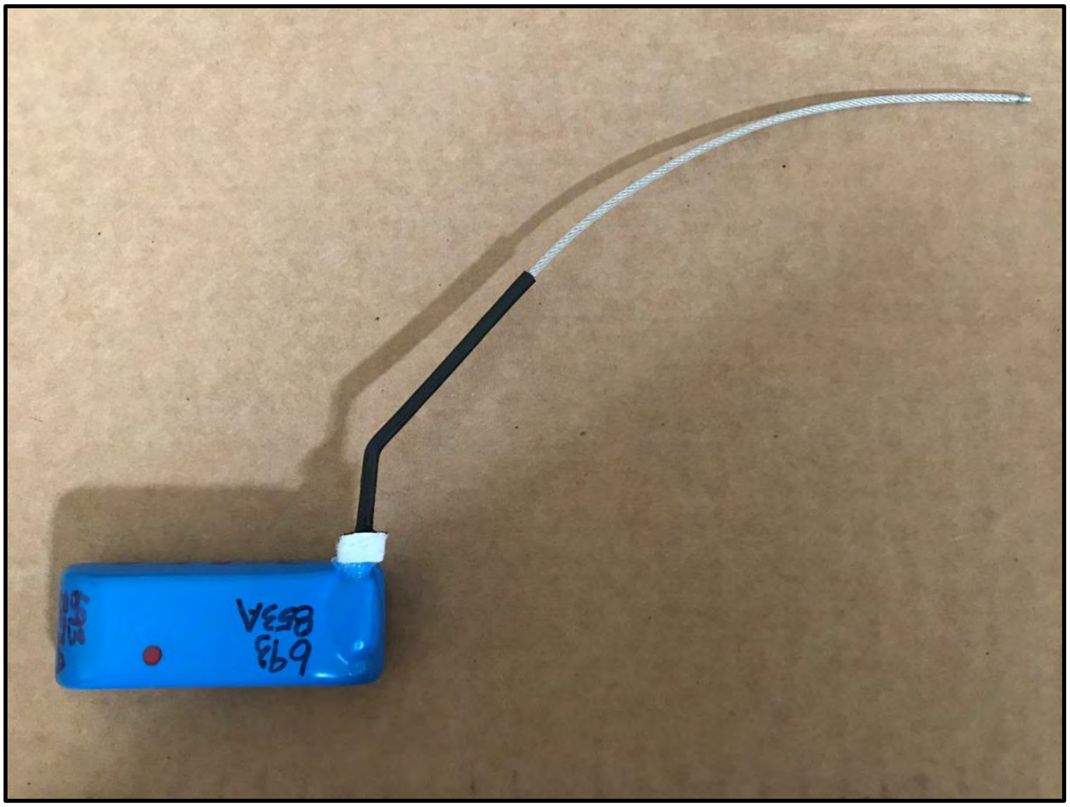

Figure 5. A Harlequin Duck satellite transmitter with a felt cuff.

Following banding and processing, each captured male harlequin was given a field examination and weighed, in order to assess its health and suitability for receiving a satellite transmitter. Males considered too small (<500 g) were released at their capture location without receiving a transmitter while harlequins in prime body condition and weighting ≥500 g were equipped with a transmitter. Wildlife veterinarians with vast prior Harlequin Duck surgery experience used sterile surgical procedures to implant the transmitters in the abdominal cavity, with an external antenna exiting the back (Korschgen et al. 1996). All capture, handling, and surgical procedures adhered to Wyoming and federal permits and were approved by the University of Southern Maine's Institutional Animal Care and Use Committee (permit # 020618-81) and the National Park Service Institutional Animal Care and Use Committee.

Figure 6. Wildlife veterinarian Malcolm McAdie preparing a male harlequin for surgery in the backcountry.

Geolocator Use and Attachment

We attached a small (1.0 g) geolocator to the plastic leg band of female Harlequin Ducks. The geolocator units (model Intego-C65) were capable of recording data for 1-2 years and were manufactured by Migrate Technology LTD (Cambridge, UK). The geolocators record near full range ambient light and support temperature and conductivity sensors, used in conjunction to provide interpretation of long-range movements. This method requires harlequins be recaptured in subsequent seasons to retrieve the geolocator device and download recorded data.

We pre-drilled two holes, approximately 9.0 mm apart, into the plastic color bands of female harlequins receiving a geolocator device. We used a waterproof epoxy to adhere a small piece of rubber bicycle inner tube, matching the size of the underneath section of the geolocator, between the drilled holes; this tubing provided a cushion between the color band and the geolocator. We then placed the geolocator on the tubing and threaded a thin plastic UV-resistant zip-tie through the two holes and cinched the geolocator tight to the color band. The excess zip-tie tails were trimmed flush and the remaining cut portion of the ties were sanded smooth (Figure 7).

Figure 7. Geolocator attached to the color leg band of a female harlequin.

During the retrieval of geolocators from recaptured females, we clipped and removed the entire color band from the leg of the bird and replaced it with a new band containing the same code. Retrieved geolocators were later connected to a laptop to download the archived data and Migrate Technology LTD software was used to interpret the data.

5.2 Satellite Data Processing

Transmitters were programmed to provide location data at varying frequencies throughout the year (multi-season duty cycle) in order to record more frequent locations during migration periods and slowed down during molt and wintering periods to conserve battery life and extend the longevity of transmitters. Transmitters were programmed to function for approximately one year to catalog the entire annual movements of harlequins (Table 1).

Table 1. Pre-programmed satellite transmitter duty cycles, 2016-2018.

Year	Season 1	Season 2	Season 3	Season 4	Season 5
2016	May – Jul 15 3 ON/18 OFF	Jul – Nov 15 3 ON/96 OFF	Nov 15 – Apr 15 3 ON/168 OFF	Apr 15 – Jul 15 3 ON/18 OFF	Jul 15 – 3 ON/96 OFF
2017	May 1 – Jun 30 3 ON/18 OFF	Jun 30- Aug 7 3 ON/12 OFF	Aug 7 – Nov 15 3 ON/168 OFF	Nov 15 – Apr 15 3 ON/336 OFF	Apr 15 – 3 ON/18 OFF
2018	Apr 15 – Jun 30 3 ON/18 OFF	Jun 30 – Aug 7 3 ON/12 OFF	Aug 7 – Nov 15 3 ON/168 OFF	Nov 15 – Apr 15 3 ON/336 OFF	Apr 15 – 3 ON/18 OFF

We used the Argos satellite-based location and collection system (Collecte Localisation Satellites 2017) to receive transmission signals and PTT diagnostic data from marked harlequins. We downloaded and archived transmission data nightly and subsequently filtered data through the Douglas Argos Filter (DAF; Douglas et al., 2012) to remove unlikely point locations. Argos processing centers report calculated accuracy estimates for each of the four highest quality location classes (i.e., location classes 3, 2, 1, and 0 had estimated accuracies of <250 m, 250 to <500 m, 500 to <1,500 m, and >1,500 m, respectively). We did not estimate accuracies for location classes A, B, or Z (invalid location) because these location classes were not used in our analyses and rarely occurred.

For satellite tagged males on their breeding areas, we designated location data as day or evening locations to assess stream and nearby lake utilization and identify roosting areas. Daytime locations were signals received ½ hour before after sunrise and evening locations were recorded ½ hour after sunset (Mountain Standard Time). All location data (class 0-3) were utilized.

Among satellite tagged males, we calculated breeding stream utilization distances in kilometers (km) by measuring the distance between the two furthest points along the harlequins breeding stream. We utilized all location data from class 0-3 signals.

5.3 Classifying Habitat Associations During Migration

For each high quality satellite signal recorded during the molt migration period, we determined whether the location was a "migration" or "stopover" point. Migration points included single point data recorded while the bird was likely actively moving in flight. Stopover points consisted of multiple (≥ 2) signals received from the same location, which would indicate the bird had temporarily stopped during migration. We then characterized the surrounding habitat for each migration data point using ArcGIS 10.6. Areas supporting "migration" points were characterized as: 1) deserts and shrublands, 2) temperate broadleaf and mixed forests, 3) temperate conifer forests, and 4) temperate grasslands, savannas and shrublands. We also classified the surrounding habitats of "stopover" points and further determined the waterbody type, which included rivers (R), mountain streams (S), coastline (C), and bay or estuaries (B) (Table 5).

6.0 RESULTS

6.1 Harlequin Capture and Color Banding

In May during the years of 2014 and 2016-18, we captured and individually color banded 19 Harlequin Ducks (males = 10, females = 9) among GTNP (n=10) and YNP (n=9) (Table 2). All harlequins from GTNP were captured on breeding streams, while harlequins captured in YNP consisted of pairs from breeding streams or harlequins congregating in early spring on the Yellowstone River at LeHardy Rapids.

Table 2. List of captured and color-banded Harlequin Ducks in Wyoming, (2014, 2016-18; n=19).

Year	Date	Band #	Location	Sex	Band Code	Weight (g)
2014	5/24	1125-02401	GRTE – Lower Berry	F	J5	461
2014	5/24	1125-02402	GRTE – Lower Berry	M	JE	615
2014	5/24	1125-02403	GRTE – Lower Berry	F	JP	565
2016	5/20	1125-02437	GRTE – Lower Berry	M	GT	575
2016	5/20	1125-02438	GRTE – Lower Berry	F	BT	475
2016	5/21	1125-02439	GRTE – Moose	F	D6	530
2016	5/21	1125-02440	GRTE – Moose	M	JC	575
2017	5/22	1125-02491	YNP - LeHardy	F	JD	578
2017	5/23	1125-02492	YNP - LeHardy	M	J3	630
2017	5/23	1125-02493	GRTE – Moose	M	JR	585
2018	5/16	1125-02494	YNP - LeHardy	F	JZ	601
2018	5/16	1125-02497	YNP - LeHardy	M	BD	604
2018	5/16	1125-02496	YNP - LeHardy	F	GH	567
2018	5/18	1125-02495	YNP - Tower	M	J6	592
2018	5/18	1125-02498	YNP - Tower	F	J5	670
2018	5/20	1125-02499	YNP – Soda Butte	M	JY	603
2018	5/20	1125-02500	YNP – Soda Butte	M	DZ	577
2018	5/22	1135-07871	GRTE – Moose	M	JL	566
2018	5/22	1135-07872	GRTE – Moose	F	G7	

Of the 19 marked harlequins, three individuals appeared unpaired at the time of capture. A female from GTNP – Lower Berry Creek (J5) was initially observed and later captured accompanying a pair on Lower Berry Creek (JE and JP) in May 2014. Secondly, a male from YNP-Soda Butte Creek (DZ) was observed and captured with a pair in May 2018. The female mate to the paired male at Soda Butte Creek (JY) escaped the net during bird extraction and was not successfully captured. Lastly, a female captured at YNP - LeHardy Rapids (JZ) in May 2018 appeared to be unpaired. During handling, we noticed this harlequin had a chronic injury with white circular opacity to its left eye. The bird seemed otherwise in good health and was re-observed on August 8, 2018 at LeHardy Rapids (Figure 8).

Figure 8. Harlequin Duck female "JZ" photographed at LeHardy Rapids on August 8, 2018.

(Photo credit Jake Briggs).

6.2 Re-observations of Color-Banded Harlequins

Of the 10 harlequins marked prior to the 2018 season, we observed two individuals (20%) returning in subsequent seasons. A paired female orignally marked in 2016 at GTNP- Moose Creek (D6) was recaptured with an unbanded male at the same site in 2017. Her mate during the 2016 season was tracked with a satellite transmitter and was confirmed deceased a couple months later during its summer molt migration. A female originally marked at YNP – LeHardy Rapids in 2017 (JD) was also re-observed the following May at LeHardy Rapids and was not recaptured. It should be noted, a second male marked at GTNP – Moose Creek in 2017, was also confirmed deceased months later during its summer molt migration (see Satellite Telemetry Results section).

Given the known fate of two satellite marked males, eight harlequins had the potential to return to their breeding streams in subsequent years. Two of the eight (25%) harlequins were confirmed returing to their breeding streams.

6.3 Seasonal Movements of Males – individual qualitative summaries

Between 2016-18, we implanted satellite transmitters in a total of nine male Harlequin Ducks in GTNP (n=4) and YNP (n=5) (Table 3). We experienced a 100% survival rate among the nine satellite tagged male Harlequin Ducks during the immediate post release time period, a timeframe when sea ducks are most susceptible to complications from surgery (Sexson et al. 2014).

Table 3. List of adult male Harlequin Ducks satellite tagged and color banded in Wyoming, 2016-18.

Capture Date	Location	Band Code	Transmitter ID	Band #
5/20/2016	GRTE – Lower Berry Creek	GT	159799	1125-02437
5/21/2016	GRTE – Moose Creek	JC	159798	1125-02440
5/22/2017	YNP – LeHardy Rapids	J3	33029	1125-02492
5/23/2017	GRTE – Moose Creek	JR	32894	1125-02493
5/16/2018	YNP – LeHardy Rapids	BD	174281	1125-02497
5/18/2018	YNP – Tower Creek	J6	174282	1125-02495
5/20/2018	YNP – Soda Butte Creek	JY	174284	1125-02499
5/20/2018	YNP – Soda Butte Creek	DZ	32793	1125-02500
5/22/2018	GRTE – Moose Creek	JL	174283	1135-07871

Grand Teton National Park (2016-18)

During May 2016-18, we placed satellite transmitters in four male harlequins captured between two breeding streams in GTNP. For each capture event, the male was paired and the female was also captured and color banded.

Moose Creek 159798 (2016); band #1125-02440

We captured and satellite tagged male 159798 on Moose Creek on May 21, 2016. While on the breeding grounds, this male generally remained in close proximity to its tagging location on Moose Creek, and also made trips to Lower Berry Creek and Owl Creek. Male 159798 utilized approximately 9.7 km of Moose Creek and also occupied the northern section of Jackson Lake, likely for roosting; signals were recorded on Jackson Lake during multiple evenings and early mornings (Figure 9).

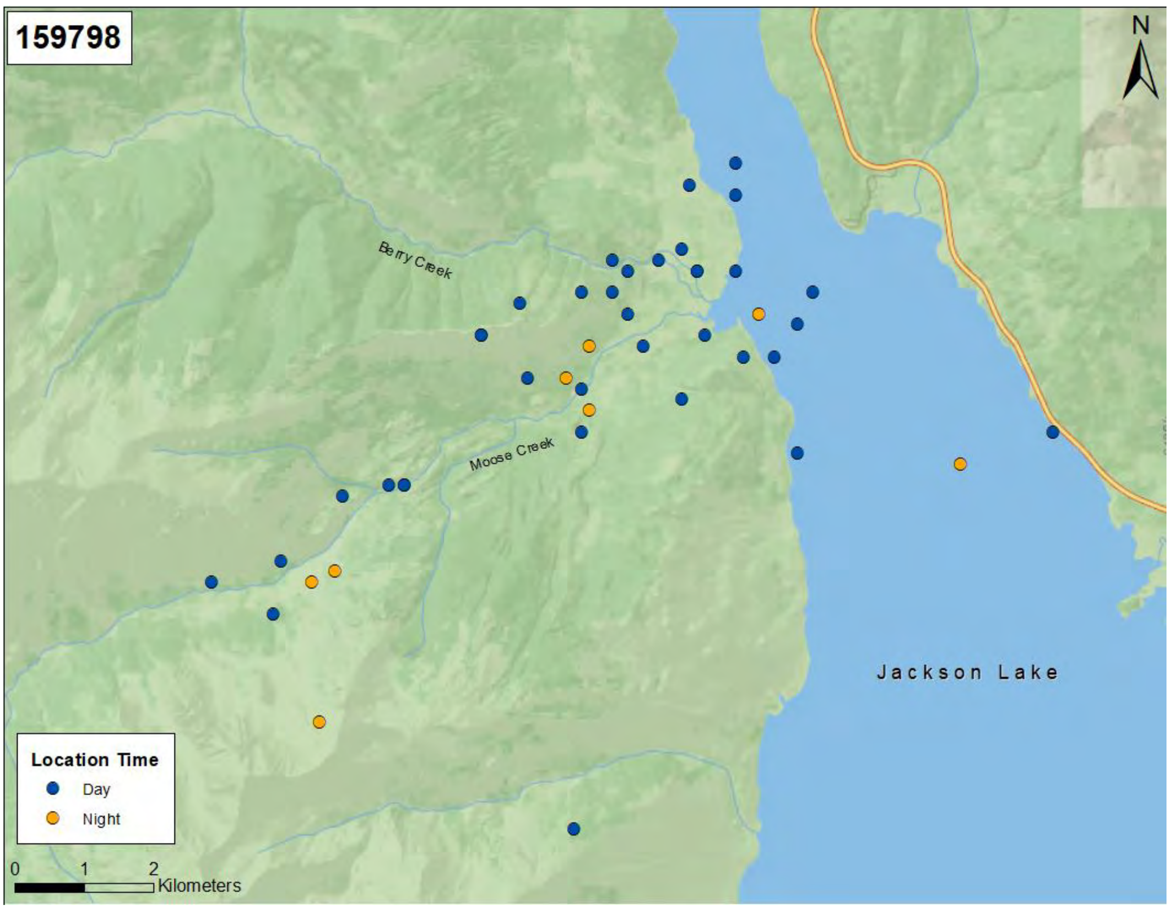

Figure 9. Locations for male harlequin 159798 on its breeding area.

The Moose Creek male 159798 departed its breeding stream between July 6-8, and migrated through the boreal zone of northeast Washington, signaling from Sherman Creek (132 km northwest of Spokane) **(N 48.632, W -118.453)** on July 11 and staging there for ≤ 8 days. The length of stay at Sherman Creek is possibly shorter but cannot be accurately calculated due to the absence of satellite locations recorded during July 11–19. On July 19, the harlequin signaled from the western shore of Vancouver Island, British Columbia, Canada, indicating its approximate arrival to the Pacific coast. The next signal was recorded on July 31 from the northwestern region of Vancouver Island. The harlequin remained in this area through October 5-9, which would identify this location as its molting site. The total approximate distance traveled from its breeding stream to its molting site was 1,442 km and the duration of migration was 10-24 days. This male remained on its breeding area for 46-49 days following tagging, before initiating its summer molt migration **Molt location: Vancouver Island, BC (N 50.072, W -127.573)** (Figure 10).

Between October 5-10, the harlequin moved from its molting area south approximately 66 km to Nootka Island, located along the west coast of Vancouver Island. It remained in this area through October 30 and flew back north approximately 16 km to the town of Nuchatlitz, western Vancouver Island, arriving between October 30 – November 7. Shortly after arriving to Nuchatlitz, the internal temperature sensor in the transmitter indicated the bird had died from an unknown cause between November 7-11. **Likely wintering area: Nuchatlitz, Vancouver Island, BC (N 49.805, W -126.972)** (Figure 10).

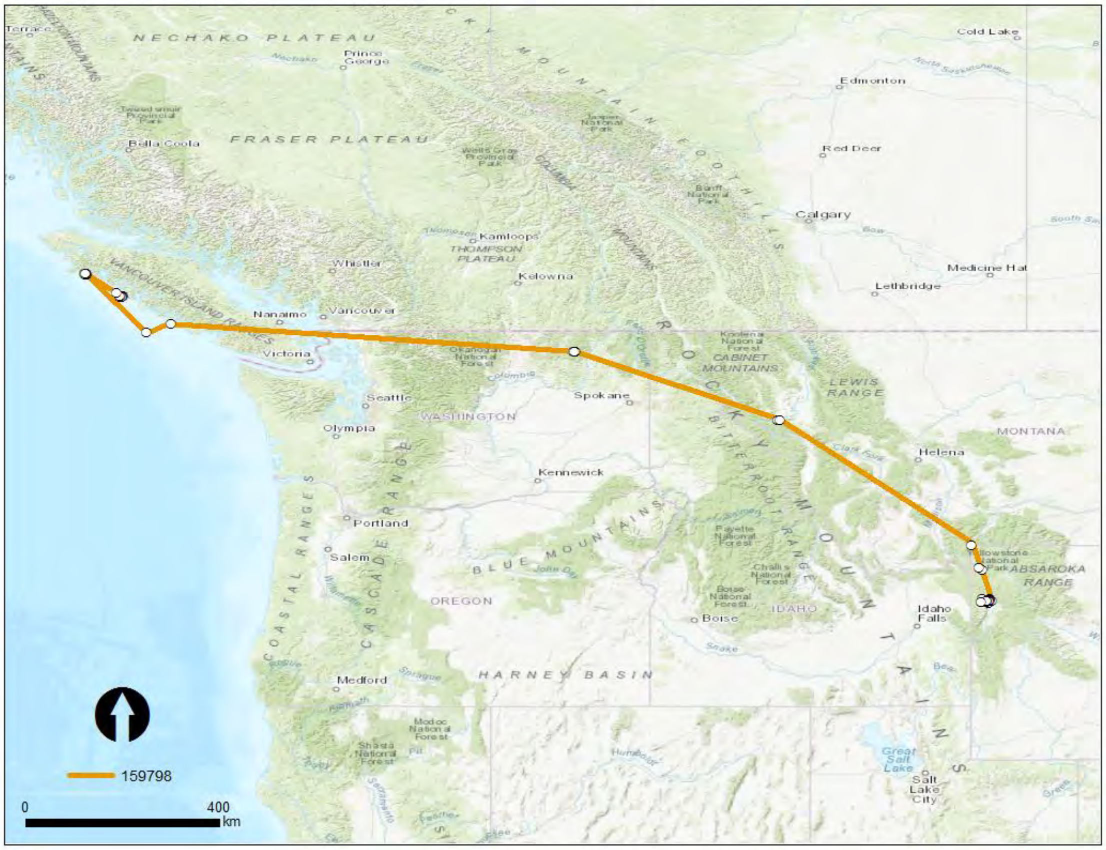

Figure 10. Migration locations of male harlequin 159798 to its molting and wintering areas.

<u>Lower Berry Creek 159799 (2016); band #1125-02437</u>

We captured and satellite tagged male 159799 on Lower Berry Creek on May 20, 2016. While on the breeding grounds, this male remained in close proximity to its tagging location on Lower Berry Creek. This male utilized approximately 6.4 km of Lower Berry Creek and also occupied the northern section of Jackson Lake, likely for roosting, as it provided signals during evenings and early mornings (Figure 11).

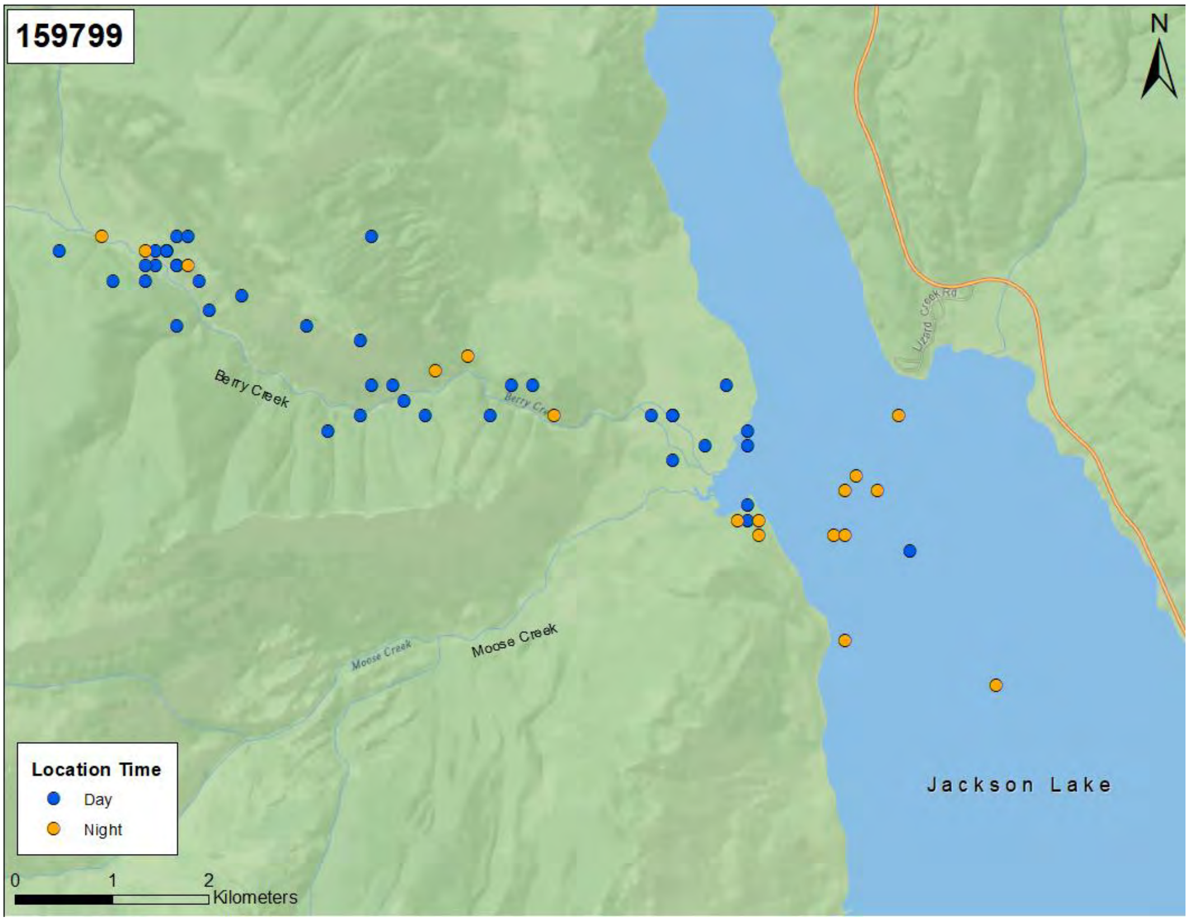

Figure 11. Locations for male harlequin 159798 on its breeding area.

This male departed its breeding stream July 1, and migrated through the forested conifer zone, signaling in Montana, Idaho, and Washington, as well as areas in the Puget Sound. This bird stopped briefly, seemingly along Henry's Fork River **(N 44.363,W -109.724)**, near Twin Groves, Idaho and then again along the Bitterroot River **(N 46.067, W -114.163)** near Gorus, Montana; a signal during migration was also recorded in the boreal zone of northeast Washington, near town of Republic. This bird initially arrived on the Pacific coast in Puget Sound, between July 3-4. Several days later, this male moved to the northern tip of Vancouver Island, in Queen Charlotte Sound, British Columbia, arriving there between July 12-13; this location was its eventual molt location. The travel duration from its breeding area to its first arrival on the

Pacific coast was 2-3 days and the total molt migration duration was 11-12 days. The total approximate distance traveled from its breeding stream to its molting location was 1,564 km. This male remained on its breeding area for 42 days following tagging and before initiating summer molt migration. **Molt location: Queen Charlotte Sound, BC (N 51.018, W -127.691)**.

This male departed its molting area between October 5-9 and flew approximately 45 km west to the northwest section of Vancouver Island and arrived there between October 5-9. This bird remained in this area and last provided a signal on December 13, before the transmitter went offline unexpectedly. The internal temperature and voltage sensors on the transmitter were both indicating normal readings. It is possible the radio suffered an electrical failure. **Apparent Wintering location: Vancouver Island (N 50.818, W -128.269)** (Figure 12).

Figure 12. Migration locations of male harlequin 159799 to its molting and wintering areas.

Moose Creek 32894 (2017); band #1125-02493

We captured and satellite tagged male 32894 on Moose Creek on May 23, 2017. While on the breeding grounds, this male remained in close proximity to its tagging location on the lower section of Moose Creek, and occasionally frequented areas of Upper Moose Creek. This male utilized approximately 7.2 km of Moose Creek. Signals during evenings and early mornings were recorded on the northern end of Jackson Lake and we suspect this male frequented this area to roost (Figure 13).

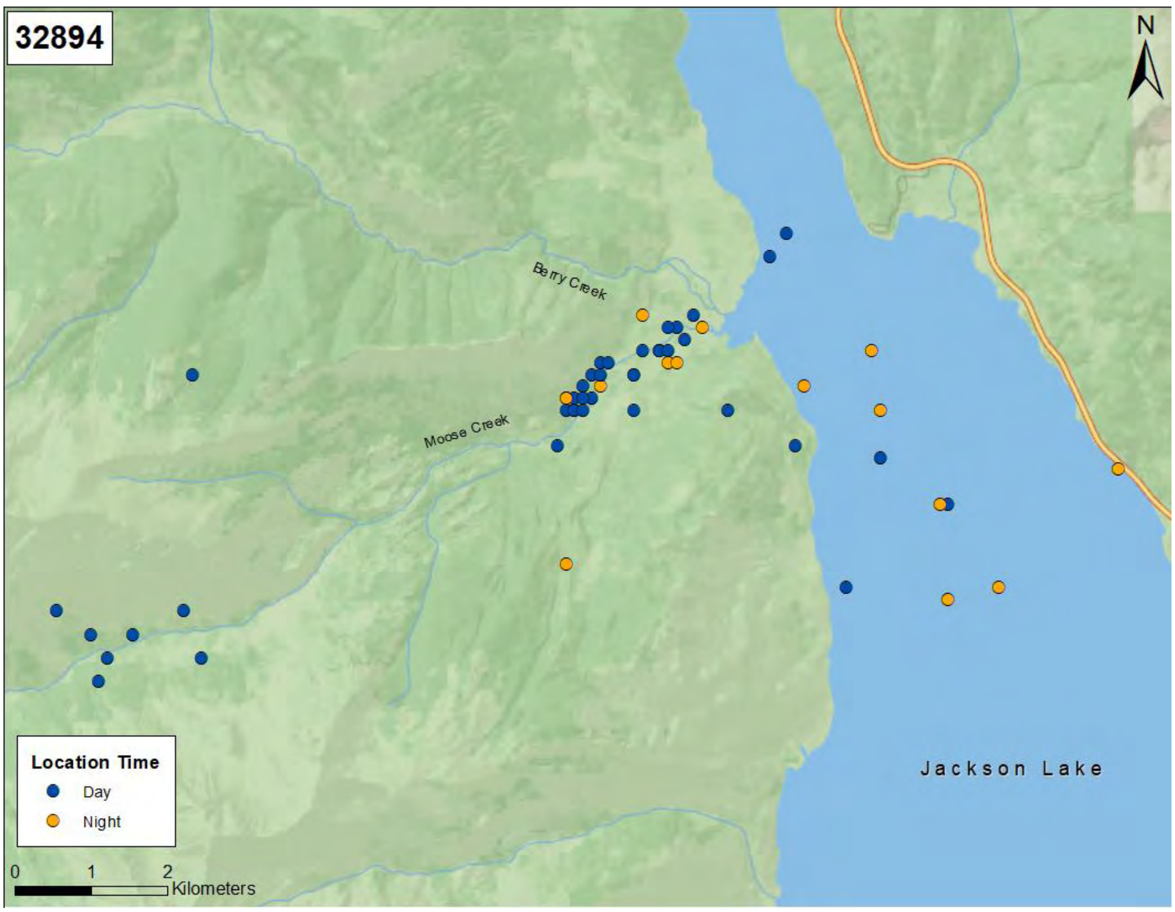

Figure 13. Locations for male harlequin 32894 on its breeding area.

The male departed Moose Creek on June 29-30. The first signal during migration was recorded on June 30 in northeast Oregon on the Imnaha River **(N 45.649, W -116.838)**, near Zumwalt, Oregon. The next signal was recorded on July 1 near Yakima, Washington. A mortality signal via the internal temperature sensor from the transmitter was received beginning on July 1 in this same location, indicating this bird died during its molt migration **(N 46.505, W -119.624)**. The last signal received while the bird was alive was July 1 at Dalton Lake, a segment of the Snake River near Kennewick, Washington **(N 46.298, W -118.798)**. The total migration distance traveled by this male before it died was approximately 747 km (Figure 14). This male remained on its breeding area for 37-38 days following tagging, before initiating summer molt migration.

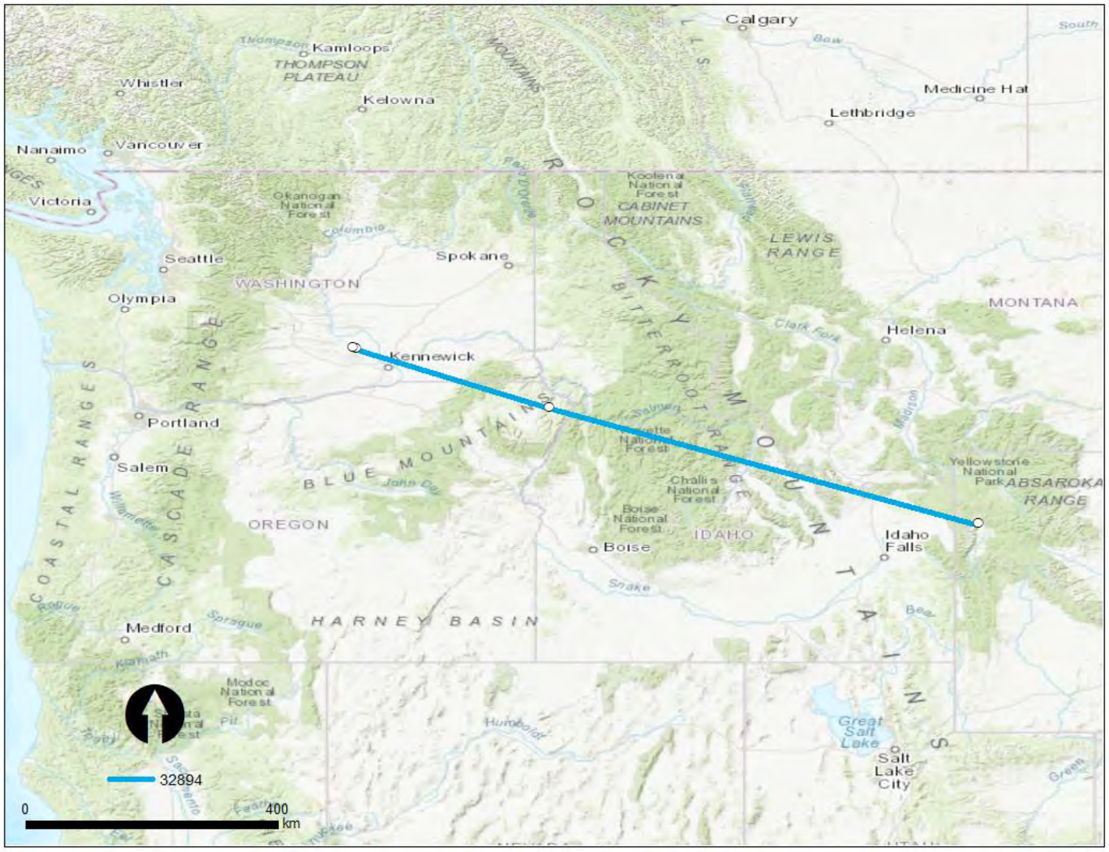

Figure 14. Locations of male harlequin 32894 during its molt migration.

Moose Creek 174283 (2018); band #1135-07871

We captured and satellite tagged male 174283 on Moose Creek on May 22, 2018. This bird utilized both the lower section and upper section of Moose Creek during the breeding season, totaling a length of stream use of 10.2 km. The bird also utilized Lower Berry Creek during late June and early July (June 30 – July 4). Interestingly, this male was the only individual that did not appear to utilize Jackson Lake for roosting (Figure 15). This bird remained on its breeding area for 45 days following satellite tagging, before initiating its summer molt migration.

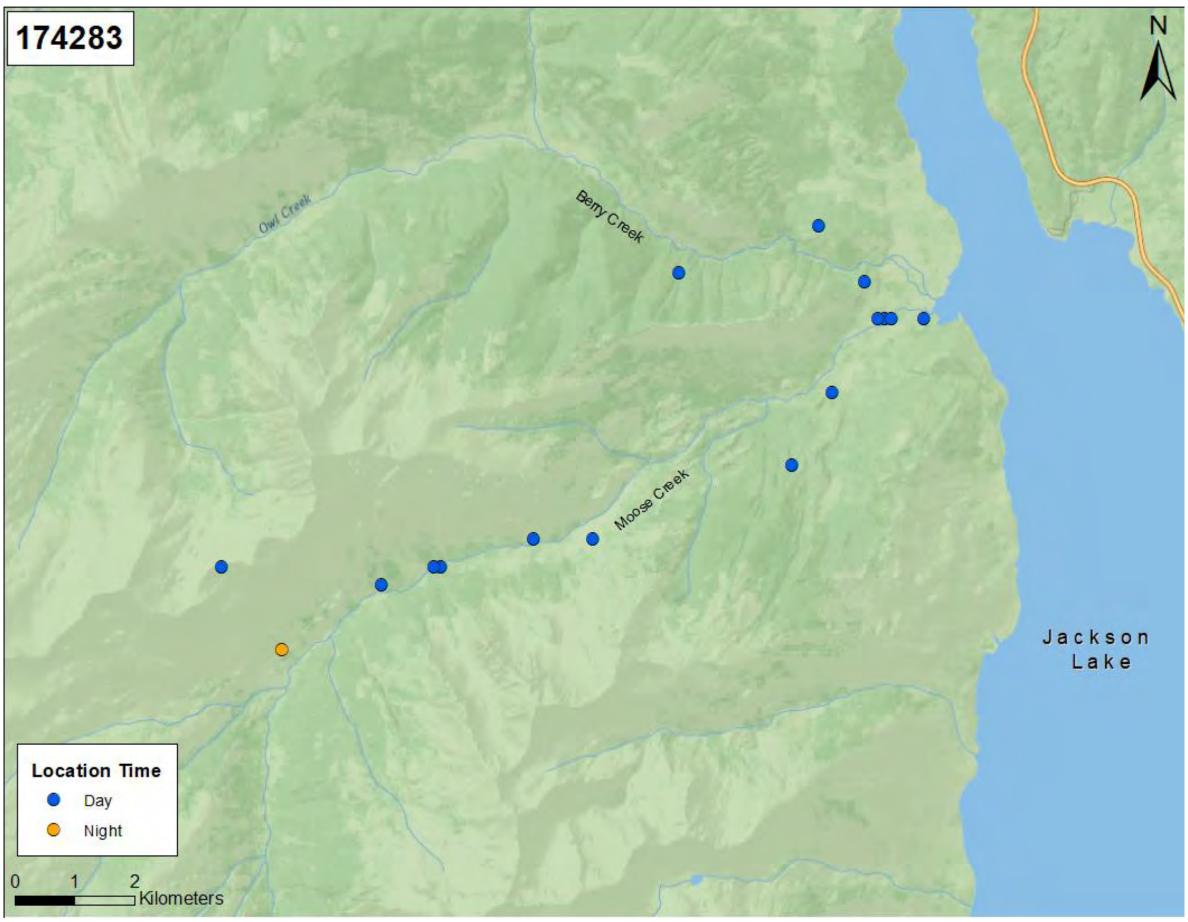

Figure 15. Locations for male 174283 on its breeding area.

This male departed Moose Creek on July 6. The next location was recorded during migration on July 7 near Spokane, Washington. Several more locations were recorded on July 7, as the bird migrated across the grasslands of eastern Washington toward the town of Yakima, Washington. The next signals included multiple locations during July 10-13 near the confluence of the Columbia River on the border of Oregon and Washington **(N 46.298, W -123.841)**. This bird remained in this area during July 7-17 (≤10 days). The next signals were recorded during July 17-20 on western shoreline of Vancouver Island, British Columbia **(N 48.860, W -125.370)**. The next signals were recorded during July 22-23, approximately 18 km to the northwest along western Vancouver Island **(N 48.944, W -125.577)**. Over the next several days (July 23-30), the bird continued to shift slightly (2-3 km) northwesterly along Vancouver Island. The next signal was recorded on August 4, approximately 158 km to the northwest, along Vancouver Island. The next signal was recorded on August 13, approximately 122 km north along the northern end of Vancouver Island **(N 50.926, W -127.932)**. This bird has remained in this area (through mid-October) where it likely molted, arriving there during August 4-13. The duration of migration was 29-38 days and the total migration distance was 1,796 km. **Molt location: Vancouver Island, BC (N 50.926, W -127.932)** (Figure 16).

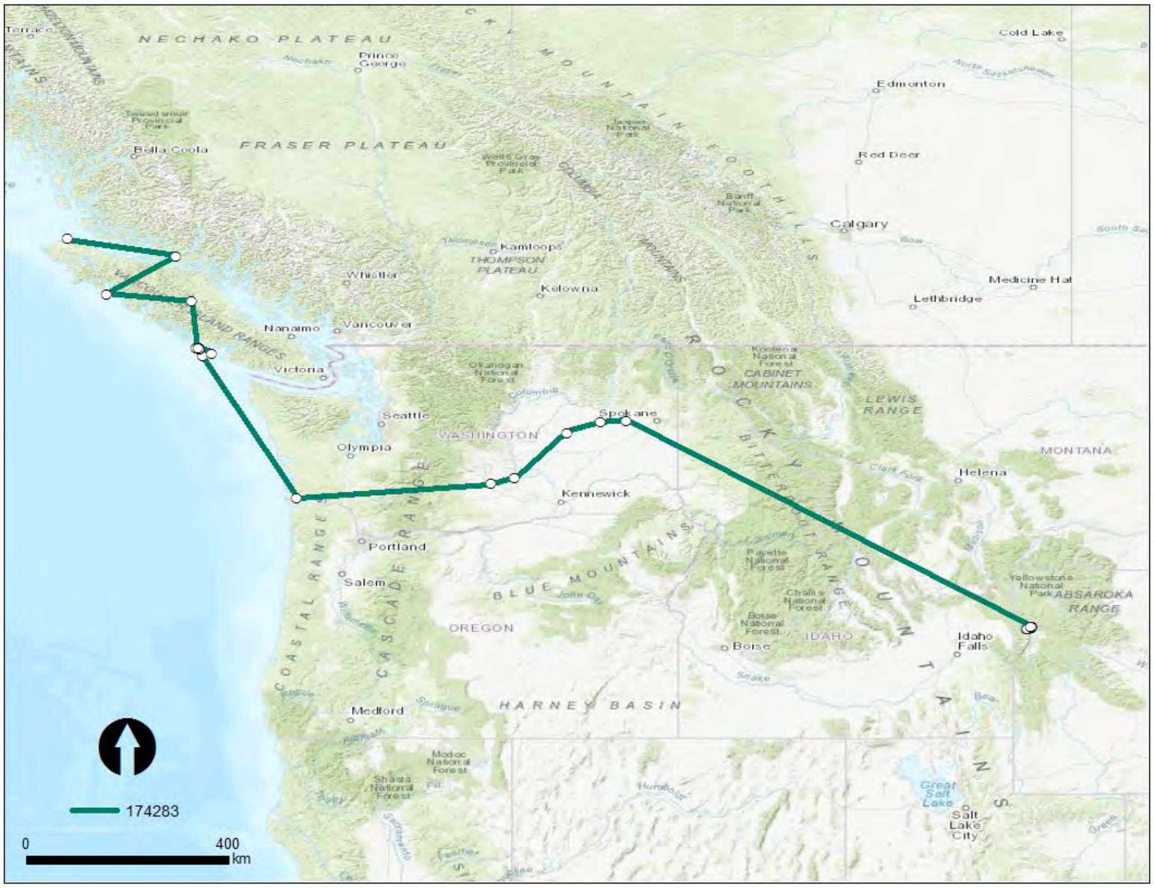

Figure 16. Locations of male 174283 during its molt migration.

Yellowstone National Park (2017-18)

During May 2017-18, we satellite tagged five male Harlequin Ducks within YNP, from a combination of breeding stream sites and the LeHardy Rapids, a staging area along the Yellowstone River, where several pairs of harlequins congregate prior to presumably dispersing to breeding streams in June.

<u>Yellowstone River – LeHardy Rapids</u>

Trapping harlequins along the Yellowstone River and at LeHardy Rapids is difficult due to the river's wide expanse and deep, fast-flowing water. The only opportunity to safely wade into the river and deploy a capture net is below the main LeHardy Rapid section and near shore. Harlequins at LeHardy generally prefer the more turbulent sections of the river for feeding and loafing activities, and interactions with the net area is minimal.

We tagged a total of two males, one in 2017 and the other in 2018, at the LeHardy Rapids. Capturing and attaching transmitters to males staging at this location provided an opportunity to not only obtain annual movement data, but to also potentially identify previously unknown breeding stream locations utilized by harlequins staging at LeHardy Rapids in early spring.

LeHardy Rapids 33029 (2017); band #1125-02492

We captured and satellite tagged male 33029 at LeHardy Rapids on May 22, 2017. It remained on its breeding area for 28-29 days following tagging, before initiating summer molt migration between June 19-20. While on the breeding grounds, this male generally remained in close proximity to its tagging location on the Yellowstone River (LeHardy Rapids), utilizing 1.6 km of stream. However, this male also visited sections of Thistle Creek, a tributary to the Yellowstone River located immediately below the LeHardy Rapids; single locations on June 2, 5, 6 were recorded at various locations along Thistle **Creek (N 44.610, W -110.384)**. Additionally, on June 4 and 5, multiple locations were recorded approximately 40 km east of LeHardy Rapids on the North Fork Shoshone River, Wyoming **(N 44.607, W -109.892)**. During June 16-19, the male began utilizing a section of the Yellowstone River approximately 4.5 km downriver from LeHardy Rapids (Figure 17).

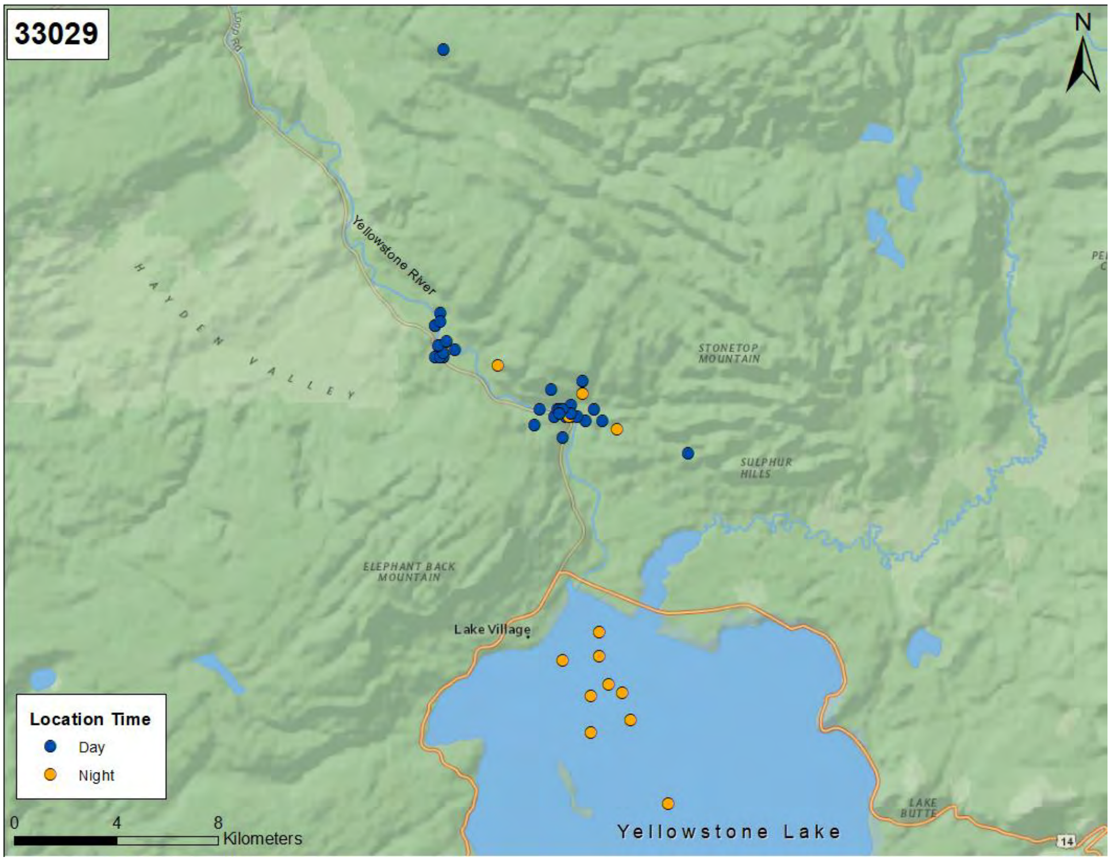

Figure 17. Locations for male harlequin 33029 on its breeding area.

A few days later, the male departed from the downstream portion of the Yellowstone River and initiated molt migration during June 19-20. On June 20 a signal was received 303 km northwest in western Montana. The next signal was recorded on June 21 approximately 340 km northwest on the Palouse River in southeast Washington **(N 46.930, W -117.923)**. The next signal was recorded on June 22 approximately 418 km northwest in central-western Washington. It then arrived to the northwest peninsula of Washington during June 22-24 and remained there until June 28. From there it moved approximately 169 km north to the central western coastline of Vancouver Island, British Columbia **(N 49.356, W -126.294)** arriving during June 28-29. The bird remained in this area throughout the molt and wintered in the same location. The distance from the capture area to the molt/winter location was 1,378 km. The male remained on the molt and wintering site for 310-312 days. **Molt and Wintering Location: Vancouver Island, BC (N 49.352923, W -126.289285)**.

Between May 6-7, the bird departed its wintering area, signaling from the Olympic Peninsula on May 6 and arrived to Puget Sound (Bainbridge Island) between May 6-7. The bird remained at Bainbridge Island through May 22-23 (16-17 days). On May 23 a signal was recorded in eastern Washington, near Chewelah. The next signal was received May 25 on the Elk River in British Columbia. The male continued to provide locations from nearby Cardona Creek **(N 50.447, W -114.992)**, a tributary of the Elk River, until June 15, when the transmitter stopped signaling (Figure 18). The loss of satellite signals was likely due to the exhaustion of the transmitter batteries, subsequently reaching the expected transmitter longevity of one year. The total duration of spring migration from winter departure to the breeding area was 17-18 days. The duration of travel from the Puget Sound spring staging location to its breeding site was 2-3 days. The linear distance between differing breeding locations in 2016 and 2017 was 735 km.

Figure 18. The annual migration locations of male harlequin 33029 to and from its molting and wintering areas.

LeHardy Rapids 174281 (2018); band #1125-02497

This male utilized an 11.1 km stretch of the Yellowstone River, as well as 1.2 km of Thistle Creek, a tributary of the Yellowstone River located immediately downstream of LeHardy Rapids. This male appeared to have visited Thistle Creek briefly on May 16. Multiple evening locations were recorded on the northern end of Yellowstone Lake near the outlet of the Yellowstone River. It appears this bird used Yellowstone Lake to roost (Figure 19).

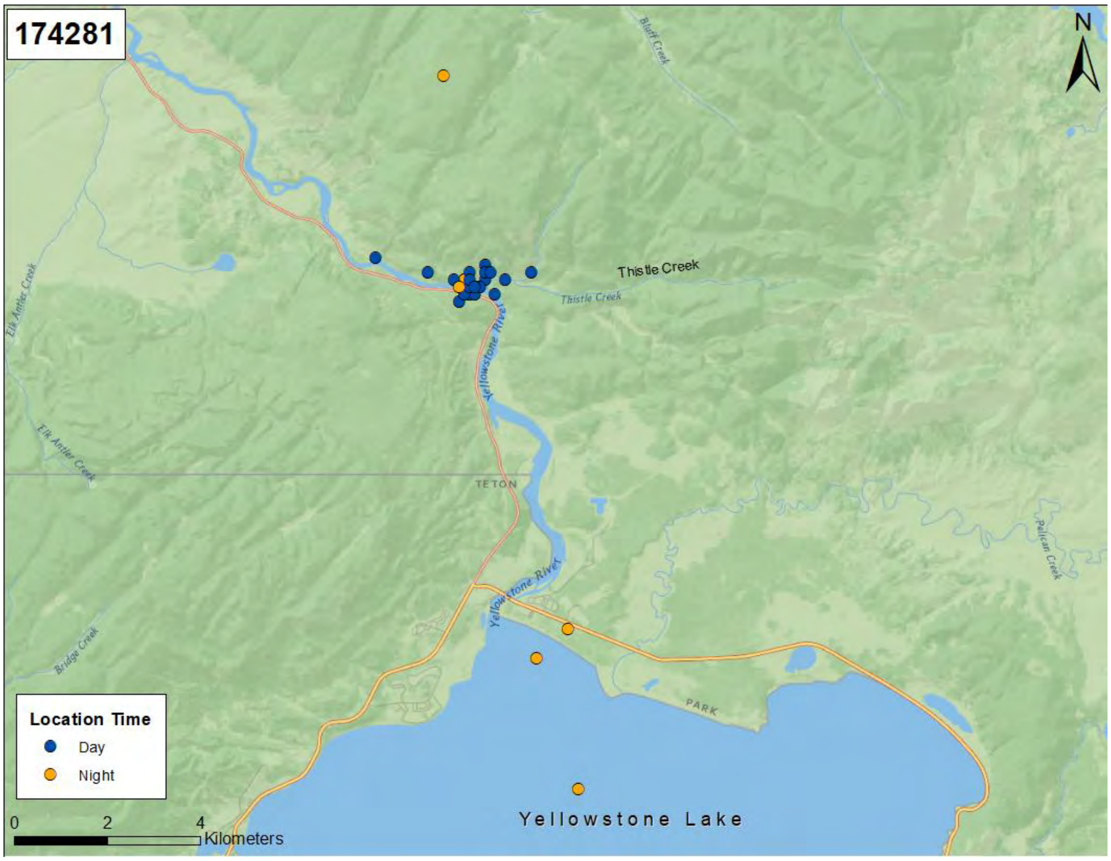

Figure 19. Locations for male harlequin 174281 on its breeding area.

The male departed the LeHardy Rapids area during June 3-5 and first signaled on the Selway River, in Idaho **(N 46.094, W -115.098)** on June 5 and then again on the Pacific coast, arriving to the northern end of Vancouver Island, British Columbia between on June 5-8. This harlequin has remained (mid-October 2018) in this immediate area since arriving in June, and would have molted in this Vancouver Island location (Figure 20). The total distance of the molt migration from LeHardy Rapids to Vancouver Island was approximately 1,508 km. The bird remained near the LeHardy area for 18-21 days following tagging before initiating molt migration. **Molt Location: Vancouver Island, BC (N 50.804, W -128.290)**.

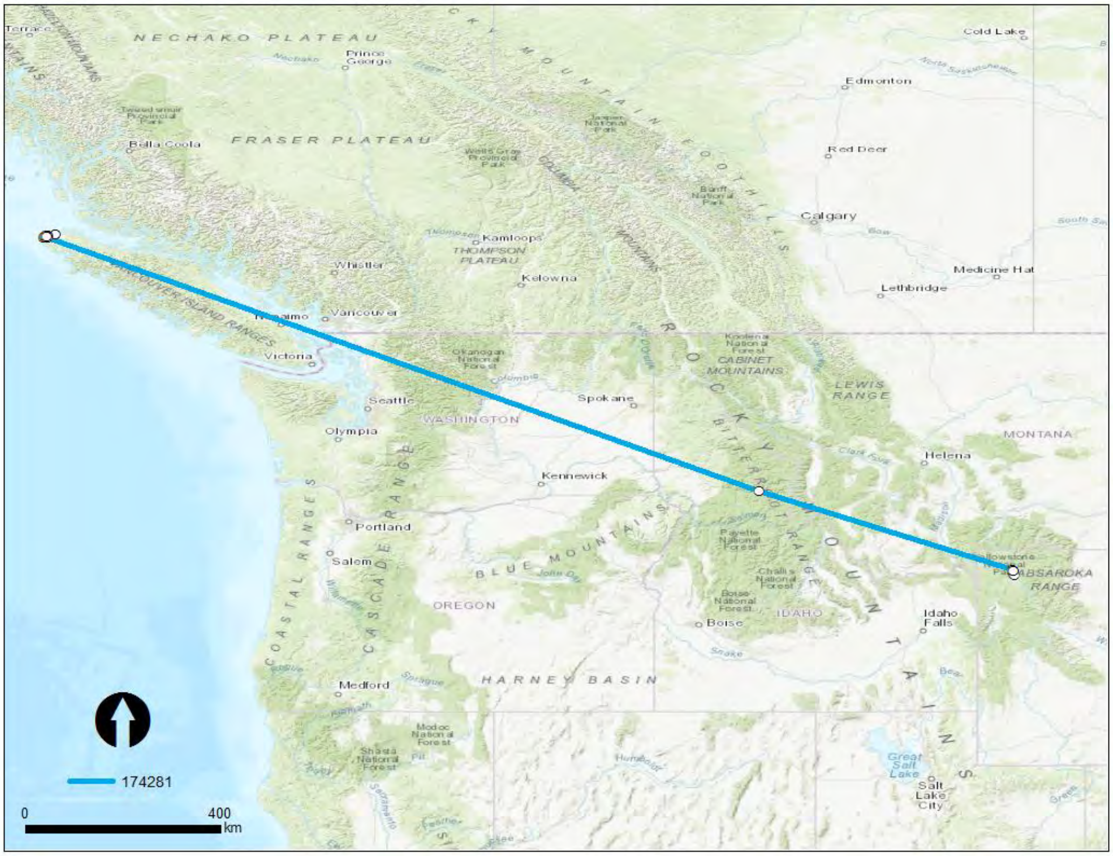

Figure 20. Locations of male harlequin 174281 during its molt migration.

<u>Tower Creek 174282 (2018); band #1125-02495</u>

This male generally remained near the capture location on Tower Creek during the breeding season, utilizing a 2.3 km stretch of the stream. Occasional locations were recorded on the Yellowstone River, slightly downstream of the outlet of Tower Creek **(N 44.895, W -110.379)**. A single location was recorded May 20 on Lost Creek, the neighboring creek located to the north of Tower Creek **(N 44.875, W -110.457)**. Two locations were recorded on June 16 from the east side of Specimen Ridge **(N 44.896, W -110.360)**, suggesting the male made visits to creeks in that area or traveled to the Lamar River (Figure 21).

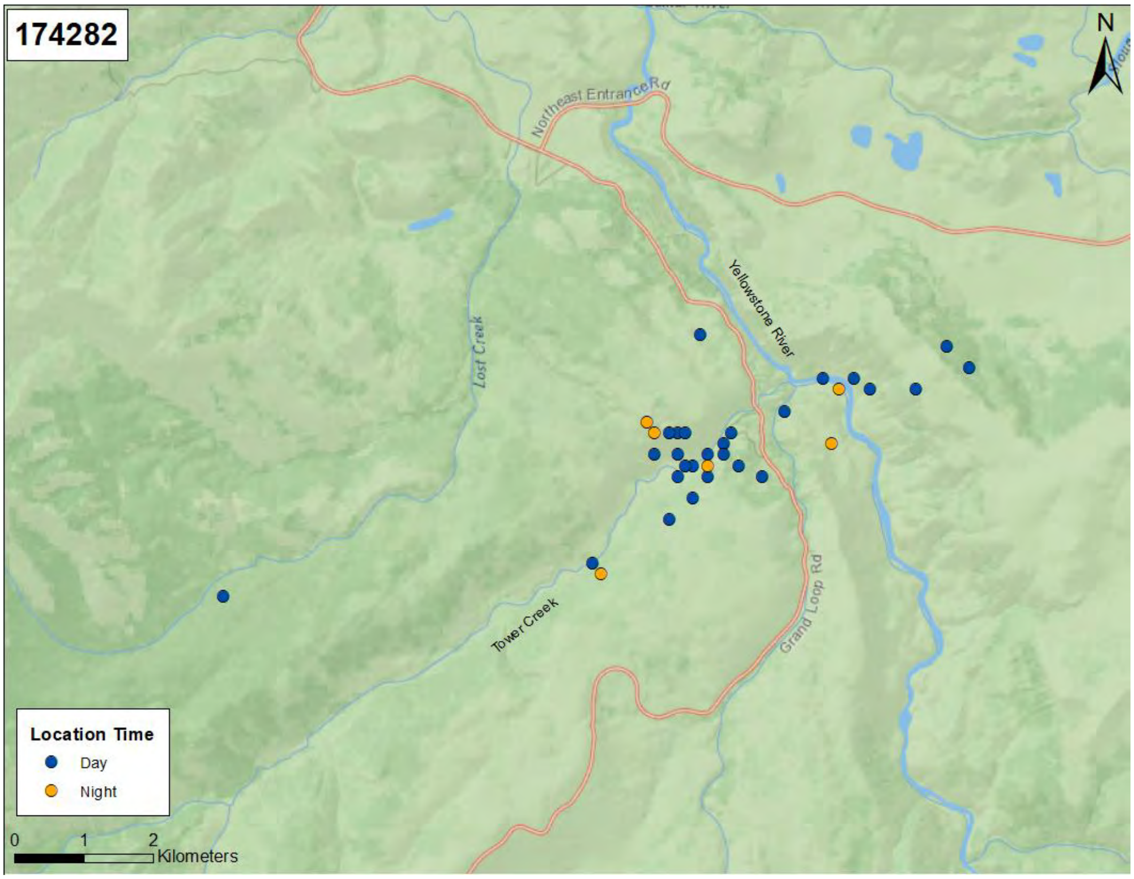

Figure 21. Locations for male harlequin 174282 on its breeding area.

The male departed Tower Creek during June 25-26, and initially signaled near the Payette National Forest in northeast Idaho (near Dixie) on June 26. The next location was July 1 on the Pacific coast near Cannon Beach, Oregon **(N 45.881, W -123.987)** (Figure 22). This harlequin has remained (mid-October 2018) in this immediate area since arriving July 1, and would have molted in this coastal location. The duration of molt migration was 5-6 days and the linear distance between its breeding and molting site was 1,068 km. The bird remained on Tower Creek for 38-39 days following tagging before initiating molt migration. **Molt Location: Cannon Beach, Oregon (N 45.881, W -123.987)**.

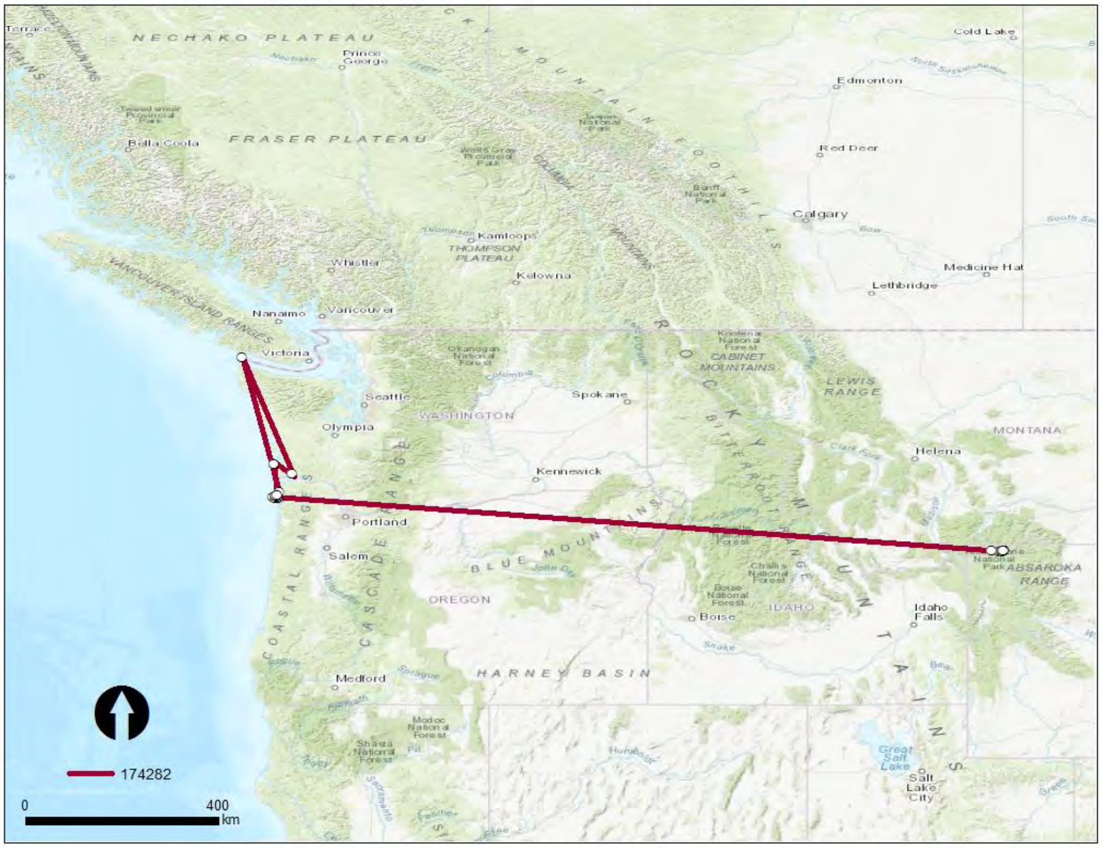

Figure 22. Locations of male harlequin 174282 during its molt migration.

<u>Soda Butte Creek 174284 (2018); band #1125-02499</u>

This male generally remained near the capture location on Soda Butte Creek during the breeding season, utilizing a 2.3 km stretch of the stream. A single location was recorded on June 16 at Amphitheater Creek, located approximately 5 km northeast of Soda Butte Creek **(N 44.973, W -110.004)** (Figure 23).

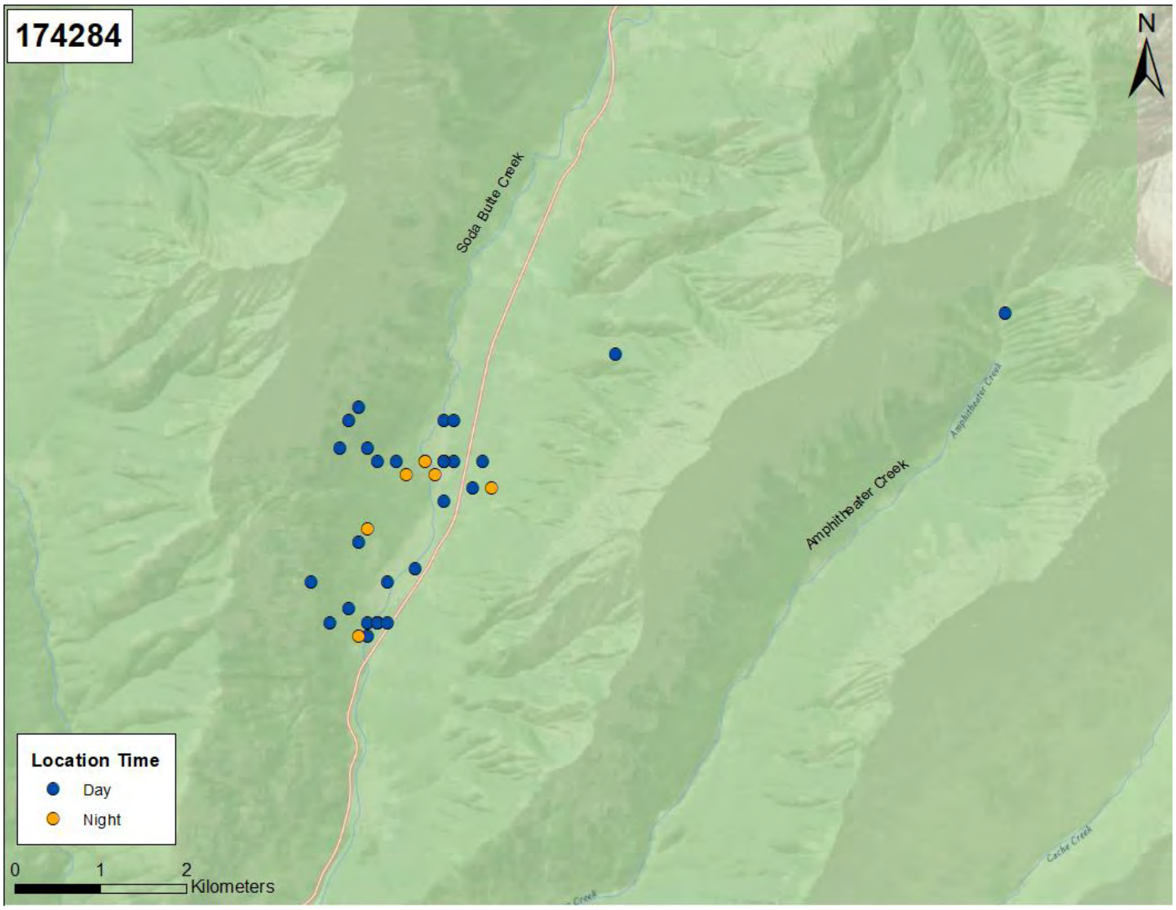

Figure 23. Locations for male harlequin 174284 on its breeding area.

This male departed Soda Butte Creek during June 23-24 and first signaled on June 24 in northeast Idaho along the Salmon River, west of North Fork, Idaho **(N 45.332, W -114.365)**. Only a single location was recorded and it is unclear if the bird stopped at this location or if the location was recorded while the bird was in flight. Two poor quality signals were received on June 25 and 26 along the Columbia River, near Wenatchee, Washington, but given the quality of the locations we could not determine whether the bird actually utilized the Columbia River. The next signal was recorded on June 27 in the Salish Sea/Puget Sound, Washington **(N 48.094, W -122.734)**. The bird has remained in this general area (mid-October) where it likely molted (Figure 24). The bird remained on Soda Butte Creek for 34-35 days following tagging before initiating molt migration. The total duration of molt migration was ≤4 days and the distance between its breeding and molting site was 1,046 km. **Molting Location: Puget Sound, Washington (N 48.094, W -122.734)**.

Figure 24. Locations of male harlequin 174284 during its molt migration.

<u>Soda Butte Creek 32793 (2018); band #1125-02500</u>

This bird appeared to be an unpaired male, accompanying a pair of harlequins during the capture event. It utilized a relatively large section of Soda Butte Creek during the breeding season in comparison to the paired male on Soda Butte Creek (174284; 22.7 km and 2.3 km, respectively). On June 16-17, two signals were recorded from Amphitheater Creek, approximately 5 km northeast of Soda Butte Creek. On June 5, a signal was recorded at Pebble

Creek **(N 44.970, W -110.127)** approximately 4 km northwest of Soda Butte Creek. On May 29, a single location was recorded on an unnamed creek located between Pebble Creek and Soda Butte Creek, near Barronette Peak **(N 44.980, W -110.091)** (Figure 25).

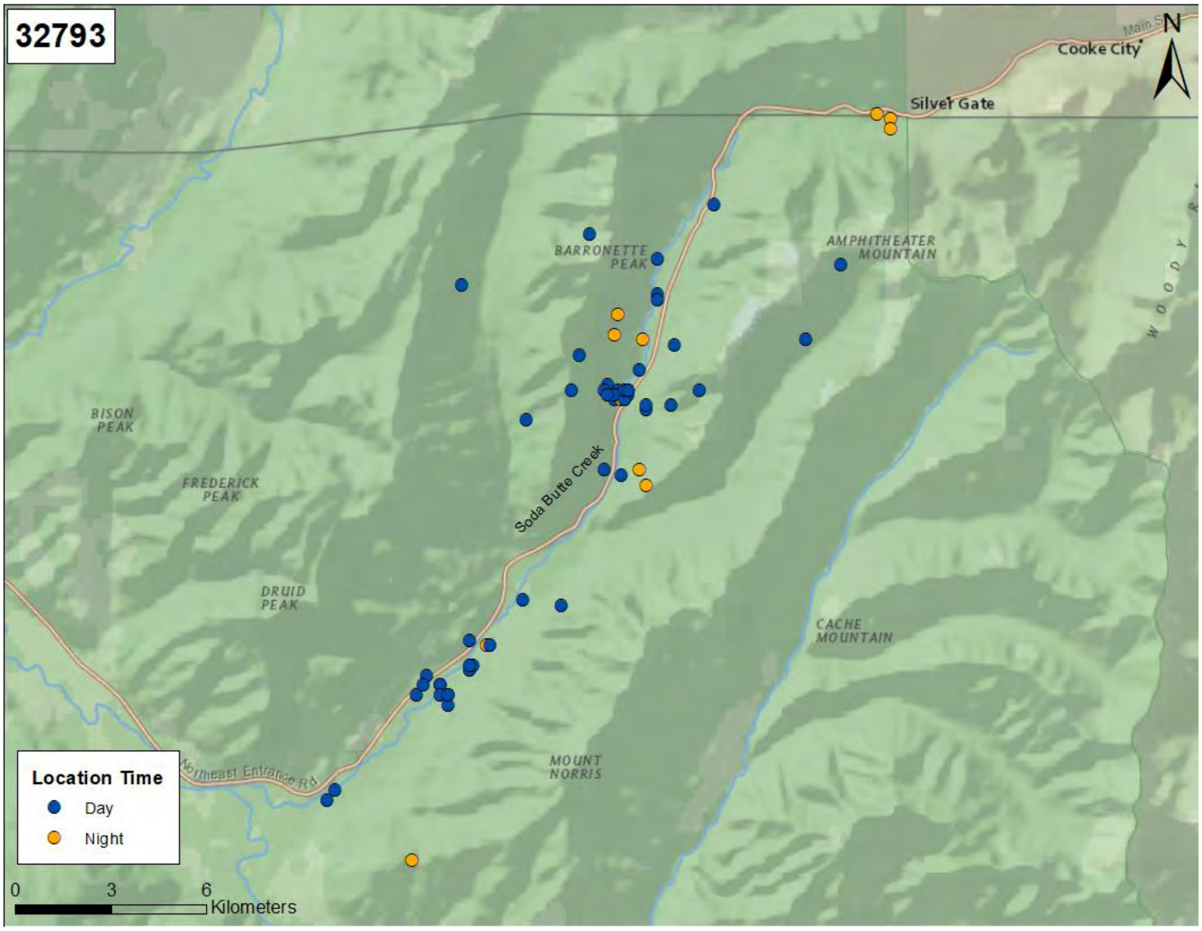

Figure 25. Locations for male harlequin 32793 on its breeding area.

This male departed Soda Butte Creek on July 4-5 and first signaled on July 5 near Two-mile Creek, west of the town of St. Regis, located in northwest Montana **(N 47.267, W -115.251)**. This was a single location and it is unclear if the bird stopped at this creek or was passing through during flight. The next signal was recorded on July 5, slightly southeast of Spokane, Washington, followed by multiple signals recorded on July 6 during flight in southern British Columbia. The next signal was recorded on July 7 from Spius Creek **(N 50.009, W -121.068)**, located 24 km southwest of the town of Merritt, British Columbia. The next sets of signals were recorded during July 8-11, on the Fraser River, near Boston Bar, British Columbia **(N 49.838, W -121.438)** (Figure 26). This bird remained in the area until July 14-15, when the temperature sensor of the radio indicated the bird had died during migration from an unknown cause.

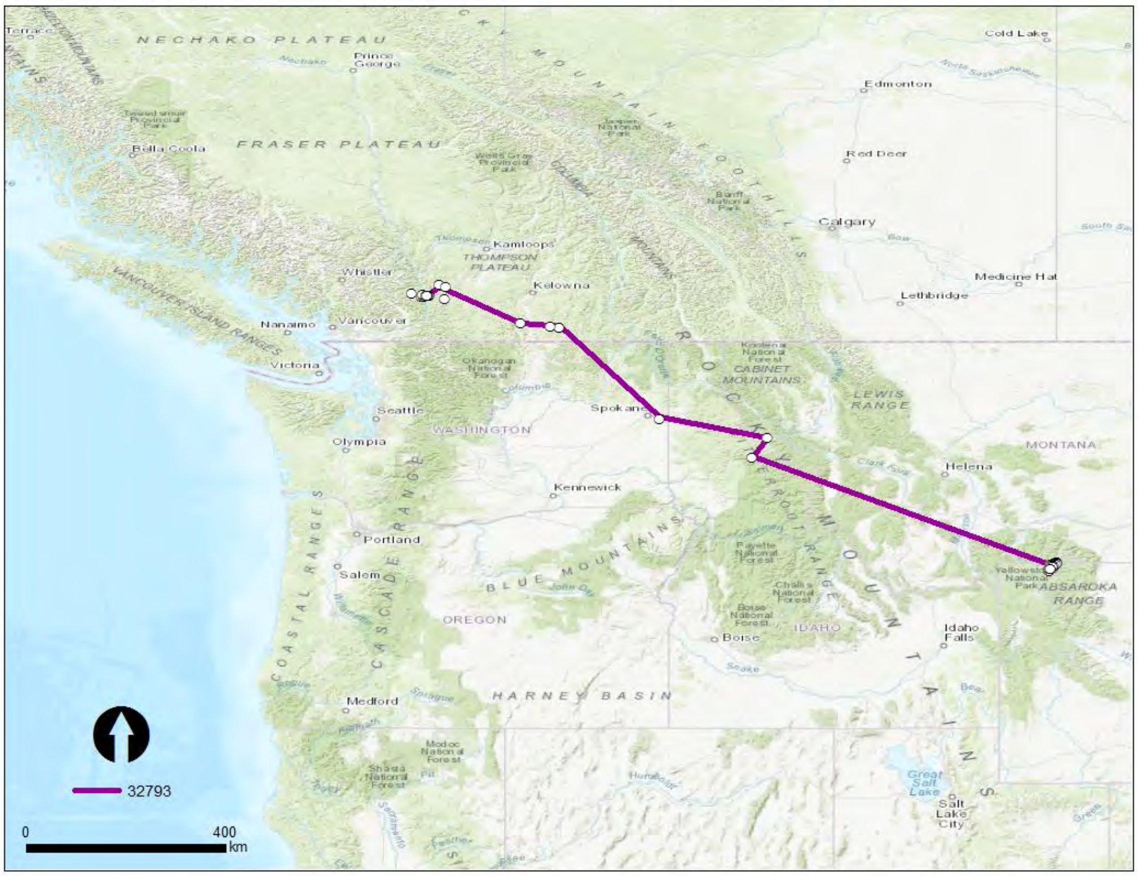

Figure 26. Locations of male harlequin 32793 during its molt migration.

6.4 Seasonal Movements of Male Harlequins – phenology

Breeding Season

Satellite tagged male harlequins remained on their breeding areas for 18-48 days following the satellite transmitter tagging procedure performed during May 16-24. Paired male harlequins tended to utilize smaller sections of their breeding stream, ranging in distances of 1.6-11.1 km.

The only male that was captured unpaired utilized a larger area of stream (22.7 km). Overall, the maximum linear distance between recorded locations on breeding streams ranged from 1.6 – 22.7 km and mean distances were 8.4 ± 1.9 km and 8.0 ± 9.1 km for GTNP and YNP, respectively. Four paired individuals (50%) made at least one visit to neighboring streams. The unpaired male made visits to two other streams. Male harlequins satellite marked in Grand Teton National Park utilized the northern end of Jackson Lake for roosting. Similarly, males staging in the spring at the LeHardy Rapids utilized the northwestern section of Yellowstone Lake to roost.

Molt Migration

All nine male harlequins initiated molt migration from their breeding areas. The departure dates varied by the individual and breeding site. Overall, male harlequins departed their breeding areas during early June through early July (June 3 - July 8). Generally, male harlequins breeding within GTNP departed their breeding areas slightly later than harlequins within YNP (June 29 – July 8 and June 3 – July 5, respectively) (Table 4).

We were able to record detailed movement data during a complete summer molt migration for seven of the nine harlequins. Two of the harlequins died from an unknown cause during the summer molt migration period, at interior locations of Washington and British Columbia.

All seven of the male harlequins completing molt migration traveled to various locations along the Pacific coast. The duration of migration, which was determined by the date of departure from the breeding area until the date harlequins reached their eventual molting site, ranged from ≤4 to 38 days. Four of the seven (57%) harlequins completed migration ≤10 days. The initial arrival location to the Pacific coast for three of the seven (43%) harlequins was also their eventual molting site, and their migration was completed in ≤6 days. The remaining four harlequins arrived to the Pacific coast and then moved to their molting site 1-37 days later. The distance between first arrival sites and eventual molting sites was 103-596 km.

Table 4. Male Harlequin Duck molt migration: timing, duration, and arrival dates, 2016-2018 (n=9).

Year-Site	Transmitter ID	Departure date[a]	Migration duration (days)	Migration distance (km)*	Arrival Pacific[b]	Arrival molt location[c]
GRTE						
2016	159799	Jul 1	11-12	1,564	Jul 3 - 4	Jul 12 - 13
2016	159798	Jul 7 - 8	10-24	1,442	Jul 14 - 18	Jul 18 - 31
2017	32894	Jun 29 - 30	na[d]	747[d]	na[d]	na[d]
2018	174283	Jul 6	29-38	1,796	Jul 7 - 10	Aug 4 - 13
YNP						
2017	33029	Jun 19 - 20	8-10	1,378	Jun 22 - 24	Jun 28 - 29
2018	174281	Jun 3 - 5	≤6	1,508	Jun 5-8	Jun 5 - 8
2018	174282	Jun 25 - 26	5-6	1,068	Jun 26 - Jul 1	Jun 26 - Jul 1
2018	174284	Jun 23 - 24	≤4	1,046	Jun 24 - 27	Jun 24 - 27
2018	32793	Jul 4 - 5	na[d]	na[d]	na[d]	na[d]
2016-18	**All**	**Jun 3 – Jul 8**	**≤4 to 38**	**747 to 1,796**	**Jun 5 - Jul 18**	**Jun 5 – Aug 13**

[a]Initial departure from breeding stream

[b]Initial arrival to Pacific waters

[c] Initial arrival to molting areas

[d]Bird died during molt migration

*Migration Distance = actual distance flown from breeding stream to first coastal location (salt water). This is not a straight line measure.

Male Harlequin Ducks utilized a wide variety of habitat during their summer molt migration. Location data were recorded primarily along sections of western Montana, north-central Idaho, and throughout Washington. One individual from YNP provided movement data during migration across southern Alberta and British Columbia. The majority of locations from all birds were recorded within temperate conifer forests. However, four individuals also signaled from a combination of deserts and shrublands along with temperate grasslands and shrublands of eastern and central Washington (Table 5; Figure 27).

Table 5. Habitat classifications utilized by male Harlequin Ducks during their summer molt migration, 2016-18.

Year-Site	ID	Stopover habitat*	Migration habitat
GRTE			
2016	159799	R	desert and shrublands,; temperate grasslands, savannas, shrublands; temperate conifer forests
2016	159798	R,S	temperate conifer forest
2017	32894	R	temperate grasslands; desert and shrublands
2018	174283	R/B, C	desert and shrublands,; temperate grasslands, savannas, shrublands
YNP			
2017	33029	R	temperate conifer forest; temperate grasslands, savannas, shrublands
2018	174281	R	temperate conifer forest
2018	174282	~	unknown
2018	174284	R	temperate conifer forest
2018	32793	R/S	temperate conifer forest

* Habitat stopover: R = River, S= Mountain stream, C = Coastline, B = Bay

We identified several areas at which harlequins stopped for varying periods of time (≥2 locations in the same area) during migration, presumably to rest or forage. These areas consisted of rivers, mountain streams, and the Pacific coastline including bays or estuaries. All eight individuals that recorded stopover locations during migration utilized rivers. Two of these harlequins also used streams and one individual also utilized the coast and bays. One harlequin (174282) did not provide any location data between the breeding area and its Pacific coast molting site.

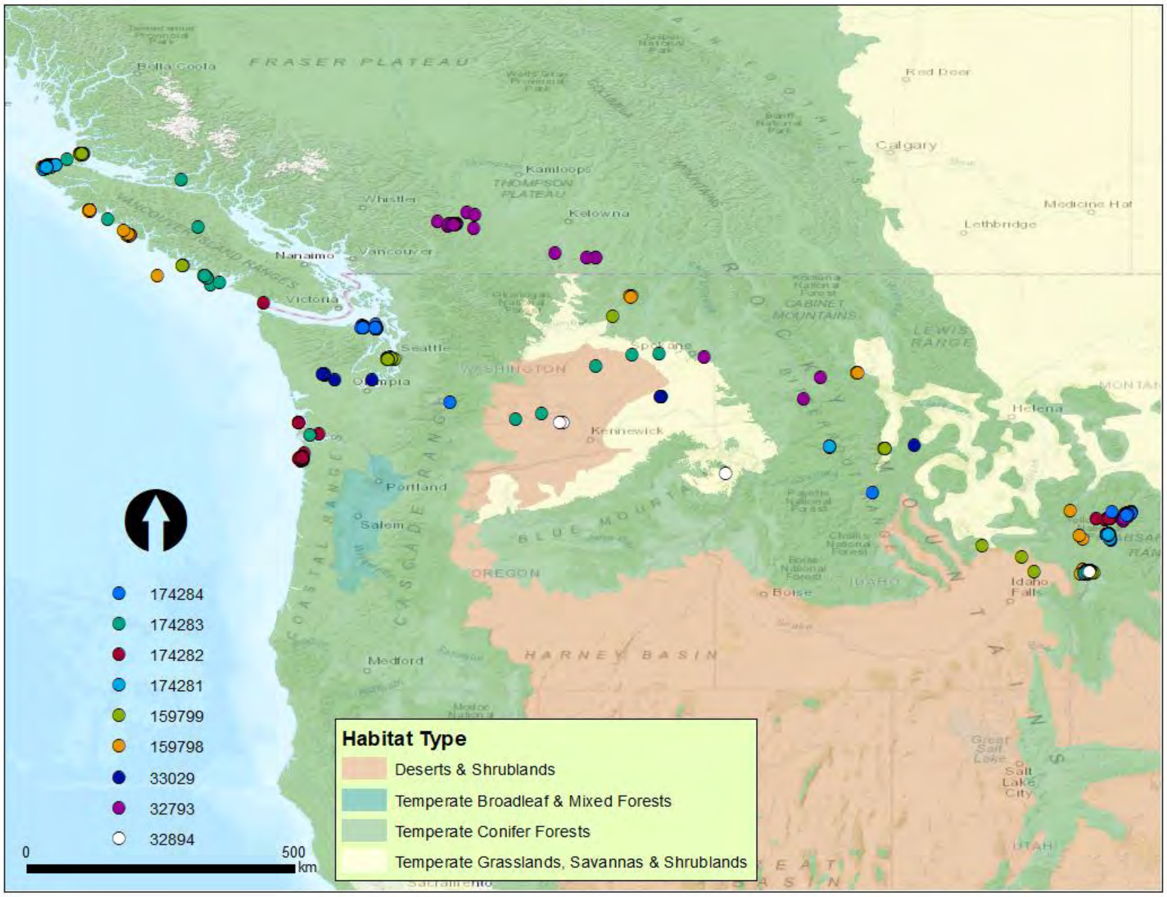

Figure 27. Male Harlequin Duck satellite telemetry locations and habitat associations, 2016-18.

The specific creeks and rivers at which migration data was recorded included: the Flathead River, Bitterroot River, and Two-mile Creek in Montana; Henry's Fork River, Salmon River, and Selway River in Idaho; the Fraser River, in British Columbia; the Palouse River, Sherman Creek, and Snake River in Washington; the Imnaha River in Oregon; and the confluence of the Columbia River in coastal Oregon and Washington (Table 6).

Table 6. Male Harlequin Duck molt migration stopover locations on creeks and rivers.

Bird ID	Tagging Location	River	State	Latitude	Longitude
159798	GTNP	Sherman Creek	WA	48.632	-118.453
159799	GTNP	Henry's Fork River	ID	44.363	-109.724
159799	GTNP	Bitterroot River	MT	46.067	-114.163
32894	GTNP	Imnaha River	OR	45.649	-116.838
32894	GTNP	Snake River	WA	46.298	-118.798
174283	GTNP	Columbia River	OR/WA	46.298	-123.841
33029	YNP	Palouse River	WA	46.930	-117.923
174281	YNP	Selway River	ID	46.094	-115.098
174284	YNP	Salmon River	ID	45.332	-114.365
32793	YNP	Two-mile Creek	MT	47.267	-115.251
32793	YNP	Fraser River	BC	49.838	-121.438

Molting Locations

We identified the Pacific coast summer molt locations of seven satellite tagged male Harlequin Ducks captured during 2016-18 in GTNP (n=3) and YNP (n=4). Arrival dates to molt locations varied and generally occurred during June and July (June 3 – July 31). However, one male arrived to its molt location during August 4-13. Three male harlequins marked in GTNP provided satellite locations to identify molting areas. Each of the birds molted in separate areas along the northeastern and western shorelines of Vancouver Island, British Columbia, Canada. Four male harlequins marked in YNP were tracked to their molting areas, which included the Oregon coast, the Salish Sea/Puget Sound, and Vancouver Island (Figure 28).

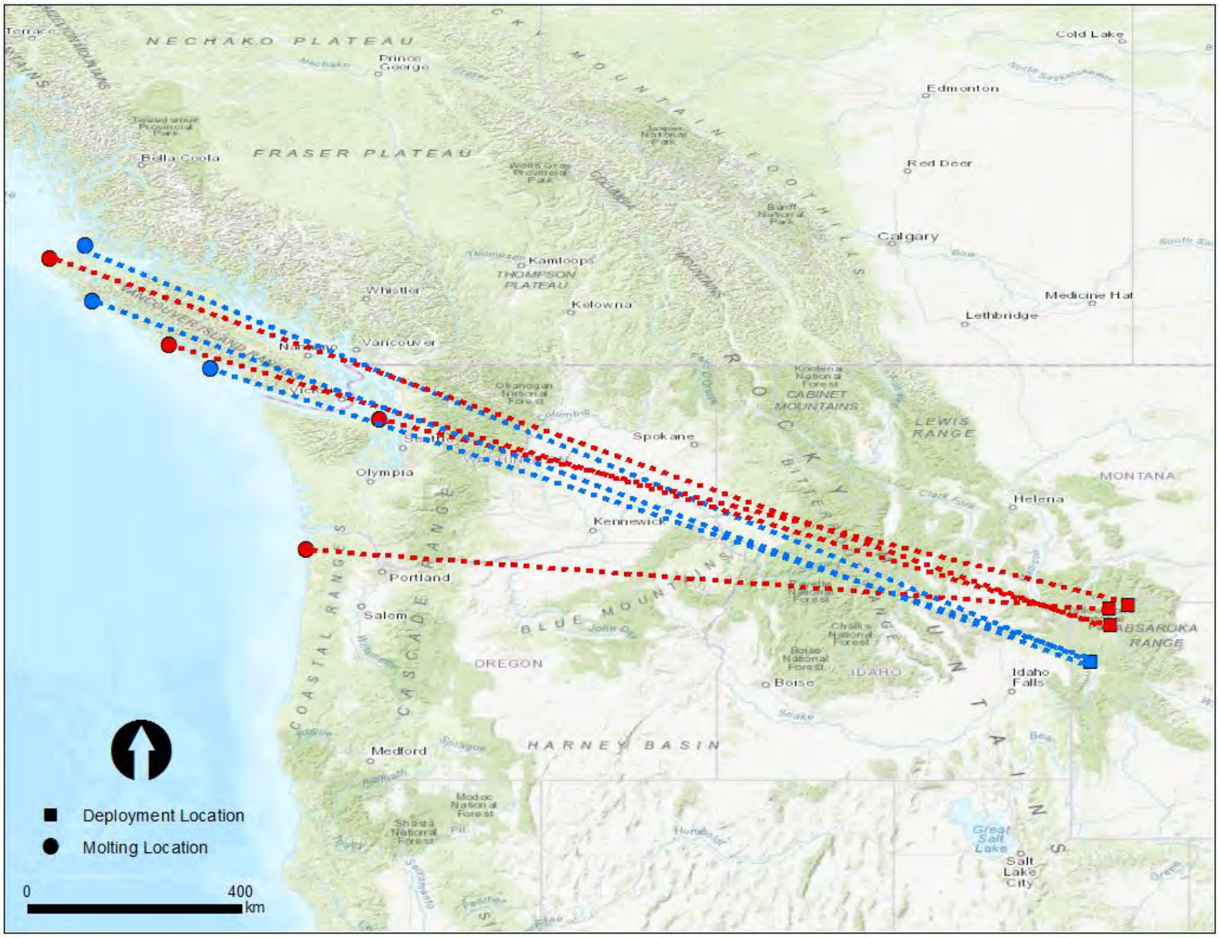

Figure 28. Molt locations of male Harlequin Ducks from breeding sites in GTNP (blue) and YNP (red), 2016-18. Lines do not necessarily represent direct migration routes.

Three male harlequins tagged in 2016 and 2017 provided satellite data throughout the molt and into the wintering period. Each of the three harlequins moved slight distances between molt and winter sites; 13, 45, and 51 km. Two of the males departed their molt locations during October 5-9 and the other during October 10-31. These three male harlequins occupied their molting areas between 66-125 days.

Overall, sites along Vancouver Island accounted for 71% of Wyoming's male harlequin molting locations. The other two molting sites included the Salish Sea, split between British Columbia and the state of Washington, and the Oregon coast, near Cannon Beach.

Wintering Locations

All three harlequins tracked to their wintering areas selected locations along the western or northern coastline of Vancouver Island (Figure 29).

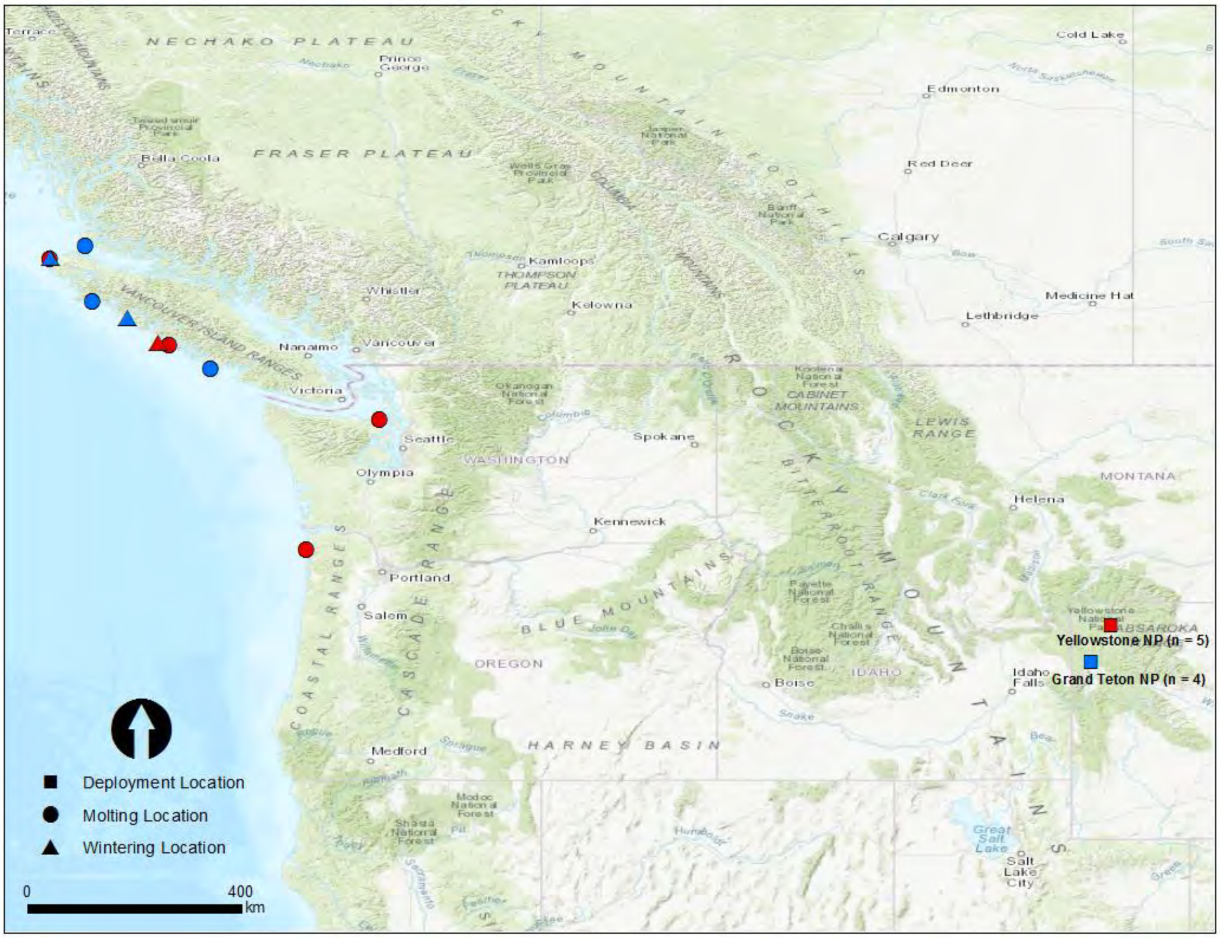

Figure 29. Molt and wintering locations of male harlequins satellite tagged in Wyoming, 2016-18.

Satellite tagged harlequins arrived to their wintering locations during October 5-31; two of the birds arrived during October 5-9 and one bird arrived during October 10-31. One male died from an unknown cause during the early wintering period (November) while another harlequin's transmitter ceased to operate in December. One male successfully provided satellite location data throughout the wintering period. This bird resided on its wintering area for 187-209 days, before departing in the spring between May 6-7.

Spring Migration

A single male harlequin tagged in YNP in 2017 (33029) provided satellite location data throughout the entire winter period, and through a complete spring migration to its eventual breeding area. This bird departed its wintering area at Vancouver Island on May 6-7 and traveled approximately 357 km to Puget Sound, near Bainbridge Island. This bird staged in this location for 16-18 days and departed for its breeding area on May 23-24, and arrived to its breeding site on May 24-26. The total duration for spring migration was 17-18 days.

Male Breeding Site Fidelity

Of the four male harlequins satellite tagged during the 2016 and 2017 seasons, only one individual successfully provided location data throughout the complete annual cycle. In May 2017, Harlequin Duck 33029 was tagged at the LeHardy Rapids in YNP, and remained in that area throughout the breeding season (May-June). The following spring (May), this male departed its Vancouver Island wintering area, staged in Puget Sound, and traveled to southeastern British Columbia, providing signals and presumably paired on Cadorna Creek, a tributary of the Elk River. The linear distance between breeding sites in subsequent years was 735 km.

6.5 Geolocator Retrieval

During 2016-18, we attached geolocators to the leg bands of four female harlequin ducks, three in GTNP and one in YNP. Three of these birds were captured during the 2016 and 2017 seasons and we revisited their breeding areas in subsequent seasons to attempt to recapture returning birds in order to retrieve the geolocators. Two of the harlequins were re-observed at their previous season locations and we were successful in recapturing one individual from GTNP. The geolocator and leg band was intact and the condition of the harlequin's leg was normal. The geolocator was shipped back to the manufacturer to extract the data and we are awaiting results.

7.0 DISCUSSION

All nine male harlequins marked with a satellite transmitter provided location data throughout their stay at their breeding areas and successfully initiated molt migrations. While on the breeding areas, individuals generally remained close to the location they were trapped, however, more pronounced movements were detected in some males. The maximum linear distance between recorded locations on breeding streams ranged from 1.6 – 22.7 km and mean distances were 8.4 ± 1.9 km and 8.0 ± 9.1 km, for GTNP and YNP, respectively. In comparison, a harlequin study in Oregon (1994-95) reported a mean distance traveled by nesting females of 1.9 km during the late nesting period and 2.1 km during the early stages of nesting. This Oregon study also determined non-nesting or unknown nesting females moved slightly greater distances, 9.0 km and 11.4 km, respectively (Bruner 1997).

In our study, with the exception of one male captured at Soda Butte Creek (32793), all male harlequins were paired at the time of capture. Within the scope of our study, we were unable to determine whether or not the females of paired males attempted to nest or how closely paired males remained to a female initiating incubation activities. We suspect paired males remain close to the females throughout pre-nesting activities and may stray once incubation has begun. Interestingly, the unpaired male utilized the greatest distance (22.7 km) of stream.

Previous studies determined male Harlequin Ducks breeding in western North America migrate to the Pacific coast to undergo a molt shortly after female harlequins initiate nests (Baldassarre 2014). This molt migration generally occurs during mid-June through late July (Robertson et al. 1997). In our study, all nine harlequins departed their breeding areas during early June through early July (June 3-July 8). Preliminary results combining the movement data of male harlequins marked with satellite transmitters from various locations in western North America suggest the timing of molt migration varies by breeding area (Savoy et al. 2017) and is likely influenced by the arrival date to breeding streams that particular spring. The streams used by harlequins in GTNP and YNP are higher in elevation (6,560 – 7,732 feet) than streams supporting males that were satellite tagged in areas of Washington, Montana, and Alberta (1,891 – 5,217 feet). Due to elevation, we suspect Wyoming's snowpack melts later in spring and harlequins are waiting for stream flows to regulate to desirable levels.

During male molt migration, rivers appear to provide important stopover resources for harlequins. Eight of nine harlequins provided satellite signals during migration at stopover sites and all eight of these birds utilized rivers. Additionally, two of these harlequins also recorded locations on mountain streams and a third bird stopped over on a river and the Pacific coast. The surrounding habitat of locations recorded during molt migration was variable. Predominantly, areas utilized by male harlequins during migration consisted of temperate conifer forests. Other lesser used habitats included desert, shrublands, and temperate grasslands. Given our overall small sample size (n=8), we cannot dismiss the possible importance of the lesser used arid habitat types during harlequin migrations.

The satellite tagged male harlequins selected molt locations primarily along the coastline of Vancouver Island, British Columbia. Five of the seven males successfully arriving to molting areas occupied Vancouver Island sites, while one male molted in the Salish Sea/Puget Sound, Washington and another along the coastline of Oregon. In comparison to Wyoming, satellite tracking of male harlequins during 2016-17 from breeding areas in Montana, Washington, and Alberta have identified Vancouver Island and areas slightly more northerly, including Queen Charlotte Sound (British Columbia) and southwestern Alaska as important harlequin molting areas (Savoy et al. 2017; Figure 30).

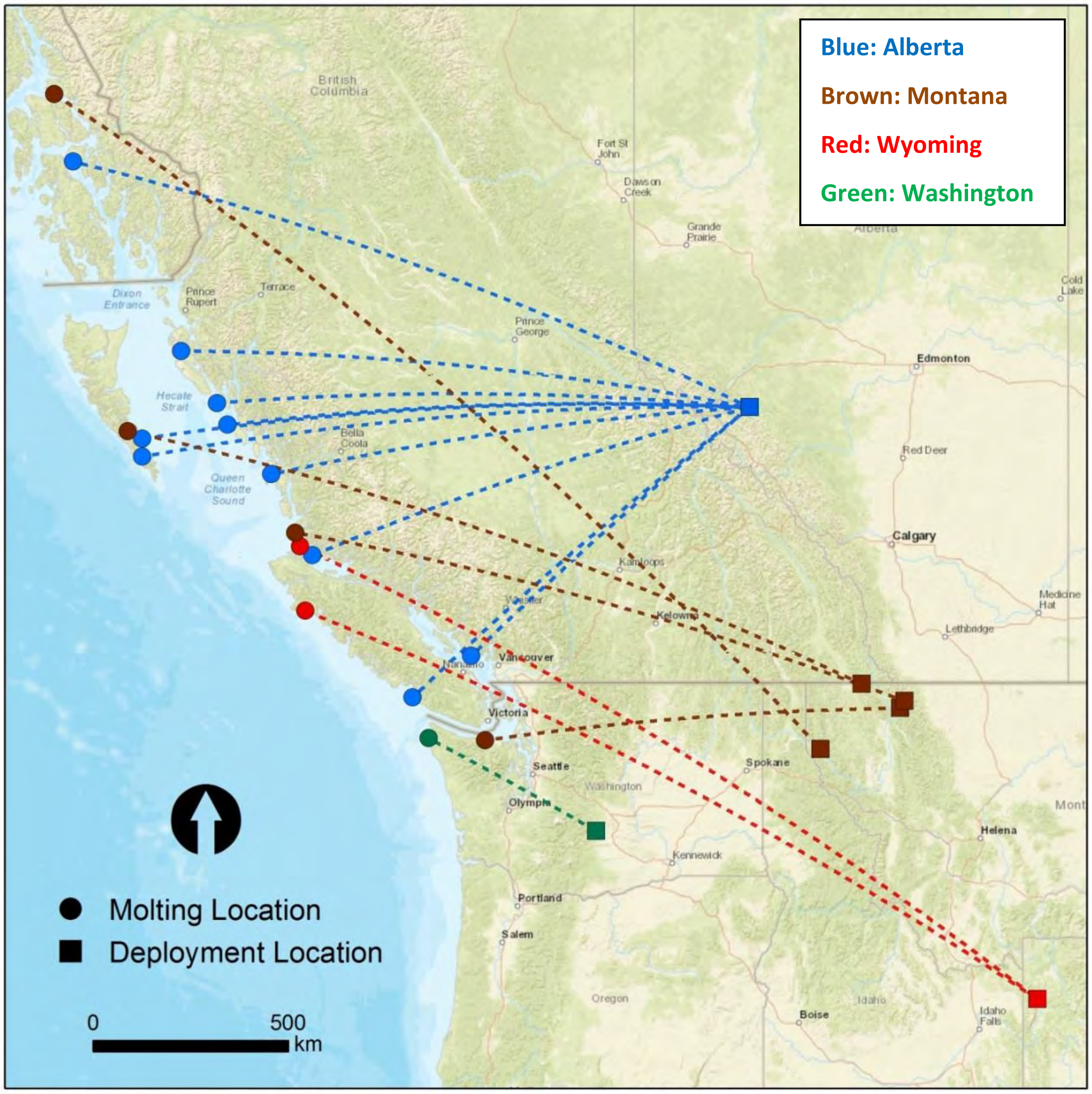

Figure 30. Molt locations of male harlequins satellite tagged in Montana, Washington, Wyoming, and Alberta, 2016-17. Lines do not represent direct migration routes.

A study summarizing harlequin band recoveries, re-observations of marked individuals, and recaptures of banded harlequins originally captured at breeding sites in Western North America, identified the Strait of Georgia on the east side of Vancouver Island as a highly important non-breeding area for harlequin ducks (Smith and Smith 2003). Recoveries (i.e., hunter harvest, recaptures) of eight juvenile harlequins banded on breeding streams in Wyoming (GTNP) during 1991-1994 were all recovered in the Salish Sea/Puget Sound, Washington (Bird Banding Laboratory). Historic recovery data of juvenile harlequins and recent Pacific coast locations identified through satellite tracking of adult male harlequins in Wyoming suggest marine areas from Vancouver Island south to Oregon are important to Wyoming's Harlequin Ducks during the non-breeding season.

Previous studies have determined both the annual survival rate and site fidelity to breeding locations for both male and female Harlequin Ducks is high. Overall, site fidelity rates from these studies tended to vary by the breeding location. Results from a marked population of harlequins from a breeding site in Alberta reported 67% of females and 58% of males returned to the same breeding sites in subsequent years (Smith 1996). A study in Alaska reported a lower site fidelity rate for both females (44%) and males (29%) (Crowley 1994). During 2014 and 2016-2017, we marked a total of 10 harlequins in Wyoming and visited each capture location for 1-2 years after the initial banding efforts. We know through our satellite tracking of five males, two individuals died during their molt migration, which would remove them from calculating breeding site fidelity rates. Of the remaining eight harlequins with the potential to return to their breeding site, two individuals (25%) returned the following year and both were females. None of the males captured during our study were re-observed in subsequent seasons. Satellite telemetry data provided by one male for a complete annual cycle determined a breeding area change of 735 km, from Wyoming to British Columbia (Table 7).

Table 7. Harlequins banded during 2014, 2016-17 seasons (n=10) and their return status.

Year	ID	Breeding Location	Sex	Return?	Status
2014	02401	Grand Teton – Lower Berry	Female	No	Never re-observed
2014	02403	Grand Teton – Lower Berry	Female	No	Never re-observed
2014	02402	Grand Teton – Lower Berry	Male	No	Never re-observed
2016	159799	Grand Teton – Lower Berry	Male	No	Transmitter went offline during winter period
2016	02438	Grand Teton – Lower Berry	Female	No	Never re-observed
2016	32894	Grand Teton – Moose Creek	Male	No	Died during molt migration
2016	02439	Grand Teton – Moose Creek	Female	Yes	Recaptured Moose Creek 2017
2017	32894	Grand Teton – Moose Creek	Male	No	Died during molt migration
2017	33029	Yellowstone - LeHardy	Male	No	Breeding location switch – British Columbia (735 km)
2017	02491	Yellowstone - LeHardy	Female	Yes	Re-observed at LeHardy 2018

A study assessing the annual survival of harlequins from a marked wintering population in British Columbia determined survival rate is high, reporting rates of 82% in males and 74% in females (Smith et al. 1999). Prior to the 2018 season, 10 harlequins were captured and marked predominantly within GTNP (n=8). The potentially low overall survival rate (1/8; 13%) of harlequins breeding within GTNP is concerning, particularly among females (1/4; 25%). The female breeding dispersal distance in harlequins appears low, as less than 20 km was reported in a long-term study in Montana (Hendricks 2000). A low survival rate among females coupled with a small breeding dispersal range could create a sink population of harlequin in GTNP and potentially all of Wyoming.

8.0 RECOMMENDATIONS FOR HARLEQUIN DUCK RESEARCH IN WYOMING

- Continue to monitor breeding streams for the return of color-banded harlequins;
- Attempt recaptures of marked harlequin females with geolocators;
- Continue to satellite mark males in Grand Teton National Park focusing on the upper portions of the streams;
- Continue to identify breeding streams in Yellowstone National Park;
- Continue to attach satellite transmitters to males and geolocators to females in Yellowstone National Park;
- Conduct brood surveys on known harlequin streams in Yellowstone National Park;
- Use VHF transmitters on females to locate actual nest sites to identify nesting habitat requirements.

9.0 ACKNOWLEDGEMENTS

Thanks to the Meg and Bert Raynes Wildlife Fund, Wyoming Game and Fish Department, Wyoming Community Foundation, and Environment and Climate Change Canada for their generous financial and logistical support. Thank you John Stephenson, Sarah Hegg, Josh Seibel, and Gia Habetz, from Grand Teton National Park for your tremendous logistical support and assistance in the field. Thank you to Doug Smith, Annie Carlson, Brenna Cassidy, and Evan Shields for their support and field assistance during Yellowstone National Park activities. Thank you to Spring Creek Animal Hospital, Jackson, Wyoming, for your help in sterilizing surgical instruments. Thank you to the University of Wyoming-National Park Service Research Station at AMK Ranch for the hospitality. Thank you to Mark Gocke with Wyoming Game and Fish

Department for capturing our field efforts through photography and sharing photographs. Thank you to Sean Boyd with Environment and Climate Change Canada for your logistical support and field assistance, as well as your expertise in Harlequin Duck ecology. Thank you to Ken Wright, for sharing your harlequin expertise and field assistance during our feasibility study effort in 2014, as well as providing field photographs. Thank you to Carl Brown for your tireless effort in hiking backcountry streams each season to locate harlequin duck pairs – your ability to glide through willows to locate pairs and guide them to the nets is second to none. Thank you to Kathleen Savoy for bravely assisting the harlequin field team in 2014, and for keeping up with Carl. Thank you to Malcolm McAdie for your exceptional skills in performing the harlequin surgeries. Thank you to Michelle Kneeland for your surgical expertise and assistance with harlequin surgeries. Thank you to Nate Huck (WYGFD) and Jake Briggs for your assistance in the field. We would like to thank the numerous hard-working, dedicated field staff from BRI who assisted with field efforts over the years and include Bill Hanson, Arcata Leavitt, Katie Low, Trevor Nelson, Vincent Spagnuolo, and Chris Timberlake.

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Wyoming 2018 Long-Billed Curlew Research Overview

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BOISE STATE UNIVERSITY
INTERMOUNTAIN BIRD OBSERVATORY

Incubating Long-billed Curlew. Heart Mountain Ranch Preserve, Wyoming; May 2018. Photo: Eugenia Sentíes.

INTRODUCTION

Long-billed Curlews (*Numenius americanus*) are a species of conservation concern due to habitat loss and degradation, environmental toxins, and human disturbance (Dugger and Dugger 2002). Boise State University's Intermountain Bird Observatory (IBO) has been studying curlew breeding success in Idaho for 10 years and, thanks to many partners and collaborators, the project has been growing with increased monitoring sites for breeding populations in the Intermountain West and the addition of satellite telemetry data since 2013 to further understand migration movements, wintering grounds, and migratory connectivity. This growth has included intensive work across Wyoming since 2014, including breeding success and satellite telemetry work.

During the spring 2018 field season, we conducted Long-billed Curlew research on BLM lands in northwestern Wyoming in the Big Horn Basin area near Cody and Powell. Specifically, we (1) performed standardized abundance surveys in four study areas – Chapman Bench, Heart Mountain Ranch Preserve, Oregon Basin, and Polecat Bench – and we (2) conducted nest searching and monitoring at three of these sites – Heart Mountain Ranch Preserve, Oregon Basin, and Polecat Bench – to assess reproductive success of this population (Figure 1). We had worked at Chapman Bench, Heart Mountain Ranch, and Polecat Bench in 2015 and Oregon Basin was a new addition as a study area in 2018. In addition to our focused work in northwestern Wyoming, we also traveled to eastern Wyoming in mid-May to deploy four new satellite transmitters – one near Saratoga and the other three south of Lusk. Since 2014, we have now deployed 23 satellite transmitters on adult Long-billed Curlews that breed in Wyoming, including: Jackson (5), Big Horn Basin (5), Upper Green River Valley (6), Saratoga (4), and Lusk (3). Lastly, we were able to "retire" transmitters (remove transmitters from living birds) from four adult curlews in Wyoming – two in the Big Horn Basin and two in Jackson.

We had first studied curlew abundance, reproductive success, and movement ecology in the Big Horn Basin in 2015 and, while we had observed a moderate density of breeding pairs during formal surveys and nest searching efforts, our 2015 efforts resulted in a small sample size of nests (n=3). This was due in large part to landscape characteristics, including subtle topography and taller bunchgrass and sagebrush, that made observations and viewing of curlews from more than 100m difficult. Also, 2015 data suggested this area had lower curlew abundance in comparison with other, wetter study sites such as the flood-irrigated pastures of the Upper Green River Valley, WY and Pahsimeroi Valley, ID (Carlisle and Coates 2016). The Big Horn Basin has been an important area for Long-billed Curlew, especially in the context of intensive work in other parts of the Intermountain West in recent years, as it has increased our knowledge of breeding success and wintering migration movements in different breeding populations/habitats. Our hope is that, in combination with our network of other study sites, these data will help inform conservation strategies for curlews and help sustain successful populations into the future.

METHODS

<u>Point Counts:</u> We conducted point count surveys at the beginning of the breeding season, soon after birds had arrived from their wintering grounds. The survey routes are predetermined routes primarily covering road-based transects (Figure 2). Point count surveys allow us to have a better understanding of local densities within study sites and provide baseline data of curlew

populations. During each point count route, we use a double-observer approach to survey for 5-minute periods at each individual point, spaced at 800 meter increments. The primary observer detects curlews using both auditory and visual observations. The secondary observer records these observations as well as any additional auditory and visual detection that the primary might have missed. Observers begin the survey at their first point 30 minutes after sunrise, and aim to complete the entire route before 11:00 am. In the case of inclement weather, including snow, heavy rain, and/or impeding winds, the survey is paused or carried out on another day with cooperating weather conditions.

<u>Incidental/Disturbance:</u> Throughout the 2018 field season, we studied disturbance of a range of potential predators as well as anthropogenic influences in our study sites, including live animals or humans on site or inanimate evidence for predators or human influence. We conducted these surveys daily, recording these factors during the course of point count surveys, pair mapping, nest searching, and habitat measurements. Through this data, we aim to describe the density and diversity of local predators and disturbances related to curlew breeding success. Types of disturbances included avian and mammalian predators, human recreation (i.e., shooting, construction, etc.), and vehicular traffic.

<u>Pair Mapping and Nest Searching:</u> Upon completion of point count surveys, field technicians spend a lot of time observe and mapping the breeding behavior of curlews. The first stage of observations usually includes observations of male and female curlews returning to their territories from wintering grounds. Important behavior includes courtship of pairs (i.e., feather stroking), initial nest site exploration ("scraping"), adding material to new nests ("grass tossing"), incubation exchanges, and predator mobbing. Incubation switches are best observed early in the morning and early evening. With each pair, females incubate eggs during the duration of the day while males incubate throughout the night. By scanning territories in the early morning and evening you can observe an incubation switch, which allows detection of an exact location of the nest cup. When any of these behaviors are observed, coordinates are taken of the vantage point, as well as distance and bearing to where the behavior/activity is seen.

Once a nest is found, we aim to minimize disturbance to the nest site and breeding pair. One initial visit allows us to take an exact location of the nest cup, as well as measure the development stage of the incubated eggs. With this information we are able to calculate a predicted hatch date to observe nesting success. After the initial visit to the nest, observations that follow are conducted at a distance from the incubating birds, as to create the least disturbance. Nest checks are conducted at 3-5 day increments to check the status of the nest. Checks were postponed during inclement weather, or in the presence of a predator. As it approaches the predicted hatching date, nests are checked on a daily basis to better determine nest fate.

<u>Satellite Telemetry:</u> Once nests are located throughout the season, we select certain birds to capture on the basis of sex and nesting stage. The capturing procedure follows the trapping of an incubating bird on the nest. Two biologists carry an 18-meter mist net parallel to the ground over the incubating bird and drop the net to the ground. If the biologists are successfully guided to the nest at an equal distance of approximately nine meters on either side of the nest, the bird is likely to remain incubating, thus sitting low on the nest cup. After we extract the bird from the

net, we carry it to a shaded area for measurements and attachment of a satellite transmitter. This includes:

- Placing a USGS aluminum band on one leg
- Placing a plastic alpha flag (green with two white letters) on the upper leg - opposite leg has numbered, aluminum band issued by the USGS Bird Banding Laboratory
- Measure wing chord and culmen and weigh the bird
- Use the leg-loop harness technique to safely attach the satellite transmitter to the lower back (synsacrum)

RESULTS

Abundance:

Curlew abundance results in Big Horn Basin show that healthy populations inhabit BLM lands in areas of northwestern Wyoming (Table 1). Out of our four study sites at which we conducted point counts, we detected 7 curlews on Chapman Bench (combined data from both East and West survey count routes; Appendices 1a and 1b), 24 curlews on Polecat Bench (Appendix 1c), 24 curlews on Oregon Basin (Appendix 1d), and 15 curlews at Heart Mountain (Appendix 1e). Due to lower detection rates in the Chapman Bench point counts, along with low detections in nest searching surveys that followed, we decided to focus our nest searching and monitoring during the 2018 field season on three other sites of interest - Polecat Bench, Heart Mountain Ranch Preserve, and Oregon Basin. Oregon Basin is BLM land situated southeast of the town of Cody and we selected it after discussions with BLM biologist Destin Harrell, who had observed a high number of curlews in prior years. Two of our study areas, Polecat Bench and Oregon Basin, were on lands with some oil development. This seemingly had little effect on curlew density or nest success; likely other habitat factors are also at play but both areas showed higher densities during point counts than Chapman Bench and Heart Mountain.

Table 1. Number of Long-billed Curlews Detected in Point Counts Surveys in the Big Horn Basin; April 2018. *Details of survey results by point and route are in Appendix 1.*

Route name (# of points)	Curlews detected	Curlews/Point
Heart Mountain Preserve (18)	15	0.83
Polecat Bench (21)	24	1.14
Oregon Basin (16)	24	1.5
Chapman Bench (33)	7	0.21

We also documented high numbers of avian predators, specifically Common Ravens, Northern Harriers, and Golden Eagles. High detection of Common Ravens and Northern Harriers were seen specifically in Oregon Basin and Polecat Bench. There were high numbers of pronghorn in all three areas as well as consistent coyote presence. Predator and potential disturbance results include, but are not limited to, an average of about 20-25 pronghorn each survey, at least four resident Northern Harriers in both Oregon Basin and Polecat Bench study areas, as well as Common Raven observations ranging from one to 100 individuals in a given survey.

Nest Success:
Cody had an abnormally high percentage of nest success during the 2018 season. Of the nine nests found and monitored from the laying or incubating stages, seven nests successfully completed the incubation and hatching stages (77.8% apparent hatch rate; Table 2, Appendix 2a, Figures 3-5). We found an additional six family groups post-hatch with healthy parents and varied numbers of mobile, foraging chicks (Table 3; Appendix 2b). Although we do suspect multiple nest failures that aren't represented in these numbers, particularly in the Oregon Basin and Polecat Bench study areas, overall nest success was quite high relative to IBO's recent work and other published studies (Dugger and Dugger 2002; i.e., about 40% Redmond and Jenni 1986). We suspect these nest failures based on our observations of nesting behaviors from multiple pairs where we were unable to find nests after numerous weeks of searching. We often observed grass tossing and other courtship behavior in these pairs, which suggested they were initiating nesting and they likely failed or abandoned attempts before we could find them. Nonetheless, an 77.8% apparent nest success rate is high and a good sign for the Big Horn Basin Long-billed Curlew population – and the three nests we found and monitored in 2015 were also successful. Importantly, of the two nests with females that we captured to remove satellite transmitters, both had successful hatches with 4 chicks. This indicates that the trapping procedure had little to no effect on their ability to complete incubation and have a successful breeding season. Also, at least for the nests we found and monitored, the various potential predators and forms of disturbance seemingly had little effect on nesting success in 2018.

Table 2. Number of Nests Found During Incubation and Hatch Rates by Study Site.

Study Site	# Nests	Hatch rate
Heart Mountain Preserve	4	100%
Polecat Bench	3	66.67%
Oregon Basin	2	50%

Table 3. Number of Additional Family Groups Found after Hatch.

Study Site	# Hatched Nests
Heart Mountain Preserve	1
Polecat Bench	1
Oregon Basin	4

Nest Searching/Monitoring Notes/Challenges: In our 2018 surveys, we faced similar challenges to 2015 in that we were unable to find nests for some territories due to the difficult terrain. Nest searching and monitoring in the Big Horn Basin provides challenges due to landscape and vegetation. Tall bunchgrass and sagebrush give curlews great protection from surveying biologists – making it difficult to observe curlews from a distance at which they feel safe. We also observed different behavior in incubation switches between male and female curlews associated with storm fronts and/or bad weather conditions. For example, when a storm front would travel through the Big Horn Basin in the afternoon, the curlew pairs would switch much earlier in the day – presumably to avoid any danger to exposed eggs that might happen if the adults switched during a storm. This became a challenge for afternoon/evening nest searching, as it was possible an incubation switch had already occurred before our "optimal" nest searching times.

Nonetheless, we were able to build upon 2015 work and increase the sample size of curlew nests in northwestern Wyoming and we observed a high nest success rate across our three study areas. The Big Horn Basin curlew populations have adapted to a challenging landscape and environment in terms of temperature, moisture, predator communities, and other factors but appear to be maintaining a healthy breeding population and to be exhibiting relatively high nest success.

Through our 2018 efforts, we were able to find and monitor nine nests in the three study sites, along with another six curlew pairs with successful nests that we discovered at the chick stage via observing intense predator mobbing and chicks with parents. Although we were not able to find exact nest locations of these additional pairs, our observations helped document successful breeding. As shown in the maps below, we have documented nests monitored, nests found after hatching, and areas of courtship and pair behavior for nests we didn't locate. Because curlews tend to have high breeding site fidelity, this data will help biologists in the future to have a better idea of common territories where nesting is likely to occur year after year.

Satellite Telemetry Results: During the 2018 field season we did not deploy additional satellite transmitters on curlews in the Big Horn Basin. However, we did capture two female curlews breeding on Heart Mountain Preserve ("Zarapita") and Polecat Bench ("Lady") that had been providing helpful data since we captured them in 2015. We were able to locate their nests and trap both of these curlews during the middle of May in order to remove the transmitters, which were still fully functional but nearing the end of the life expectancy for the batteries so we determined it would be best to capture them before batteries died.

We also traveled to both Lusk and Saratoga in efforts to broaden the curlew migration data for Wyoming populations. With private landowner permission, we deployed a transmitter on an adult male curlew on private land of ZN Ranch near Saratoga and three satellite transmitters (two females and one male) on private prairie grasslands south of Lusk. With these deployment of these new satellite transmitters we hope to gain more information on migration routes and wintering areas of eastern Wyoming breeding curlew populations (Figure 6; https://ibo.boisestate.edu/curlewtracking/locations/; https://schall11.github.io/curlew_vision/#). Specific results for the four adult curlews outfitted with new satellite transmitters in 2018 include:

- Saratoga (ZN Ranch):
  - LM (2-letter alpha flag), adult male – migrated to coastal northern Sonora, north of Los Mochis, Mexico
- Lusk:
  - LK, female – migrated to northeastern Tamaulipas, near Matamorros, Mexico
  - KU, female – migrated to Laguna Santiaguillo in central Durango
  - KP, male – migrated to the border of the states of Aguascaliente and Zacatecas in central Mexico, near the city of Loreto

Outreach: While studying in the Big Horn Basin, we were able to introduce Long-billed Curlews to many local people. Many had not heard of the species before while some had seen these striking birds, but had no idea what their name was. Heart Mountain Ranch Preserve hosts a range of school and public programs. We were able to reach out to a large homeschooling group of kids and adults about our project and how we are able to track curlew migration. By participating in a public hike as local bird specialists, we were able to communicate with many Big Horn Basin residents about our project and the conservation of this species. Visitors seemed very excited to learn about this species, and surprised to learn about a shorebird that breeds in their hometown grasslands. Outreach is always an important part of the curlew project, and we made sure to share our research with as many people as we could throughout the field season. Lastly, we worked alongside a local newspaper writer, Mark Davis of the Powell Tribune, to contribute to an article about our research (http://powelltribune.com/stories/curlew-nest-success-high-in-basin,14471).

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Figure 1. Long-billed Curlew study sites in the Big Horn Basin area of northwestern Wyoming during the 2018 field season.

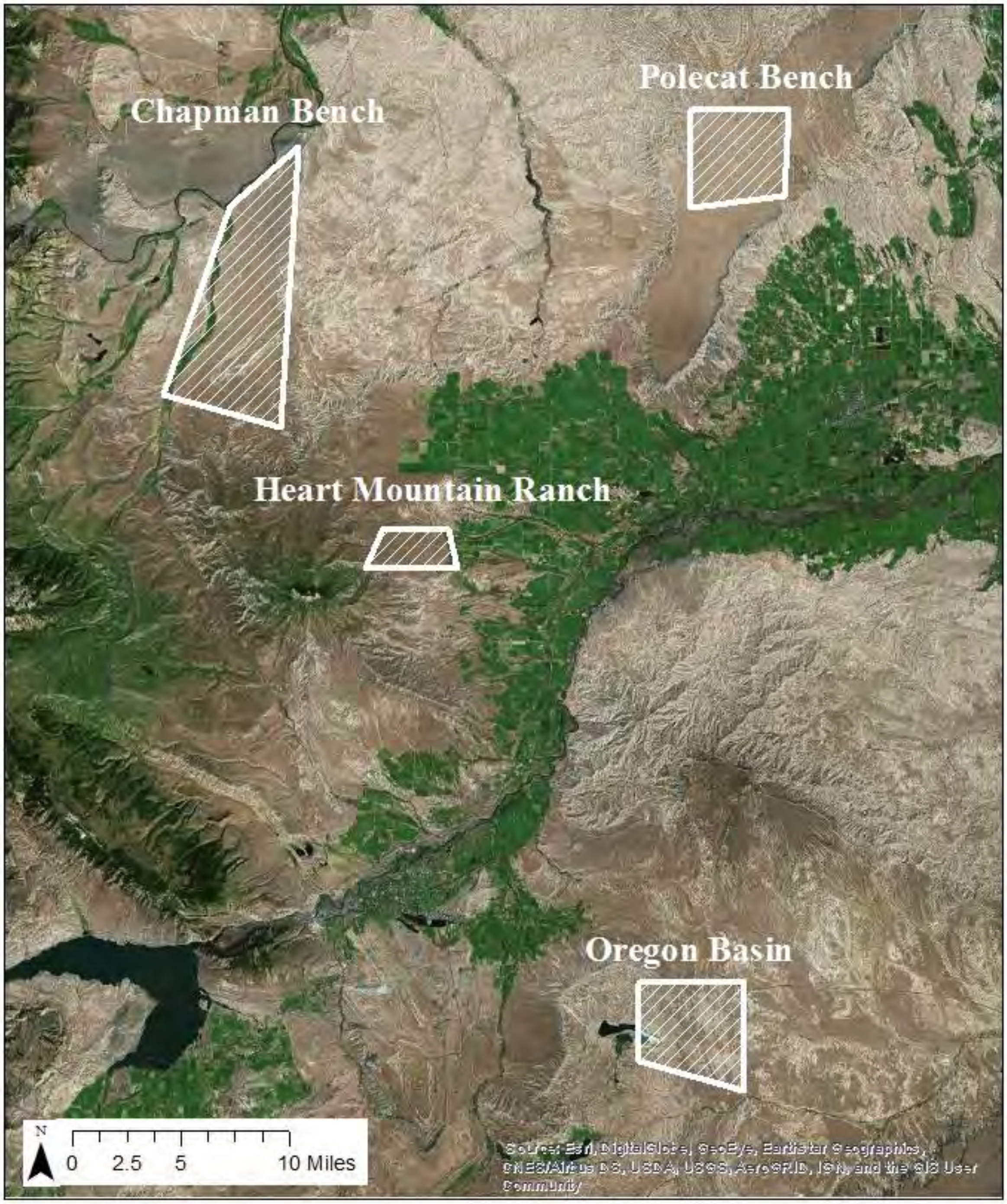


Figure 2. Maps of 2018 Point Count Survey Routes Covering Long-billed Curlew Study Sites in the Big Horn Basin Area of Northwestern Wyoming.

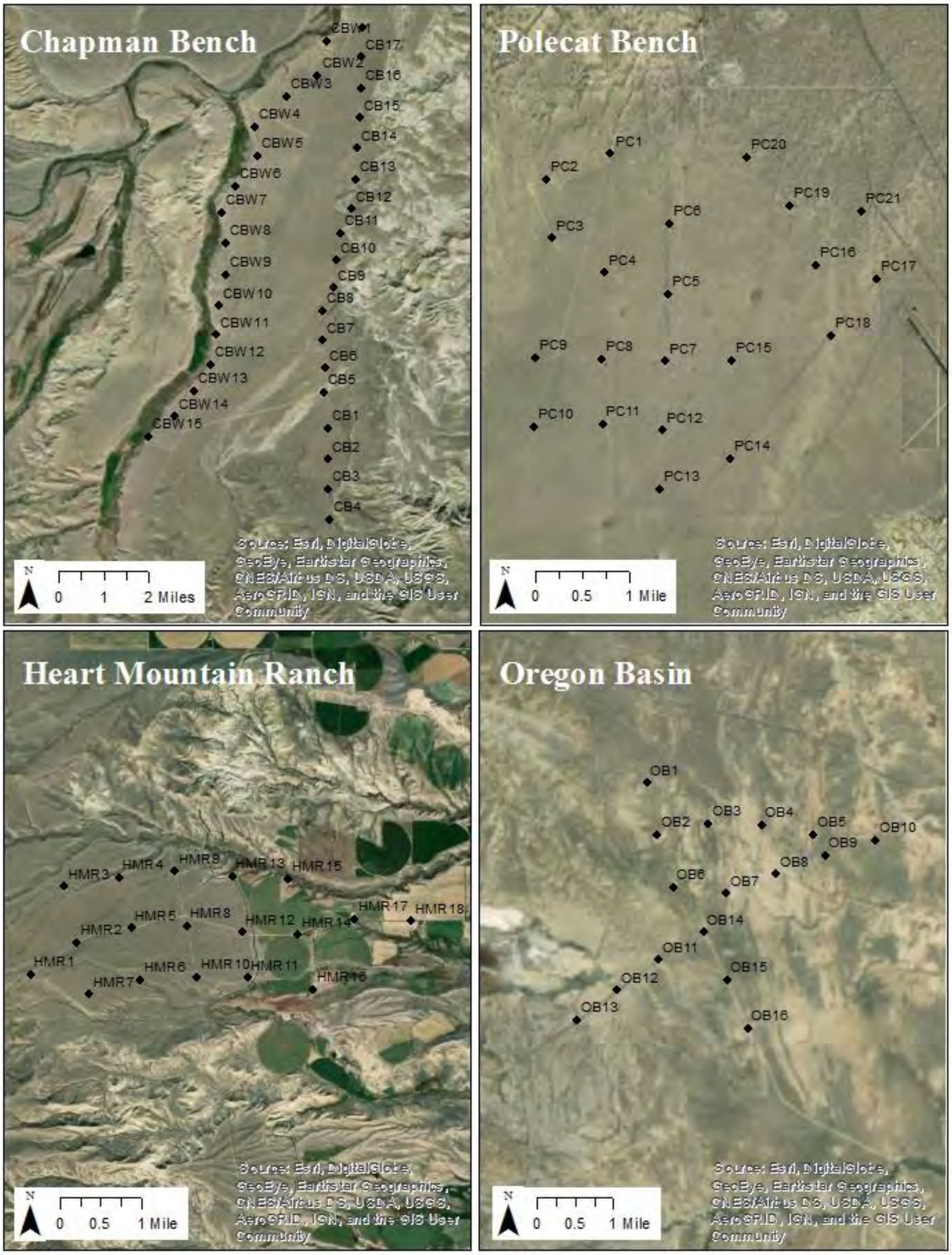


Figure 3. Locations of Long-billed Curlew nests, chicks, and pairs in the Heart Mountain Ranch Preserve; April-July, 2018.

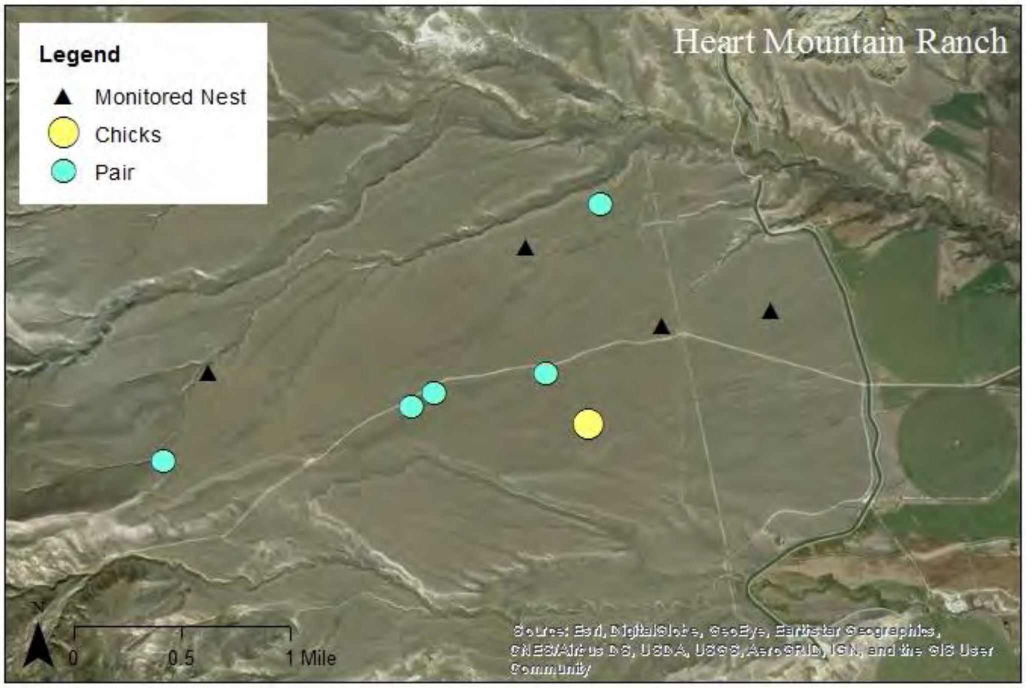


Figure 4. Locations of Long-billed Curlew nests, chicks, and pairs in Oregon Basin; April-July, 2018.

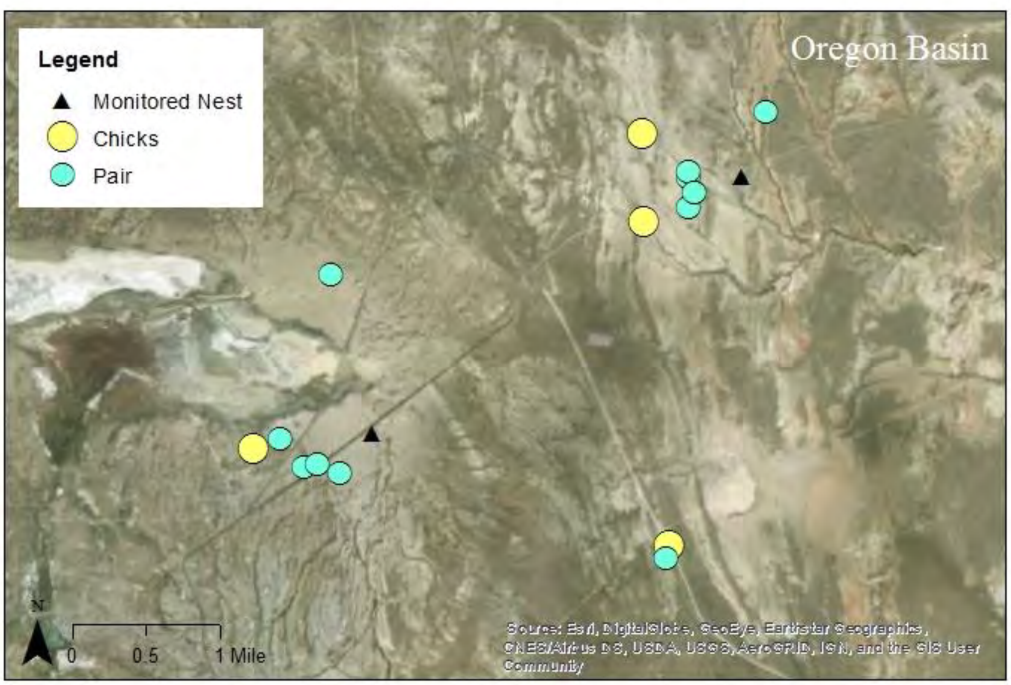


Figure 5. Locations of Long-billed Curlew nests, chicks, and pairs in Polecat Bench; April-July, 2018.

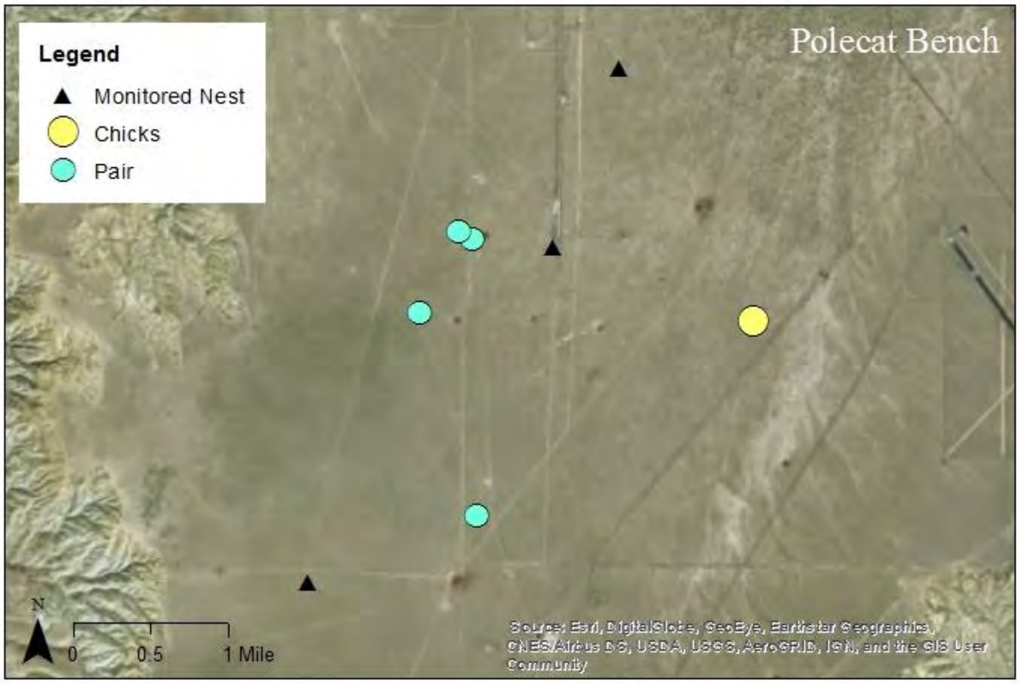
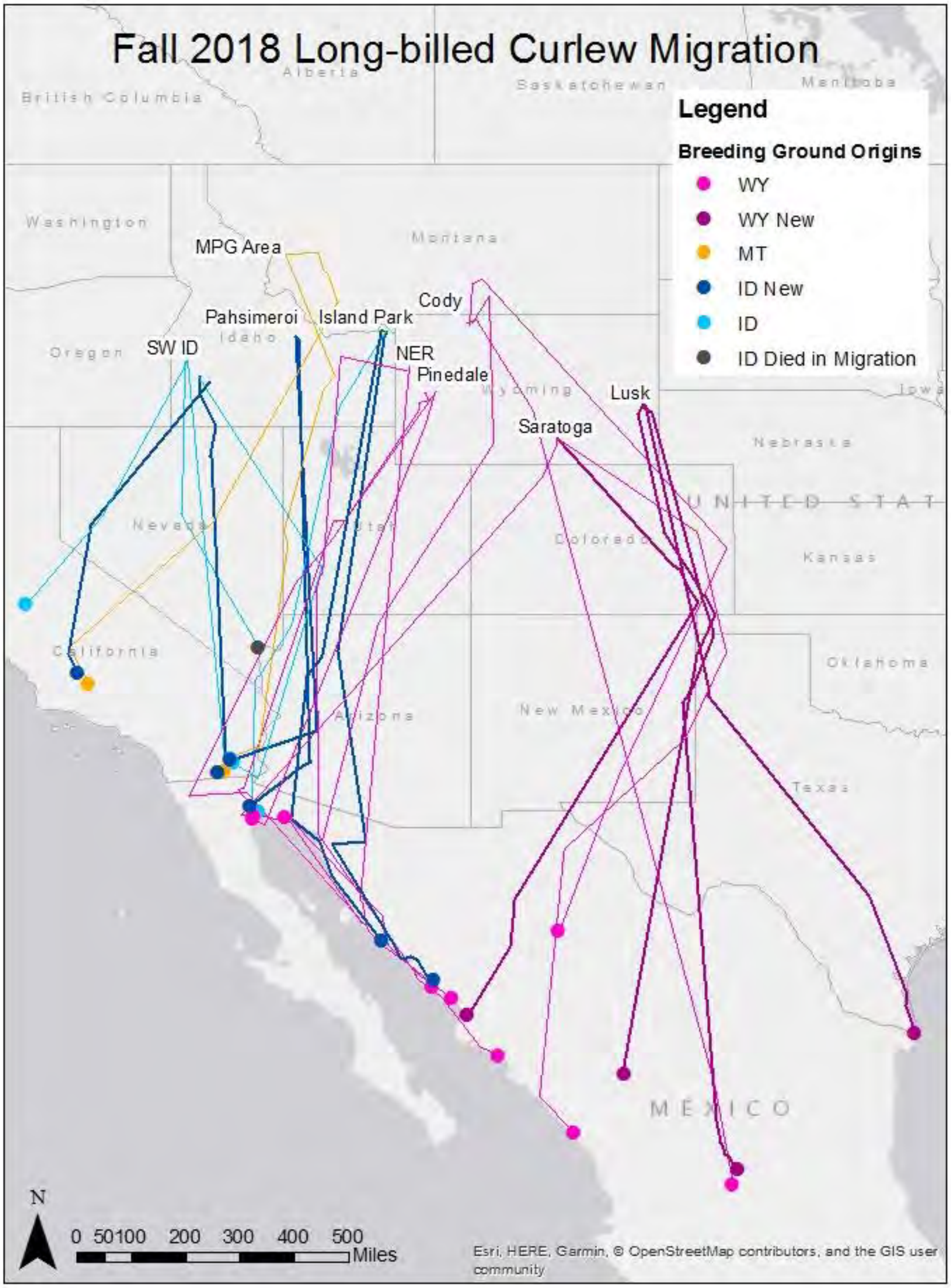


Figure 6. 2018 Fall Migration Pathways for Long-billed Curlews Wearing Satellite Transmitters, with Color-coding by State of Origin and "New" Indicating a Newly-Captured Bird in 2018.

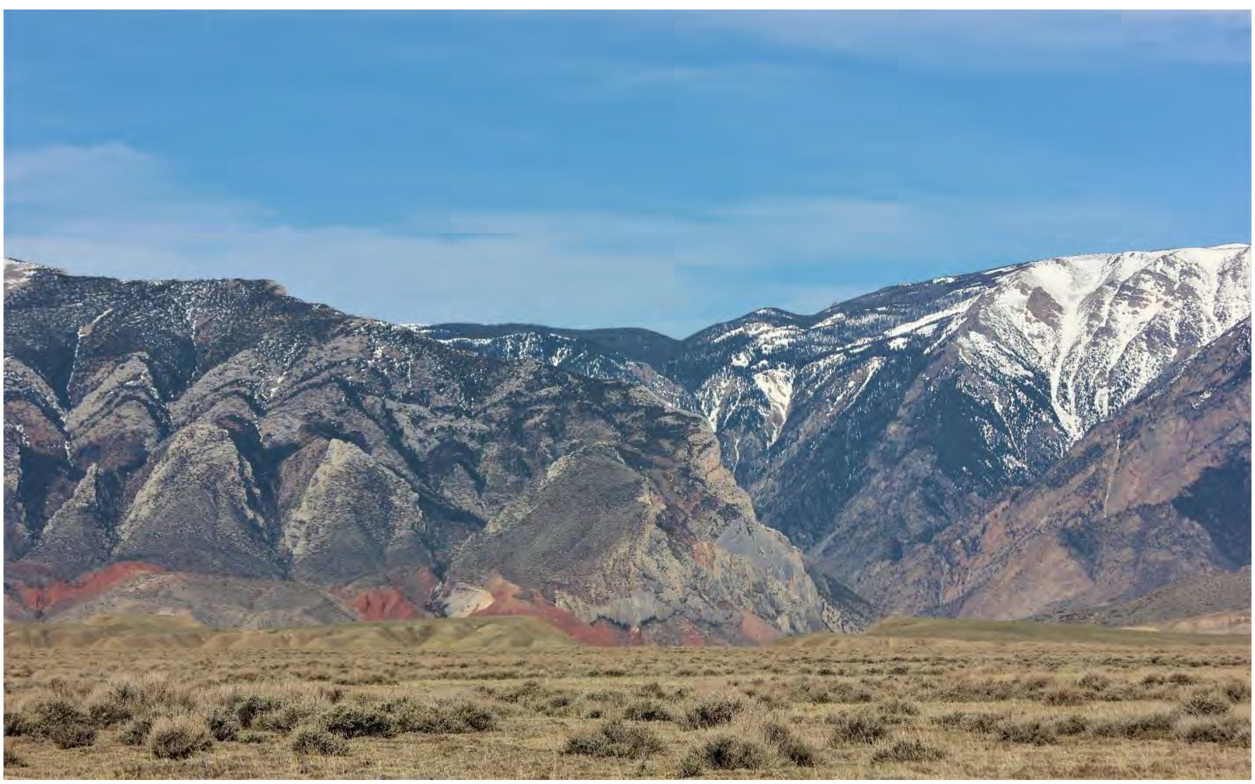


PROJECT PHOTOS
STUDY SITES

Heart Mountain Ranch Preserve

Oregon Basin

Polecat Bench



Chapman Bench

MONITORING

Monitoring curlews in Oregon Basin, June 2018. Photo: Eugenia Sentíes

CURLEWS

Pair of courting Long-billed Curlew at Heart Mountain, April 2018. Photo: Eugenia Sentíes.

Long-billed Curlew flying in Oregon Basin area, April 2018. Photo: Eugenia Sentíes.

Long-billed Curlew, Lusk, WY. May 2018. Photo: Eugenia Sentíes.

NESTING

Long-billed Curlew incubating at Heart Mountain, May 2018. Photo: Eugenia Senties.

Eggs on nest of Long-billed Curlew, Polecat Bench. May 2018. Photo: Eugenia Senties.

Chicks of Long-billed Curlew, Heart Mountain. June, 2018. Photo: Eugenia Sentíes.

TRAPPING

Trapping Long-billed Curlew in Lusk. May, 2018. Photo: Brady Vandeberg, WGFD.

Alpha flag and band of Long-billed Curlew in Lusk. May, 2018. Photos: Eugenia Sentíes.

Bill length measurement of Long-billed Curlew in Lusk. May, 2018. Photos: Eugenia Sentíes.

DNA samples of Long-billed Curlew in Lusk. May, 2018. Photos: Eugenia Sentíes.

Weight measurement of Long-billed Curlew in Lusk. May, 2018. Photos: Eugenia Sentíes.

Long-billed Curlew marked with alpha flag, band and transmitter in Lusk. May, 2018. Photo: Madeline Voshell.

Long-billed Curlew ready to be released in Lusk. May, 2018. Photo: Eugenia Sentíes.

Appendix 1. 2018 Long-billed Curlew point count survey results for four study areas (five transects) in the Big Horn Basin, Wyoming.

Appendix 1a. Chapman Bench – East.

Route name	Point	UTM Coordinates			# Detections
		UTM Zone	UTM x	UTM y	
Chapman Bench East	CB1	12 T	646952	4559740	-
Chapman Bench East	CB2	12 T	646952	4958200	-
Chapman Bench East	CB3	12 T	647005	4958200	-
Chapman Bench East	CB4	12 T	646998	4957450	-
Chapman Bench East	CB5	12 T	646754	4960630	2
Chapman Bench East	CB6	12 T	646815	4961240	-
Chapman Bench East	CB7	12 T	646685	4961940	1
Chapman Bench East	CB8	12 T	646792	4962650	-
Chapman Bench East	CB9	12 T	647028	4963240	-
Chapman Bench East	CB10	12 T	647081	4963940	-
Chapman Bench East	CB11	12 T	647203	4964590	-
Chapman Bench East	CB12	12 T	647439	4965230	-
Chapman Bench East	CB13	12 T	647493	4965970	-
Chapman Bench East	CB14	12 T	647516	4966770	-
Chapman Bench East	CB15	12 T	647561	4967530	-
Chapman Bench East	CB16	12 T	647592	4968300	-
Chapman Bench East	CB17	12 T	647554	4969080	-
Chapman Bench East	CB18	12 T	647576	4969830	1

Appendix 1b. Chapman Bench – West.

Route name	Point	UTM Coordinates			# Detections
		UTM Zone	UTM x	UTM y	
Chapman Bench West	CBW1	12 T	646602	4969440	-
Chapman Bench West	CBW2	12 T	646424	4968580	1
Chapman Bench West	CBW3	12 T	645537	4968050	-
Chapman Bench West	CBW4	12 T	644882	4967270	-
Chapman Bench West	CBW5	12 T	644949	4966540	-
Chapman Bench West	CBW6	12 T	644485	4965740	-
Chapman Bench West	CBW7	12 T	644173	4965120	-
Chapman Bench West	CBW8	12 T	644196	4964330	2
Chapman Bench West	CBW9	12 T	644211	4963540	-
Chapman Bench West	CBW10	12 T	644069	4962740	-
Chapman Bench West	CBW11	12 T	644066	4962010	-
Chapman Bench West	CBW12	12 T	643891	4961271	-
Chapman Bench West	CBW13	12 T	643494	4960604	1
Chapman Bench West	CBW14	12 T	642962	4959977	2
Chapman Bench West	CBW15	12 T	642375	4959421	-

Appendix 1c. Polecat Bench.

Route name	Point	UTM Coordinates			# Detections
		UTM Zone	UTM x	UTM y	
Polecat Bench	PB1	12 T	670201	4973370	-
Polecat Bench	PB2	12 T	669429	4973040	-
Polecat Bench	PB3	12 T	669522	4972330	1
Polecat Bench	PB4	12 T	670158	4971930	4
Polecat Bench	PB5	12 T	670947	4971690	1
Polecat Bench	PB6	12 T	670937	4972550	-
Polecat Bench	PB7	12 T	670934	4970880	3
Polecat Bench	PB8	12 T	670157	4970880	3
Polecat Bench	PB9	12 T	669357	4970880	2
Polecat Bench	PB10	12 T	669357	4970040	5
Polecat Bench	PB11	12 T	670157	4970040	1
Polecat Bench	PB12	12 T	670913	4970040	3
Polecat Bench	PB13	12 T	670907	4969330	-
Polecat Bench	PB14	12 T	671751	4969720	-
Polecat Bench	PB15	12 T	671734	4970910	1
Polecat Bench	PB16	12 T	672727	4972090	-
Polecat Bench	PB17	12 T	673481	4971940	-
Polecat Bench	PB18	12 T	672933	4971240	-
Polecat Bench	PB19	12 T	672387	4972800	-
Polecat Bench	PB20	12 T	671862	4973370	-
Polecat Bench	PB21	12 T	673271	4972760	-

Appendix 1d. Oregon Basin.

Route name	Point	UTM Coordinates			# Detections
		UTM Zone	UTM x	UTM y	
Oregon Basin	OB1	12 T	669061	4927204	-
Oregon Basin	OB2	12 T	669235	4926430	-
Oregon Basin	OB3	12 T	670002	4926614	-
Oregon Basin	OB4	12 T	670809	4926616	2
Oregon Basin	OB5	12 T	671597	4926491	2
Oregon Basin	OB6	12 T	669491	4925649	-
Oregon Basin	OB7	12 T	670300	4925572	2
Oregon Basin	OB8	12 T	671044	4925882	4
Oregon Basin	OB9	12 T	671782	4926190	-
Oregon Basin	OB10	12 T	672539	4926430	-
Oregon Basin	OB11	12 T	669300	4924550	3
Oregon Basin	OB12	12 T	668692	4924072	3
Oregon Basin	OB13	12 T	668098	4923605	4
Oregon Basin	OB14	12 T	669968	4924978	-
Oregon Basin	OB15	12 T	670339	4924278	2
Oregon Basin	OB16	12 T	670682	4923554	2

Appendix 1e. Heart Mountain Ranch Preserve.

Route name	Point	UTM Coordinates			# Detections
		UTM Zone	UTM x	UTM y	
Heart Mountain Preserve	HMR1	12 T	653315	4949531	-
Heart Mountain Preserve	HMR2	12 T	653966	4950001	1
Heart Mountain Preserve	HMR3	12 T	653760	4950781	1
Heart Mountain Preserve	HMR4	12 T	654536	4950931	-
Heart Mountain Preserve	HMR5	12 T	654725	4950221	5
Heart Mountain Preserve	HMR6	12 T	654869	4949491	-
Heart Mountain Preserve	HMR7	12 T	654153	4949271	-
Heart Mountain Preserve	HMR8	12 T	655507	4950271	2
Heart Mountain Preserve	HMR9	12 T	655327	4951031	4
Heart Mountain Preserve	HMR10	12 T	655674	4949551	1
Heart Mountain Preserve	HMR11	12 T	656388	4949561	-
Heart Mountain Preserve	HMR12	12 T	656290	4950201	1
Heart Mountain Preserve	HMR13	12 T	656137	4950981	-
Heart Mountain Preserve	HMR14	12 T	657089	4950181	-
Heart Mountain Preserve	HMR15	12 T	656933	4950971	-
Heart Mountain Preserve	HMR16	12 T	657313	4949411	-
Heart Mountain Preserve	HMR17	12 T	657876	4950421	-
Heart Mountain Preserve	HMR18	12 T	658673	4950411	-

Appendix 2. 2018 Long-billed Curlew nests found in three Big Horn Basin, WY study areas.

Appendix 2a. Nests Found and Monitored from Incubation Stages.

Study Area	Coordinates		
	UTM zone	UTM x Coordinate	UTM y Coordinate
Heart Mountain Preserve	12 T	654627	4950851
Heart Mountain Preserve	12 T	655363	4950453
Heart Mountain Preserve	12 T	655934	4950542
Heart Mountain Preserve	12 T	652967	4950144
Oregon Basin	12 T	671430	4926003
Oregon Basin	12 T	668586	4923930
Polecat Bench	12 T	671362	4972709
Polecat Bench	12 T	670904	4971380
Polecat Bench	12 T	669160	4968862

Appendix 2b. Approximate Nest Area (nest not found/monitored) Coordinates Where Chicks Were Observed.

Study Area	Coordinates		
	UTM zone	UTM x Coordinate	UTM y Coordinate
Heart Mountain Preserve	12 T	654984	4949925
Oregon Basin	12 T	670638	4926321
Oregon Basin	12 T	670669	4925631
Oregon Basin	12 T	670929	4923114
Oregon Basin	12 T	667660	4923789
Polecat Bench	12 T	672400	4970874

Status Report:
Common Loon

WYOMING

2019

A Series Publication of BRI's Center for Waterbird Studies

Status of Western Breeding Loon Populations

The loon is a key biosentinel of aquatic integrity for lake ecosystems across northern North America. In Wyoming, Common Loons are listed as a Species of Greatest Conservation Need, as determined by the Wyoming Game and Fish Department. In 2012, Biodiversity Research Institute (BRI), in partnership with Yellowstone National Park (YNP), initiated a study to monitor and understand the local breeding loon population. In 2013, BRI created a dedicated working group in collaboration with governmental agencies such as Yellowstone and Grand Teton National Parks, Wyoming Game and Fish Department, and Bridger-Teton and Caribou-Targhee National Forests. The goals of BRI within the Wyoming Loon Working Group are to insure that Wyoming's small and isolated breeding population of Common Loons is self-sustaining with a realization that a wider understanding of loon ecology and threats will be important to assist governmental agencies with their management and outreach efforts.

Western US Breeding Populations

In the western United States, Common Loons regularly breed in Montana, Washington, and Wyoming—with breeding pairs in Idaho occasionally found (Figure 1). Today, the western US breeding population is estimated at 119 territorial pairs—combining Montana (80 pairs), Washington (17 pairs), and Wyoming (22 pairs). Based on scattered historical nesting records in California, Oregon, and Idaho, the western breeding population has experienced a contraction of its breeding range in the past century.

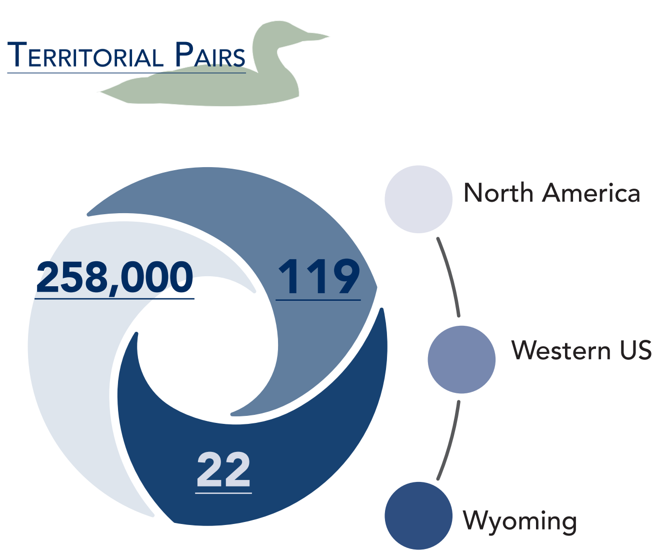
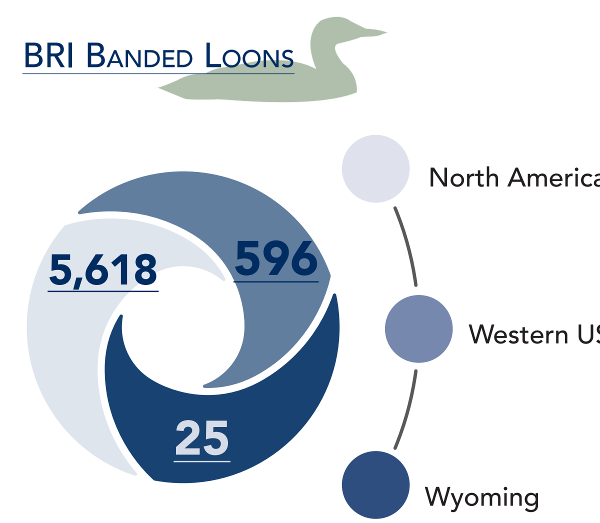


Figure 1. The breeding and wintering range for the Common Loon in the western United States. Movements of loons are based on recoveries (n=37), recaptures (n=65), and re-observation of individuals banded by BRI researchers. The winter range densities are taken from the National Audubon Society's Christmas Bird Count, 2002-2012, and are categorized in three levels of encounter rates.

To help understand the breeding ecology, migration patterns, and overwintering fidelity of Common Loons in the western US, BRI has banded 369 loons (162 adults and 207 juveniles) at their breeding lakes from 1995 to 2018. During migration, BRI banded 60 spring and 41 fall migrant loons on Walker Lake, Nevada from 1998 to 2004 and in wintering areas 126 loons were banded in California from 1997 to 2012. All told, 596 loons have been banded in the western US since 1995.

Findings from recovered or resighted color-banded loons demonstrate that breeding loons in Washington overwinter along the Washington and Oregon ocean shoreline. While Montana breeding loons regularly overwinter in California. The geolocator recovered from an adult female at Wolf Lake, Wyoming in 2015 indicates overwintering around the southern end of the Baja Peninsula—a migration of more than 2,400 km.



Common Loons in the western US are known to overwinter from Washington south to both the ocean and Gulf sides of the Baja Peninsula, with varying densities as described by Christmas Bird Counts (Figure 1). Most of the western US breeding loon population overwinters along this area.

Wyoming Breeding Population

With only 22 observed territorial pairs, the Wyoming loon population is one of the smallest in the species range (Fig. 1 and 2). This population is not only the most southern loon population in the west, but it is also isolated from contiguous populations to the north by more than 220 miles. This makes immigration, and therefore dispersal and rescue from other populations, unlikely.

The breeding population is distributed across:

- Yellowstone National Park—16 pairs;
- Caribou-Targhee National Forest—5 pairs;
- Bridger-Teton National Forest—1 pair; and
- irregularly in Grand Teton National Park.

Surveys from 2015-2018 identified several lakes with oversummering individuals in the Wind River Range.

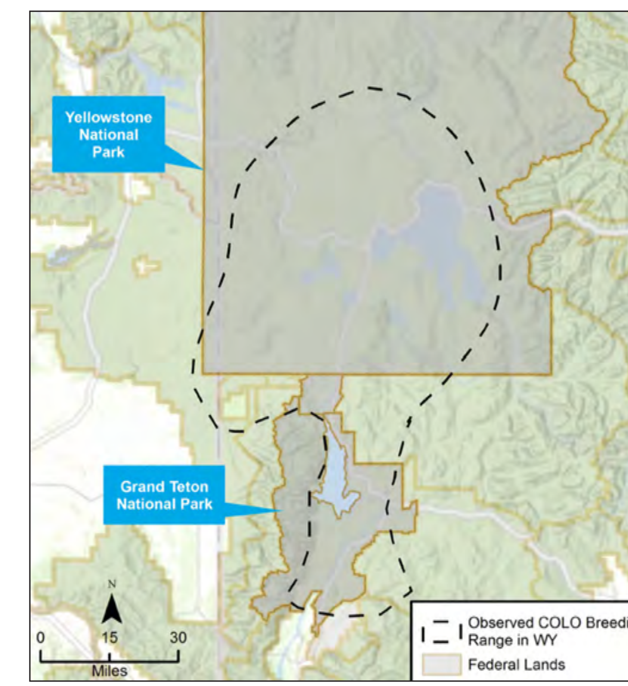
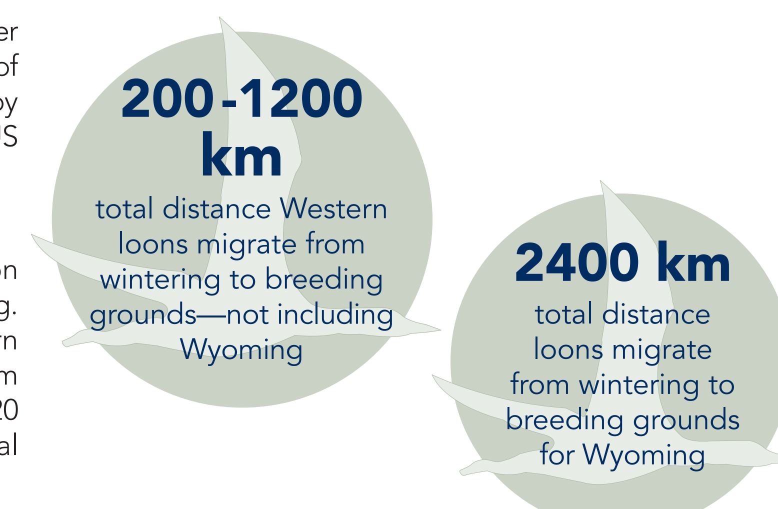


Figure 2. Generalized breeding range of Common Loons in northwestern Wyoming.



Breeding Loons in the Greater Yellowstone Ecosystem

Based on monitoring efforts by the National Park Service and Wyoming Game and Fish Department since 1989, we know the Wyoming breeding loon population (measured as number of territorial pairs; Figure 3a). From 1989 to 2006, the number of known territorial pairs ranged from 16 to 21 (Figure 3a). This variation over the 18-year time period is typical and is likely related to adult mortality events and even the accuracy of surveys. However, there was a perceived decline after 2006.The reasons for this decline is unknown, but human disturbance of nesting pairs and loss of breeding adults are suspected. From 2008 to 2010, surveys were not comprehensive. However, since BRI started conducting standardized surveys in 2013 there has been a recorded increase in the number of territorial pairs to 22 in 2018.

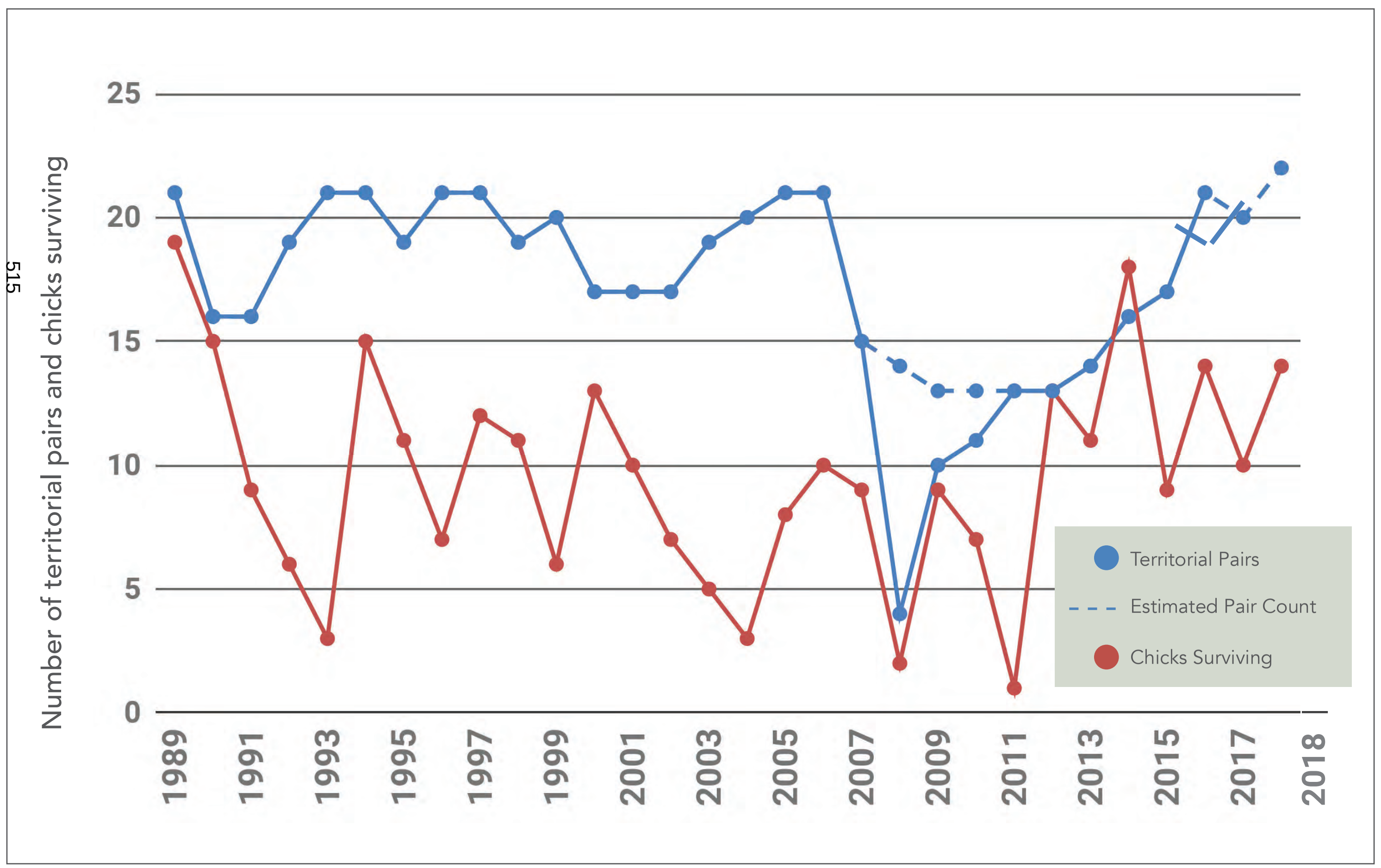


Figure 3a. The number of territorial pairs in northwest Wyoming experienced a significant decline in 2007. Recently, it appears the population is rebounding with new pairs forming. Note, surveys from 2008 to 2010 were not comprehensive.

Loon productivity is best measured as chicks surviving (i.e., those living at least 6 weeks) per territorial pair. In Wyoming, 19 of the 29 years of measured productivity (66%) since 1989 were above the well-established sustainability threshold of 0.48 CS/TP value (Figure 3b; Evers et al. 2010). This statistic is encouraging. For the past eight years, productivity has been above 0.48 CS/TP (90% of the years), which may be related to the increase in territorial pairs now being observed. Having exceptionally low productivity years, such as in 1993, 2004, 2008, and 2011, are typical of loon populations over time.

Typically, for long-lived birds, 20% of the breeding population produces 50% of the young, which is evident in the northwest Wyoming breeding population. Territories with high quality individual loons and/or pairs include Arizona, Cygnet, Indian, and Riddle Lakes. These territories should be prioritized for long-term management.

Figure 3b. Wyoming loon productivity by three-year periods, compared with a well-established national productivity model that uses chicks surviving per territorial pair as a sustainable population benchmark.

Conservation Concerns for Population Sustainability

Loons are long-lived; they have relatively low fecundity and a poor ability to colonize new breeding areas. Given its small size and disjunct location, the breeding loon population in Wyoming is at particularly high risk of local extinction. During the breeding season, general threats to this population include: (1) direct human disturbance to nests and chicks and take of adults; (2) water level fluctuations (especially related to climate change); (3) changes in prey abundance and composition; and, (4) contaminants (e.g., lead and mercury) and toxins (e.g., cyanobacteria). On the wintering grounds (see Figure 1), Wyoming's loon population is susceptible to hazards such as marine oil spills and commercial fishing nets.

Direct Human Disturbance and Take

Canoes and kayaks pose a threat when accessing shallow water areas typical of loon nesting and brood sites. Motorboats may represent a lesser disturbance factor, unless they are within a nesting or nursery area. Excessive angler wading in shallow vegetated areas can disturb nesting and foraging activity. Discarded fishing line poses mortality risks from entanglement. **ACTION: Improve public awareness.**

526

In an effort to restore native cutthroat trout populations of Yellowstone Lake, the National Park Service is removing lake trout through gillnetting. Loons are attracted to the fish activity and can become entangled and drown. **ACTION: Monitor location, timing, and set-depth of the nets.**

Climate Change / Water Level Fluctuations

Loons nest on the water's edge where changing water levels can pose a serious threat. A rise in water level can flood eggs on a nest; a fall in water level can leave a nest high and dry (Fig. 4). Fluctuations on a lake are seasonal and are related to snow melt and storms. Climate change forces may be related to increases in events and magnitude. **ACTION: Place rafts in territories of need.**

Changes in Prey Abundance and Composition

Changes in fish species composition and availability on Yellowstone Lake over the last two decades—loss of cutthroat trout to increasing populations of lake trout—may have an adverse effect on piscivorous birds such as Ospreys and Bald Eagles, and possibly the Common Loon. **ACTION: Increase cutthroat trout populations.**

Contaminants and Toxins

The anthropogenic release of mercury into the environment is a serious problem in North America and around the world. Wyoming ecosystems that are sensitive to the atmospheric deposition of mercury from regional and even global sources include lakes, especially those with abundant shoreline wetlands and frequent water level fluctuations. Lead fishing tackle is poisonous to loons and causes fatalities. Cyanobacteria toxin outbreaks can have lethal effects. **ACTION: Monitor trends of contaminant and toxin levels.**

Oil Spills

Marine oil spills can have significant impacts on winter populations of loons, through oil ingestion and oiling of feathers causing hypothermia. **ACTION: Determine where Wyoming breeding loons overwinter.**

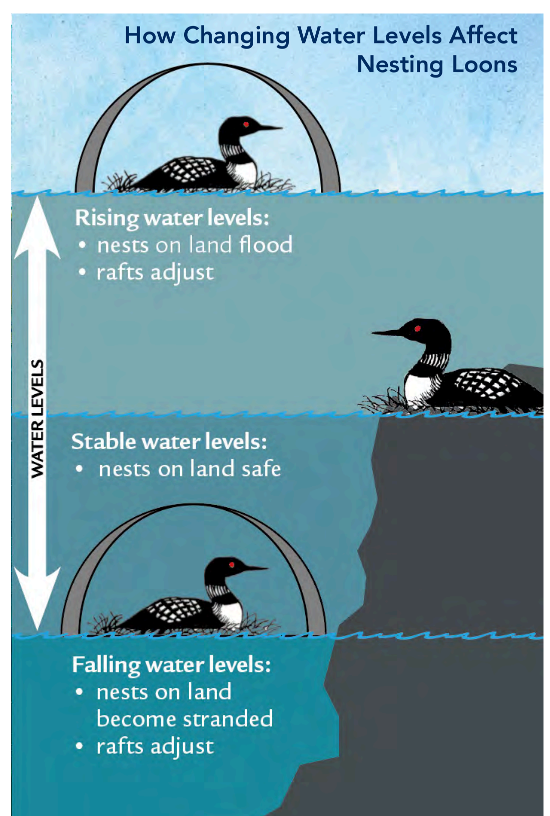


Figure 4. Rafts, or artificial nesting platforms can significantly improve nesting success.

Looking Forward to the Future

Evidence of the loon's ability to acclimate to changing conditions demonstrates that properly designed conservation efforts can often be beneficial. General threats to North America's loon population are well-established (Fig. 5). In Wyoming, BRI's research over the past seven years recommends prioritizing the following actions to help understand and protect loon breeding populations and maintain their long-term sustainability.

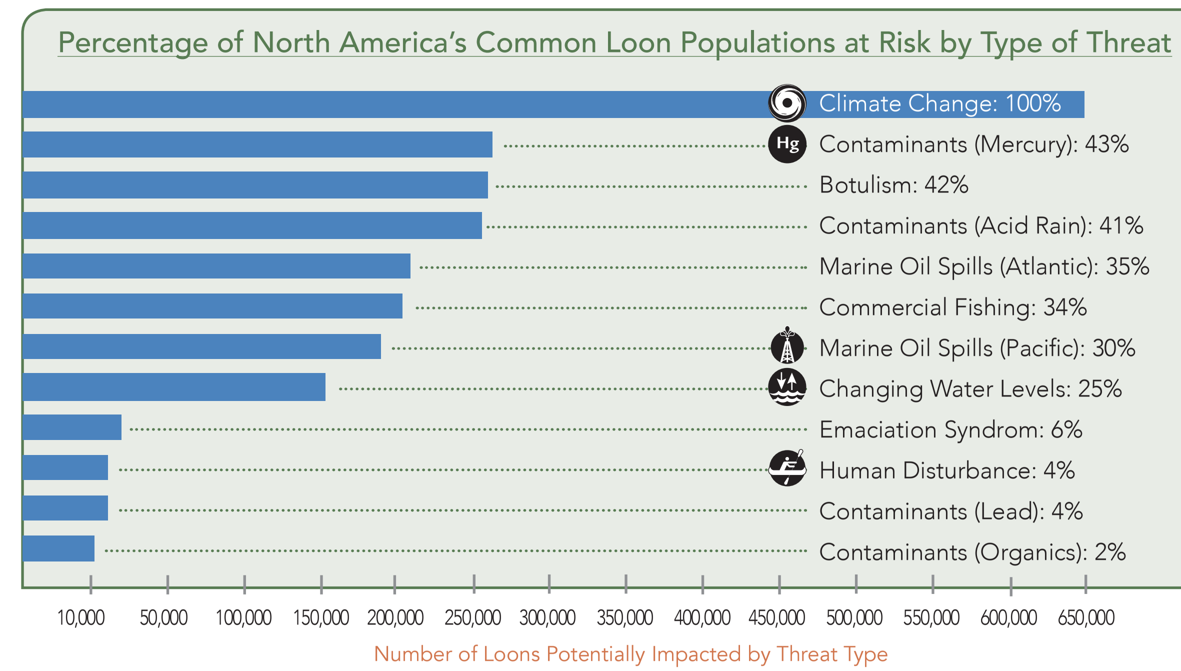


Figure 5. The percentage of Common Loons potentially adversely impacted by 12 major threat categories. Threats associated with an icon are important for Wyoming's breeding loon population.

Monitoring

- *Recommended action:* Continue to conduct standardized surveys of the breeding population, including the Wind River Range.

planned BRI activity — Continue to track color-banded adults and returning juveniles to determine site fidelity, local territory movements, age at first breeding, and individual performance.

Management

- *Recommended action:* Expand the use of artificial nest platforms to mitigate loss of productivity due to water level fluctuations. Use avian guards.
- *Recommended action:* Continue closures of nest sites vulnerable to human disturbance, using ropes and floating signs.
- *Recommended action:* Continue working with YNP biologists to modify gillnetting locations and timing to reduce loon bycatch.

Research

planned BRI activity — Continue the capture, banding, and sampling of loons to track individuals and determine health including contaminant body burdens (e.g., mercury and lead and stable isotopes).

planned BRI activity — Determine inter- and intraseasonal movements through the use of geolocators and satellite transmitters.

Outreach

planned BRI activity — Continue to create a greater awareness of the presence and requirements of breeding loons using dioramas, exhibits, communication pieces, and video and slide presentations.

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Biodiversity Research Institute's mission is to assess emerging threats to wildlife and ecosystems through collaborative research and to use scientific findings to advance environmental awareness and inform decision makers.

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COMMON LOON DISTURBANCE MONITORING STUDY, 2018

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Susan Patla, Nongame Biologist, Wyoming Game and Fish Department

ABSTRACT

The Common Loon (*Gavia immer*) is a designated Species of Greatest Conservation Need in Wyoming and considered the most at-risk nesting avian species in the state (WGFD 2017). Human disturbance, along with other factors, have been suspected as being a source of nest failure in Wyoming's small and isolated breeding population (McEneaney 1987, WGFD 2017, BRI unpublished data). Recent monitoring efforts by BRI have focused on obtaining data on baseline site occupancy, production, nest success, disturbance sources, habitat quality, containments, and Common Loon health through ground observations and capture events (BRI unpublished data). Although a great deal of valuable information has been obtained by BRI and state and federal agency biologists since 1987, there remains a lack of site-specific disturbance information for most nest sites in the region. In 2018, the Wyoming Game and Fish Department funded a separate monitoring study to focus specifically at six nest sites located on or adjacent to the Caribou-Targhee National Forest to identify potential disturbances that occur during the nesting period from late May through the end of June. This work represents the first intensive effort to focus solely on identifying causes of disturbance to nesting pairs in the region using concentrated ground observations but builds on past findings and guidance from monitoring work conducted since 1987. Field biologists from BRI provided valuable help to complete this work.

In 2018, 17 nesting pairs in the Greater Yellowstone Ecosystem were documented to have nest sites (BRI/RCF unpublished data). Six of the 17 were the focus of this study. We documented several disturbance events related to recreational angling, backpacking and hiking, vehicle traffic, loon observers, and watercraft activity. It appeared that three of the six nests in this study that failed correlated with significant human disturbance events. Disturbance events at two other nests were documented, and these nests did succeed in fledging one chick each. However, one ~20 day old chick was lost after site protections were lifted and recreational and research traffic increased, similar to the sixth nest, where a ten-day-old chick was lost for unknown reasons after an increase in human recreation activity in the area occurred. Although it is difficult to pinpoint exact cause and effect for nest failures and brood reductions, overall, the amount and types of disturbance that were documented exceeded our expectations. Our results suggest that management actions will be required if this at-risk nesting population is to remain sustainable over time.

INTRODUCTION

A small population of nesting Common Loons (loons) in Wyoming occurs only in the northwest corner of the state in Yellowstone National Park (YNP), and just south of the park on the Caribou-Targhee (CTNF) and Bridger-Teton National Forests, and Grand Teton National Park. This population is separated from its nearest neighbor by over 300 km (Spagnuolo 2015). Wyoming Game and Fish Department (WGFD) Nongame Program biologists, and YNP biologists have been monitoring nesting lakes since the 1980s. Biodiversity Research Institute (BRI) completed a 5-year study on loons (2012-2017) in Wyoming, which included monitoring all nesting and suspected nesting lakes for nesting activity and productivity (BRI unpublished reports).

The highest concentration of nest sites outside of YNP occurs on small lakes on the CTNF east of the Idaho State line (BRI/RCF reports). Recreation users are mainly from Idaho and visit these lakes to view wildlife, fish (at a few lakes), camp, picnic, and boat (CTNF 2003). A commercial operator also has camps close to two of the lakes (CTNF permit).

Human disturbance has been considered a direct threat to nesting loons in the GYE for many decades (McEneaney 1987, YNP and WGFD monitoring reports). Documentation of human-caused nest failures is limited to a few accounts of fisheries crews; however, indirect evidence of human disturbance to loons has been growing. This effort represents the first focused effort to identify specific threats.

METHODS

Most monitoring efforts in the past have consisted of short monitoring visits (i.e., 45-minute observation periods for WGFD 2-3 times per season) or efforts to capture and band loons (BRI/RCF reports and unpublished data, WGFD data). Consequently, we have little information on the extent of human disturbance or inter-specific disturbances during the pre-nesting and incubation periods that could result in either loons failing to initiate nesting or nest abandonment and failure to hatch eggs. Avian and mammalian predation might also be a cause of nest failures. We strived for 1-2 hour on-site monitoring periods scattered throughout the day at nesting lakes to document both human and wildlife activity, as well as occupancy and nest initiation by loons. Monitoring began 13 May and field observations continued until the end of 26 June. Data were collected on the number and types of human activity, the occurrence and types of intrusions by other loons, and presence of any potential predators. Observers who conducted observations at lakes were careful to avoid disturbing loons and to be as concealed as possible from other human visitors.

Carl Brown, WGFD, was the lead field biologist on this project under the direction of Susan Patla. He coordinated efforts with BRI staff and CTNF biologist Sabrina Derusseau and District Ranger Elizabeth Davey.

RESULTS

All previous observations are from WGFD data available at the Lander Regional Office and in Nongame Annual Completion Reports, YNP data, BRI reports (2013-2016), and BRI/RCF reports (2017-2018).

Breeding Summaries

Territory 1

At this site in 2018, the nest failed. We documented four canoe disturbance events that likely caused nest abandonment. Only one canoe observation out of five did not flush loons off nest. Limited disturbance has been documented at this site in recent years. Other nesting season disturbances at Berman include the drawing down of water which poses a significant late season risk to fledging chicks. In addition, unpaired adult loons have been seen challenging the nesting pair which could also lead to nest failure.

Territory 2

An active nest was documented for the first time in 2018 but failed (WGFD data). Overnight camping and extended use by anglers are suspected as the source of nest failure. We documented that hiking on the established trail at 300m from the nest caused birds to flush during surveys, multiple times. We also observed the presence of anglers causing loons to flush off the nest, even from the opposite side of the lake. This pair was extremely sensitive to all human activity, including loon monitoring. We believe this may be the reason an active nest has never been documented previously at this site.

Territory 3

One chick fledged from this site in 2018. We documented a Sandhill Crane (*Grus canadensis*) nest abandonment immediately following a party of kayakers that floated the lake on 25 May and walked around the small floating island where the loon pair was also incubating. No human disturbance had been documented at this site prior to 2018 surveys and it was thought that no boating occurs on this lake (WGFD data).

Territory 4

Nest failure in 2018. Disturbance from an individual walking on the shore may have caused this.

Territory 5

Two chicks hatched, one chick fledged, and one chick over ~20+ days old was lost. Two attempts were made to capture adults in 2018 (BRI/RCF unpublished data). This is the first time that loon chicks were documented at this site in 15 years (WGFD data), following an emergency closure by the USFS at site due to documented vehicle disturbance. Definitive nest site found for first time near suspected 2017 location. Confirmation that previous surveys and banding attempts have very likely flushed individuals off nest. Site is extremely sensitive to any parties within a few hundred meters of shoreline on foot or in vehicles. Two nocturnal captures took place on 8 June and 22 June. A three-week-old loon chick was lost between the 9 and 22 June.

<u>Territory 6</u>

One chick was seen on the lake with adults, with the last sighting of the bird at ~10 days old but is not considered to have fledged. No other chicks were documented. An increase in recreationists was observed prior to the loss of this chick, but no direct evidence was gathered at this highly sensitive site.

DISCUSSION

Loons in the mid-west and New England are fairly tolerant of humans, and often nest on lakes with highly developed waterfront property that is occupied throughout the breeding season. Loons also can use floating nesting rafts on reservoirs with constantly fluctuating water levels (Evers et al. 2010). Recreationists and watercraft operators are kept away from nests by use of information, including markers and signs, that inform users of nesting pairs, and loons are known to tolerate activities, if closures are not violated. These mitigation efforts seem to be dependent on a loon population that has habituated over long periods of time, and ultimately can tolerate a high degree of human activities.

Common Loons in Wyoming have long been suspected of being more easily disturbed, but an intensive and focused effort to investigate this has been lacking (McEneaney 1987, BRI unpublished report, WGFD 2017). In 2018, 17 nesting pairs were documented to have nesting loons (BRI/RCF unpublished data). Six of these territories were in our study area, three of which failed after documented human events, another two were impacted by human disturbance events and fledged one chick each, and the sixth lost a ten-day-old chick after human recreation activity on its neighboring trail increased.

Territory 1's nest was abandoned after four out of five canoe parties caused birds to flush off nest five times for up to 30 minutes in direct sunlight. Off nest movements at this site were otherwise dominated by 1min nest switching events. Territory 2 was declared failed after two parties spent 48hrs camping at the lake, the only major disturbance event up to that point in the year. Birds had previous flushed off nest by hikers at distances of 300m, even when taking precautions. Birds at Territory 4 abandoned nest after a single documented human disturbance. Territory 3 has always been considered not to be used by recreationists due to it being fishless and eventually 96% covered by lily pads. This site had a landing party walking on its island before lily pads dominated the water's surface, which was followed by a neighboring Sandhill Crane nest abandonment. Territory 5 fledged a chick for the first time in 15 years following an emergency USFS closure after it was observed that a single ATV not following a voluntary closure flushed the incubating female off the nest. Territory 6, a trail-less lake in YNP, lost a hatched chick of almost two weeks after hatching. This occurred after a large party of anglers was seen heading towards its location, the only body of water worth fishing along that trail.

Free Fishing Day in Wyoming, the first Saturday in June, draws in individuals to Territory 2, which resulted in birds being flushed off the nest in 2018. A Memorial Day opener in YNP also coincides with one of the most critical periods for nesting loons, Trumpeter Swans (*Cygnus buccinator*), and other waterbirds. These events also occur before lily pads dominate many shorelines, creating more attractive shore and watercraft angling opportunities than post nesting periods. Stocking currently fishless bodies of water would create future disturbance events due to an inherent increase in human visitation. Stocking lakes in the CTNF that appear to have high BMAA (cyanotoxins) needs to be considered carefully due to the unknown health effects to humans.

The most definitive previous case in the region of human disturbance causing a loon nest failure was documented in YNP when a biological research crew conducted shore surveys during a partial site closure for nesting loss (Carl Brown, pers. obs.). Stocking of should be coordinated with WGFD Nongame Program personnel to avoid disturbing nesting birds, and information about nesting waterbirds and disturbance should be provided to other wildlife outfits to help them in their mission to avoid disturbing nesting sites.

In 2018, loons were pushed off the nest by the presence of loon observers at distances of 300m multiple times at Territory 2, are suspected of doing so at Territory 6. It is likely based on data from this study that monitoring parties may have repeatedly, and largely unknowingly, disturbed birds at Territory 5 since at least 2013 while attempting to document occupancy and nesting or while attempting diurnal captures. Two attempted captures at Territory 5, after chicks were ~20 days old, occurred in July 2018 (BRI unpublished data). Considerate anglers following verbal and printed instructions to minimize disturbance still caused a female to flush from nest at Territory 2 in 2018. Loon observers often have been able to read loon leg bands during the nesting period. Based on our observations of very minimal and short lived on/off bouts of nesting loons at Territory 1, this indicates that benign observations may flush individuals off the nest, thinking that the pair has not yet initiated nesting. These previous actions that may have resulted in disturbance events seem to be based on assumptions that loon behavior in the GYE is similar to other more habituated populations.

Diurnal capture in past years at Territory 5 may have resulted in a pair being captured during the same event, potentially resulting in an incubating bird to be removed from the nest for an extended period. Birds banded at Territory 5 in 2014, which sees repeated disturbance events from vehicles each year (likely 20-40 during the nesting period) have moved to different lakes, perhaps in response to this type of intensive disturbance. Repeated diurnal and nocturnal captures at many locations indicate that some pairs have become very sensitive to such disturbances. Geolocators that must be attached to a bird by leg band and recaptured to obtain data, require two handlings. Some sites have seen over ten capture events to re-acquire these devices (BRI data). Information gained from such devices should be weighed against the risks for each nesting pair.

Partial or full closures of lakes until 15 July would likely improve the hatching success at most sites, and buffers around other lakes, similar to actions taken at Territory 5 in 2018, would be needed to be effective at many locations. A closure of Fish Lake until 15 July would result in a loss of an estimated 20 visitations by the public; however, most recreation at the site does occur after this date. Discussion and evaluation of monitoring techniques and capture protocol by waterbird crews will help to avoid unnecessary disturbances and to minimize impacts.

Human disturbance undoubtedly extends outside of this relatively quiet, but increasingly popular, stretch of Grassy Lake Road. Neighboring National Parks likely received close to 4-5 million of visitors each in 2018. Breeding loons have not been documented in Grand Teton National Park since 2013, apart from a reported pre-flighted loon chick seen with adults on Jackson Lake in 2018. GTNP Territory 1 has been without loons since 2013, and the only report of loon chicks on GTNP Territory 2 was in 2010 (Walter Scherer, pers. comm.). Neighboring GTNP Territory 3 saw an estimated 210-360 people visit the location every hour in 2017. Increasing recreation rates pose a threat to this population of 17 nesting pairs, where single disturbance events often result in nest failures (Evers et al. 2010, BRI reports and unpublished data).

Since monitoring surveys to nesting lakes can account for most early season visits to some sites, exceptional care must be taken by biologists to avoid causing nest abandonment or loss of young chicks. I (Carl Brown) worked for BRI for multiple season (2014, 2015), and collecting data for the 2018 monitoring program made me realize that past monitoring actions may have caused more disturbance than was realized at the time and methods should be carefully reevaluated to assess risk to nesting loons.

This research and documentation are part of a larger effort by researchers and managers to identify disturbance and threats from both biotic and abiotic factors for this highly at-risk nesting population. This study has evolved from previous efforts by YNP, GTNP, WGFD, USFS, BRI, and RCF. We hope the information provided will be valuable in planning future research, monitoring, and management efforts for sustaining the nesting population of Common Loons in Wyoming.

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Table 1. Disturbances and threats to Common Loons (*Gavia immer*). Water recreation = water craft, swimming; Observers = biologists, birders, photographers; Angling = individuals fishing; Vehicles = disturbance from vehicle traffic, Draw down = threat from removal of water from reservoirs or ephemeral lakes; Trail use = disturbance threat from hikers on established trails; Fish stocking = potential threat due to fish stocking in lakes; * = probable cause of Sandhill Crane (*Antigone canadensis*) nest abandonment.

Territory	Water recreation	Observers	Angling	Camping	Vehicles	Draw down	Trail use	Fish stocking
1	X		X	X		X	?	X
2	X	X	X	X			X	X
3	X*		X	X		X		X
4	X	X	X	X	?			
5	X	X	X	X	X		X	X
6	X	X	X	X				

2018 Western Asio flammeus Landscape Study (WAfLS) Annual Report

Version 1.0

Short-eared Owl, Bob Tregilus (WAfLS volunteer).

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ABSTRACT

The Short-eared Owl (*Asio flammeus*) is an open-country species that breeds in the northern United States and Canada, and has likely experienced a long-term, range-wide population decline. However, the cause and magnitude of the decline are not well understood. Following Booms et al. (2014), who proposed six conservation actions for this species, we set forth to address four of these objectives within the Western Asio flammeus Landscape Study (WAfLS) program: 1) better define and protect important habitats; 2) improve population monitoring; 3) better understand owl movements; and 4) develop management plans and tools. Population monitoring of Short-eared Owls is complicated by the fact that the species is an irruptive breeder with low site fidelity, resulting in large shifts in local breeding densities, often tied to fluctuations in prey density. It is therefore critical to implement monitoring at a scale needed to detect regional changes in distribution that likely occur annually. We recruited 622 participants, many of which were citizen-scientist volunteers, to survey at study sites embedded over 87 million ha within the states of California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming during the 2018 breeding season. We surveyed 368 transects, 331 of which were surveyed twice, and detected Short-eared Owls on 57 transects. We performed multi-scale occupancy modeling and maximum entropy modeling to identify population status, habitat and climate associations. Our estimated occupancy rates suggest an increase in abundance in Idaho and Nevada as compared with 2017, and a continuing decrease in abundance in Utah and Wyoming. These numbers and the newly established estimates in other states will help us to put future changes into perspective. As expected, our occupancy modeling found that the probability of detecting Short-eared Owls was impacted by day of the year, time of the survey and local wind conditions. We most often found Short-eared Owls in stubble agriculture areas with lower levels of grazing. Cropland at the transect scale was a large predictor in site occupancy. Consistent with recent years our MaxEnt analysis found Short-eared Owls were more likely in areas of shrubland, cropland, and marshland, and grassland. Our results continue to find that Short-eared Owls have a climate association that puts them at great future risk, primarily their apparent preference of landscapes with higher relative precipitation and moderate seasonality. As our summers continue to become drier, as is expected under most climate scenarios, we would expect a further decrease in the population of this species, possibly through the climate's effect on prey abundance. As a result of the consistent implementation of this program within Idaho and Utah, we have established with high confidence that the breeding density of Short-eared Owls in 2018 was lower than 2015 and 2016 within these states, yet has increased in Idaho over levels measured in 2017. Lastly, our results demonstrate the feasibility, efficiency, and effectiveness of utilizing public participation in scientific research (i.e., citizen scientists) to achieve a robust sampling methodology across the broad geography of the western United State. We look forward to the continued implementation of this program in future years.

Key Words: citizen-science | conservation | habitat use | occupancy | population trend | Short-eared Owl

Significance Statement

WAfLS is the largest geographic survey of Short-eared Owls in the world. The abundance estimates and habitat associations from this effort provides critical insight to land managers across the Intermountain West to influence species-specific and general conservation actions.

Acknowledgements:

We are deeply grateful for the 622 participants/volunteers that invested their time and money to complete the surveys described in this report. This program would not exist without their continued dedication and commitment (see Appendix I & II for complete list of participants and affiliated organizations).

We thank the U.S. Fish and Wildlife Service Wildlife and Sport Fish Restoration Program (WSFR) for their critical funding of this program through the Competitive State Wildlife Grant Program (C-SWG). We could not have expanded the program to all eight western states without their support. We thank the Western Association of Fish and Wildlife Agencies (WAFWA) for their coordination and management of the funding for this project and the Pacific Flyway Council Non-game Technical Committee for their support in the development of the grant proposal.

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INTRODUCTION

The Short-eared Owl (*Asio flammeus*) is a global open-country species often occupying tundra, marshes, grasslands, and shrublands (Holt et al. 1999, Wiggins et al. 2006). In North America, the Short-eared Owl breeds in the northern United States and Canada, mostly over-wintering in the United States and Mexico (Wiggins et al. 2006). Swengel and Swengel (2014) conducted surveys for this species in seven midwestern states, finding Short-eared Owls breeding in large intact patches of grassland (>500 hectares) with heavy plant litter accumulation, and little association with shrub cover. Within Idaho, Miller et al. (2016) found positive associations with shrubland, marshland and riparian areas at a transect scale (1750ha), and with certain types of agriculture (fallow and bare soil) and a negative association with grassland at a point scale (50ha). However, until now habitat use has not been broadly explored within the Intermountain West of North America.

Booms et al. (2014) argued that the Short-eared Owl has experienced a long-term, range-wide, substantial decline in North America. They based this claim on a summary of Breeding Bird Survey and Christmas Birds Count results from across North America (National Audubon Society 2012, Sauer et al. 2017). Table 1 illustrates the general downward trend in Short-eared Owl populations in western North America between 1966 and 2015 (note the region-wide values), as estimated from the Breeding Bird Survey; however, only California had a clearly significant result (Sauer et al. 2017). Booms et al. (2014) acknowledged that neither the Breeding Bird Survey nor Christmas Bird Count adequately sample the Short-eared Owl population in North America as the species is not highly vocal and is most active during crepuscular periods and at night, resulting in very few detections.

Table 1. Annual Breeding Bird Survey (BBS) trends in states and regions of the western United States from 1966 – 2015 (Sauer et al. 2017) with 95% confidence intervals. Only California evaluated out to 50 years had a statistically significant result†, illustrating the potential lack of measurement power of the BBS methodology to evaluate Short-eared Owl populations.

Region	Sample	50-Year Rate	95% CI	10-Year Rate	95% CI
California	7	-6.70	(-11.19, -2.59)	-6.64	(-14.89, 2.14)
Idaho	22	-2.72	(-6.80, 0.63)	-3.97	(-17.84, 6.00)
Montana	43	1.33	(-2.53, 5.01)	7.09	(-5.97, 21.83)
Nevada	9	2.58	(-4.14, 9.61)	4.3	(-9.57, 42.11)
Oregon	28	-1.24	(-4.07, 1.84)	-0.6	(-5.36, 12.34)
Utah	19	1.03	(-6.34, 9.44)	-6.07	(-22.88, 12.41)
Washington	25	-2.48	(-6.64, 1.95)	-8.69	(-22.77, 4.14)
Wyoming	33	0.08	(-4.90, 4.95)	19.2	(-1.16, 46.81)
Great Basin	110	-1.56	(-4.12, 0.64)	-3.43	(-10.18, 4.80)
Western BBS	133	-0.95	(-3.33, 1.04)	-1.8	(-7.68, 5.14)

†Statistical significance measured with 95% Confidence Interval failing to overlap zero.

Relative to winter range, Langham et al. (2015) used Breeding Bird Survey data, Christmas Bird Count data and correlative distribution modeling with various future emission scenarios to predict distribution shifts of North American bird species in response to future climate change. Their results predict that 90% of the winter range of Short-eared Owls in the year 2000 may no longer be occupied by 2080 and, even with a northward shift in winter range, the total area of winter range is expected to reduce in size by 34% (National Audubon Society 2014).

Booms et al. (2014) and Langham et al. (2015) have highlighted the apparent disconnect of current and predicted population trends of Short-eared Owls and current conservation priorities. Booms et al. (2014) proposed six measures to better understand and prioritize actions associated with the conservation of this species. We have chosen to focus on four of those measures: 1) better define and protect important habitats; 2) improve population monitoring; 3) better understand owl movements; and 4) develop management plans and tools.

Public participation in scientific research, sometimes referred to as citizen science, can take many forms ranging from contributory to contractual (Shirk et al. 2012). Public participation in scientific research has a long history of contributing data critical to the monitoring of wildlife (e.g., Breeding Bird Surveys [Sauer et al. 2014], Christmas Birds Counts [National Audubon Society 2012], eBird data for conservation [Callaghan and Gawlik 2015], and Monarch Butterfly monitoring [Ries and Oberhauser 2015]). Public participation projects can deliver benefits to multiple constituents including the volunteers themselves, the lead researchers, the conservation community and the general public. For a contributory project, the volunteer gains increased content knowledge, improved science inquiry skills, appreciation of the complexity of ecosystems and ecosystem monitoring, and increased technical monitoring skills (Shirk et al. 2012). The primary advantage to the researcher for a contributory project is at the project scale (decreased cost, increased sample size and geographical scale; Shirk et al. 2012). Researchers must structure programs appropriately to achieve desired results, as unstructured citizen science data collection may not provide sufficient resolution to meet program objectives (Kamp et al. 2016).

The WAfLS program began in 2015 with an Idaho state-wide effort and a limited pilot in northern Utah (Miller et al. 2016). In 2016, we expanded to an Idaho and Utah state-wide program. In 2017, we once again expanded, this time into the neighboring states of Nevada and Wyoming. After securing dedicated funding, in 2018 we were able to add California, Montana, Oregon, and Washington to encompass all of the western states with significant amounts of Short-eared Owl habitat. Our program objectives include: 1) identify habitat use by Short-eared Owls during the breeding season in the study area; 2) establish a baseline population estimate to be used to evaluate population trends; 3) develop a monitoring framework to evaluate population trends over time; and 4) evaluate if these objectives can be met by using a large network of citizen science volunteers through contributory public participation in a scientific research framework as described by Shirk et al. (2012).

Short-eared Owl, Washington, Becky Lyle (WAfLS volunteer).

METHODS

Study area

Our 2018 study area included the eight western states encompassing most of the Intermountain West and west coast of the United States. We stratified this region by placing a 10km by 10km grid over the states, and within these grid cells, we quantified presumed Short-eared Owl habitat within our study area using Landfire data (US Geological Survey 2012), or in the case of California, we used the State's Vegetation Classification and Mapping Program (VegCAMP) data. We used the VegCAMP data in California because of it's superior quality as compared with Landfire. The VegCAMP data was only used for grid cell selection and not in the data analysis. Grassland, shrubland, marshland/riparian, and agriculture land cover classes were considered to be potential Short-eared Owl habitat (Wiggins et al. 2006). Grids with at least 70% land cover consisting of any of these four classes (60% in California) were included in our survey stratum. All other grids were then removed from further consideration. The result consisted of 6,040,000 hectares within California, 9,460,000 hectares within Idaho, 25,220,000 hectares within Montana, 10,260,000 hectares within Nevada, 9,740,000 hectares within Oregon, 7,760,000 hectares within Utah, 5,530,000 hectares within Washington, and 13,810,000 hectares within Wyoming (Fig. 1).

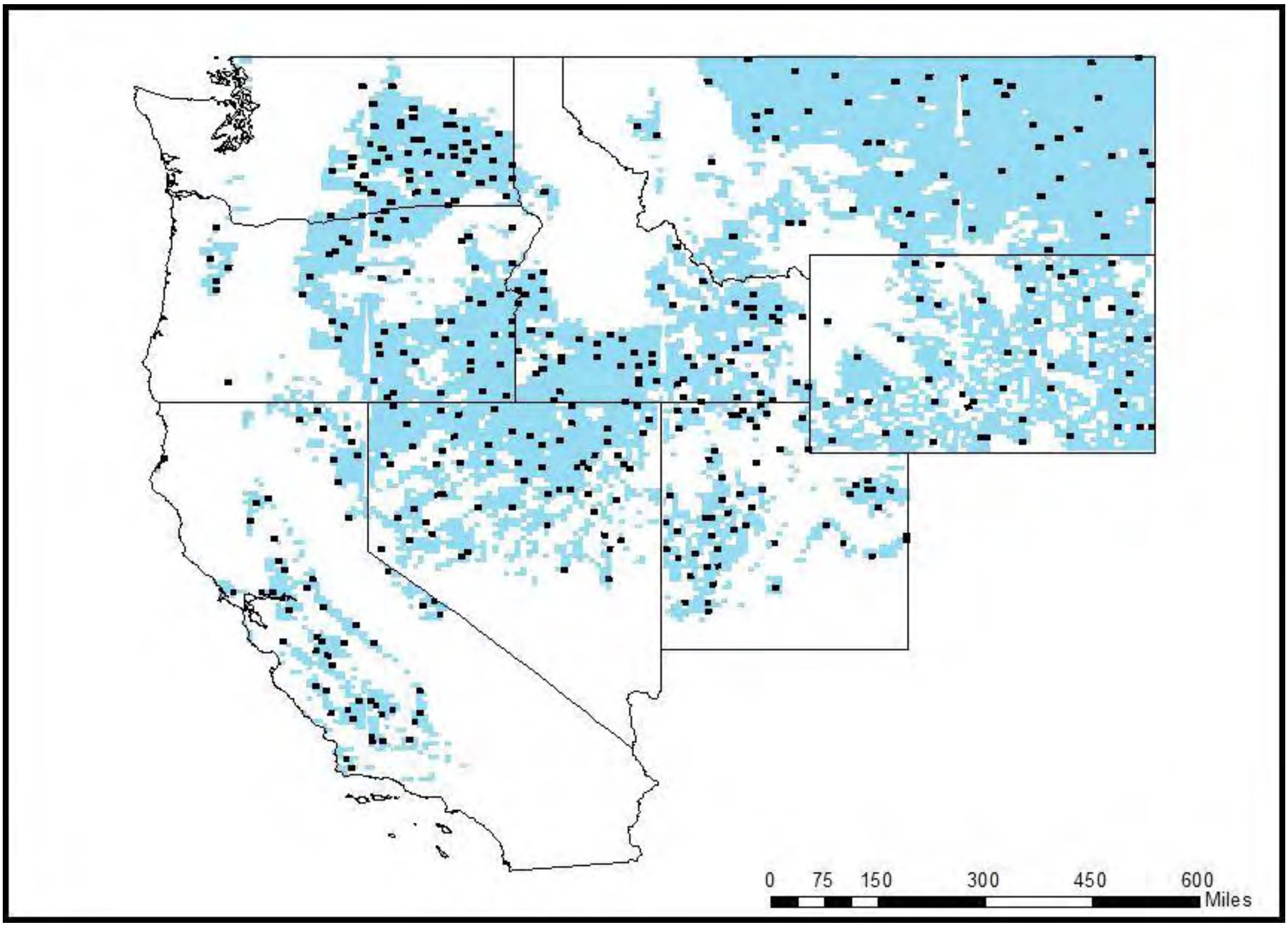

Figure 1. Distribution of strata (blue area) and spatially-balanced survey transects (black squares) for Short-eared Owl surveys during the 2018 breeding season across the states of California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

Transect selection

We selected survey transects within the stratum using a spatially-balanced sample of 10km by 10km grid cells using a Generalized Random-Tessellation Stratified (GRTS) process (Stevens Jr. and Olsen 2004). We eliminated grid cells with no secondary roads, a requirement of our road-based protocol. We selected a spatially-balanced sample of 50 grid cells per state (Fig. 1). We selected additional groups of randomly-selected grid cells in each state in groups of ten that could be offered to additional volunteers only if the original 50 grid cells were all committed. These additional surveys were integrated into the analysis in the same manner as the base 50. Only one additional group of surveys were offered to volunteers, in Idaho.

We delineated a survey route within each grid cell along a 9km stretch of secondary road (Fig. 2), the maximum survey length feasible using the protocol and our justification for choosing a 10km by 10km grid structure (Larson and Holt 2016). If multiple possible routes were available within a single grid cell, we chose routes expected to have the least traffic, routes on the edge of the greatest amount of roadless habitat, or routes with the highest likelihood of detecting Short-eared Owls (a potential source of bias discussed later). In limited cases, such as when road access issues arose, the survey routes were allowed to extend outside of the grid cell, but never for the purpose of accessing other habitat areas. Larson and Holt (2016) reported that in favorable conditions Short-eared Owls could be correctly identified at distances up to 1600 meters, with high detectability up to 800 meters. Calladine et al. (2010) had a mean initial detection distance of 500 - 700m, with a maximum recorded value of 2500m. As our analysis method is robust against false negative detections, but less so against false positive detections, we chose to assume a larger average initial detection distance of 1km. Therefore, we considered all land within 1km of the surveyed points as sampled habitat (Fig. 2).

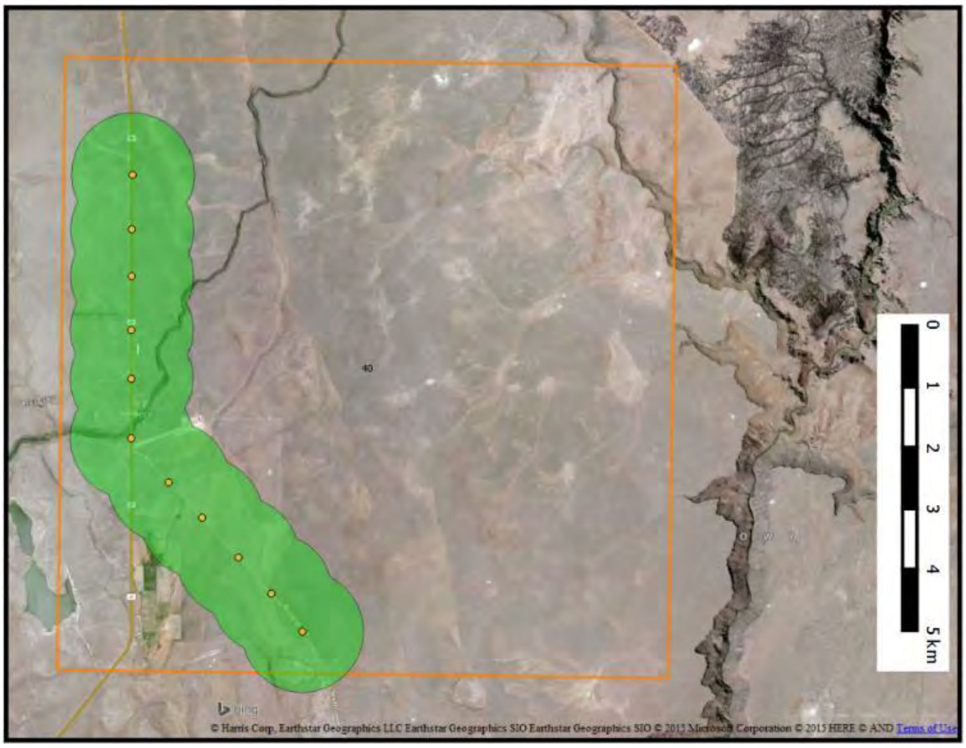

Figure 2. Example illustration of 10km × 10km grid cell (orange), 11 road-based survey points (yellow), and area surveyed within 1km of survey points (green). Green-shaded area is only area used in the analysis.

Hot-spot grids

In each state we also sampled a small number of "hot-spot" grid cells (one to eight per states). These grid cells were subjectively located in places that we expected to find Short-eared Owls, as the sites were intended to be used for drawing comparison of relative abundance among these sites from year to year. We implemented a consistent protocol for sampling these grid cells but did not include the results in the habitat or abundance analyses as they do not meet the assumptions of these analyses and would have biased our results.

Public participation recruitment

We identified a coordinator for each state that was responsible for recruiting survey participants for their routes. Most state coordinators relied heavily upon citizen scientist volunteers. For citizen scientist volunteer recruitment we used a combination of partnerships, listservs, social media, and personal contacts to complete our roster. Our most successful recruiting tool was to reach out to existing volunteer organizations such as naturalist groups and birding groups, electronically, through submitted newsletter articles, and in person. In some cases, we reached out to professional biologists to cover remote grids or grids on restricted lands (e.g., reservation lands or national laboratory lands closed to the public). The reliance on professional biologists differed among the states. For example, Nevada Department of Wildlife in addition to recruiting volunteers, invited a network of professional biologists that they have engaged for their winter raptor survey routes. The result is that we had a larger proportion of paid biologists surveying in Nevada than in other states.

We began recruiting volunteers two months prior to the beginning of the survey window. Volunteers were asked to register for their survey online. Across the eight states, roughly ⅔ of our volunteers were non-professional citizen scientists, whereas ⅓ were professional biologists either volunteering to survey routes or assigned by their agency or company to complete the route. We completed between 76% and 94% of the assigned surveys in each state. Those surveys not completed were a combination of failures to recruit volunteers for some grids, inaccessible survey locations (occurs most often in newly added participating states), late snowmelt that prevented access, and some volunteers not completing their surveys. The states that have participated for a longer period of time tended to get more surveys completed (e.g., 93% for Idaho and 94% for Utah). Our historical rate of route non-completion among volunteers is 10 – 15%.

We provided training materials (e.g., owl identification), a procedure manual, maps, civil twilight schedules and datasheets to volunteers to help ensure survey quality. We provided window signs for participant's vehicles to help them appear more official and alleviate concerns by local land owners. We provided seven online training videos and held two live launch webinars (recording also posted online) prior to the start of the season. We held three in-person training sessions in Idaho (~30 total participants), and one in Utah, which was attended by ~35 volunteers. We asked volunteers to submit data via an online portal utilizing Jotform's online service.

Owl surveys

The survey design involved making two visits to the route during the period when Short-eared Owls are engaging in their courtship flight. Each survey window was three weeks long for the first visit and another three weeks for the second visit. Survey windows were adjusted for each route based upon elevation (Table 2). Survey timing was chosen to attempt to coincide with the period of highest detectability during the courtship period when male owls perform elaborate courtship flights (Fig. 3). Volunteers could choose any day within their survey window to perform their survey, however we asked volunteers to separate the two visits by at least one week. In Montana we had to delay some of the surveys due to snow cover remaining on the ground. We expect to adjust the timing later in subsequent years for these areas.

Table 2. Suggested survey timing for each of the two visits derived from mean elevation of the survey grid cell and expected courtship period of Short-eared Owls within each participating state.

CA, ID, MT, OR, WA	Elevation below 4000ft.	Elevation 4000 - 6000ft.	Elevation above 6000ft.	
Visit 1	March 1 - March 21st	March 16 - April 7th	April 1st - April 21st	
Visit 2	March 22nd - April 15th	April 8th - April 30th	April 22nd - May 15th	
NV, UT	Elevation below 5000ft.	Elevation 5000 - 6000ft.	Elevation above 6000ft.	
Visit 1	March 1 - March 21st	March 16 - April 7th	April 1st - April 21st	
Visit 2	March 22nd - April 15th	April 8th - April 30th	April 22nd - May 15th	
WY	Elevation below 5000ft.	Elevation 5000 - 6000ft.	Elevation 6000 - 7000ft.	Elevation above 7000ft.
Visit 1	March 10 - March 31st	March 24 - April 14th	April 7th - April 28th	April 14th - May 5th
Visit 2	April 1st - April 22nd	April 15th - May 6th	April 29th - May 20th	May 6th - May 27th

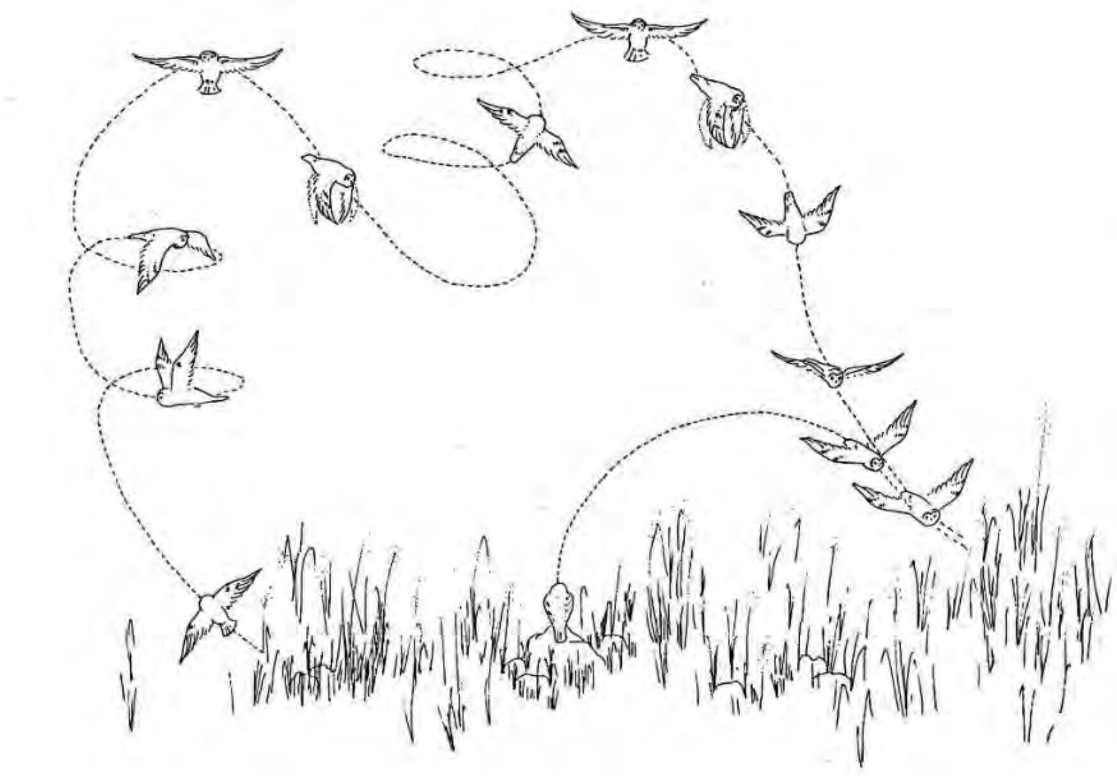

Figure 3. Illustration of male courtship display flight (Wiggins et al. 2006; included with permission).

Observers surveyed points separated by approximately ½ mile (800m) along secondary roads from 100 to 10 minutes prior to the end of local civil twilight, completing as many points as possible (8 – 11 points) during the 90-minute span (Larson and Holt 2016). The multi-scale analyses methods we used relax the assumption of point independence enabling the intermediate point spacing with overlapping area surveyed (i.e., 800m spacing instead of 2000m).

Volunteers surveying in California, Carie Battistone (WAfLS State Coordinator for California).

At each survey point observers performed a five-minute point count, noting each individual bird minute-by-minute (e.g., for an owl observed only during minutes 2 and 3 of the five-minute period, we would assign a value of "01100"). For each observation of a Short-eared Owl, observers recorded whether the bird was seen, heard (hoots, barks, screams, wing clip, bill snap), or both, and the behaviors noted (perched, foraging, direct flight, agonistic, courtship).

Habitat data

At each point observers collected basic habitat data during each visit as we expected some land cover to change during the period (e.g., agricultural field may have been plowed and the cover could therefore change from stubble to bare soil between visits). Observers noted the proportion of habitat within 400m of the point (in general, about half the distance between survey points) that consisted of tall shrubland (above knee height), low shrubland (below knee height), cheatgrass mono-culture, complex grassland, marshland, fallow agriculture, retained stubble agriculture, plowed soil agriculture, and green agriculture (new green plant growth visible; Table 3; see Appendix III for full protocol). Mixed grassland and shrubland was classified as shrubland if there were at least shrubs regularly distributed through the area. We also had volunteers count the number of visible livestock and estimate the proportion of the point radius open to livestock grazing. The grass categories of cheatgrass mono-culture and complex grassland, represent an evolution from early years of the program where we simply collected grass height. We have assumed that these new categories better represent the attributes that may be preferred by Short-eared Owls.

Table 3. Definition, variable name used in models, mean, standard deviation (SD), range, position within multi-scale hierarchy, and source of covariates evaluated for influence in occupancy analysis of Short-eared Owls within during the 2018 breeding season.

Variable	Name in Models	Mean ± SD	Range	Hierarchy	Source
Wind (Beaufort)	Wind	2.4 ± 1.5	0 – 7	Detection	Survey
Sky (1 – 4)	Sky	2.8 ± 1.2	1 – 4	Detection	Survey
Day-of-year	julian	98 ± 18	61 – 147	Detection	Survey
Minutes before civil twilight	minCiv	62 ± 25	-17 – 143†	Detection	Survey
Low shrub 400m	lShr	21 ± 33	0 – 100	Point-scale Avail.	Survey
High shrub 400m	hShr	13 ± 26	0 – 100	Point-scale Avail.	Survey
Cheatgrass monoculture 400m	cheat	4 ± 14	0 – 100	Point-scale Avail.	Survey
Complex grassland 400m	hGr	16 ± 29	0 – 100	Point-scale Avail.	Survey
Marsh 400m	marsh	3 ± 10	0 – 100	Point-scale Avail.	Survey
Fallow ag 400m	fallow	5 ± 16	0 – 100	Point-scale Avail.	Survey
Stubble ag 400m	stubble	8 ± 21	0 – 100	Point-scale Avail.	Survey
Dirt ag 400m	dirt	4 ± 14	0 – 100	Point-scale Avail.	Survey
Green ag 400m	green	10 ± 23	0 – 100	Point-scale Avail.	Survey
Grazing 400m	graze	42 ± 43	0 – 100	Point-scale Avail.	Survey
Livestock 400m	ls	14 ± 70	0 – 2000	Point-scale Avail.	Survey
Sagebrush 1km	Sageland	0.27 ± 0.30	0.00 – 0.98	Occupancy	GIS
Shrubland 1km	Shrubland	0.23 ± 0.27	0.00 – 0.98	Occupancy	GIS
Grassland 1km	Grassland	0.20 ± 0.25	0.00 – 0.94	Occupancy	GIS
Cropland 1km	Cropland	0.13 ± 0.18	0.00 – 0.85	Occupancy	GIS
Marshland 1km	Marshland	0.01 ± 0.03	0.00 – 0.29	Occupancy	GIS
Development 1km	Develop	0.07 ± 0.08	0.00 – 0.48	Occupancy	GIS

†All survey points started prior to 120 minutes before the end of civil twilight were dropped from the analysis.

Statistical analysis

We performed multi-scale occupancy modeling (Nichols et al. 2008, Pavlacky et al. 2012) and Maximum Entropy modeling (MaxEnt; Phillips et al. 2006, 2017). Multi-scale occupancy modeling was chosen for its strength in evaluating fine-scale (point-scale in our case) habitat associations and providing a more refined alternative to abundance estimation. MaxEnt modeling provides study-wide habitat mapping, integrating current and future climate scenarios into the predictions.

Grassland. Utah, Deborah Drain (WAfLS volunteer).

Multi-scale Occupancy Modeling
For multi-scale occupancy modeling we implemented a minute-by-minute replacement design, allowing for simultaneous evaluation of detection, point-scale occupancy, and transect-scale occupancy (Nichols et al. 2008). Similar to Pavlacky et al. (2012) we used a modified version of Nichols et al. (2008) where the point-scale occupancy uses spatial replicates, but unlike Pavlacky et al. (2012) we also included our temporal replicates (i.e., two visits) essentially producing a model where the Θ parameter represents a combination of point-scale occupancy and point-scale availability.

For multi-scale occupancy analysis, we collected transect level data using Geographic Information System (GIS) analysis by buffering all surveyed points by 1km, the presumed average maximum detection distance, and quantifying the proportion of each cover type from the 2012 Landfire dataset (Table 2; US Geological Survey 2012).

We evaluated variables influencing the probability of detection (day-of-year, minutes-before-civil-twilight, wind, sky cover, etc.), availability at the point scale (vegetation and grazing values collected by observers within 400m of point, ~50ha), and transect occupancy (cover types collected through GIS data within 1km of all sampled points; Table 2). The 10km by 10km grid structure was used to distribute and spatially balance the transects, as all analyses utilized the 1750ha area surrounding the points actually surveyed (1km radius buffer).

We used a sequential, parameter-wise model building strategy (Lebreton et al. 1992, Doherty et al. 2010), ranking models using Akaike Information Criterion adjusted for small sample size (AIC_c; Burnham and Anderson 2002). We first evaluated each variable by assessing the null model, the model with just the variable of interest, and the model with the variable of interest and the square of the variable of interest. We eliminated the variable from further consideration if the null model ranked highest, otherwise we propagated forward the highest ranking of the variable of interest or the variable and it's square. We first selected candidate variables influencing the probability of detection (*p*) by considering all combinations of the retained variables and chose all variables appearing in models within two ΔAIC_c of the top model. We then fixed the variable set for probability of detection and repeated the procedure for variables influencing the occupancy at the point-scale (Θ). Lastly we repeated the procedure for variables influencing transect occupancy (Ψ) to arrive at our final model set for each analysis.

For inference we used model averaging of all models falling within two ΔAIC_c of the top model, that also ranked higher than the null model (Burnham and Anderson 2002). For each variable appearing within this final model set for the occupancy analysis, we created and present model averaged predictions by ranging the variable of interest over its measured range while holding all other variables at their mean value.

Maximum Entropy Modeling
For the MaxEnt analyses, we used the same base Landfire dataset (US Geological Survey 2012), but integrated in a different way. We produced study-wide raster maps of the proportion of each cover type within 150m of each 30m × 30m pixel on the landscape (e.g., shrubs, sage, grass, etc.). Similarly, we created study-wide maps of elevation and an ecological relevant sample of the 19 standard climate variables derived from 1970 – 2000 (worldclim.org; Fick and Hijmans 2017; Table 4). All values were then resampled down to 30-second blocks (~1km; resolution of the climate data) using bilinear interpolation.

We used all presence and pseudo-absence (locations that we failed to detect owls, but cannot be certain that they were absent) observations from the past four years in the analysis (2015, 2016, 2017, 2018). The result is that the model best represents Idaho with four years of data, then Utah with three years of data, Nevada and Wyoming each with two years of data, and the other four western states with the most limited data. We evaluated the MaxEnt model feature class (linear, quadratic, hinge) and regularization parameters (0.5 – 3.0) using AIC_c (Shcheglovitova and Anderson 2013).

Table 4. Climate, geographic, and habitat variables and source of variables included in MaxEnt analysis.

Variable	**Source**
Annual Mean Temperature (°C)	worldclim.org bio_1
Mean Diurnal Range (Mean of monthly (max temp - min temp)) (°C)	worldclim.org bio_2
Isothermality (BIO2/BIO7) (* 100)	worldclim.org bio_3
Temperature Seasonality (standard deviation *100)	worldclim.org bio_4
Max Temperature of Warmest Month (°C)	worldclim.org bio_5
Min Temperature of Coldest Month (°C)	worldclim.org bio_6
Temperature Annual Range (BIO5-BIO6) (°C)	worldclim.org bio_7
Mean Temperature of Wettest Quarter (°C)	worldclim.org bio_8
Mean Temperature of Driest Quarter (°C)	worldclim.org bio_9
Mean Temperature of Warmest Quarter (°C)	worldclim.org bio_10
Mean Temperature of Coldest Quarter (°C)	worldclim.org bio_11
Annual Precipitation (mm)	worldclim.org bio_12
Precipitation of Wettest Month (mm)	worldclim.org bio_13
Precipitation of Driest Month (mm)	worldclim.org bio_14
Precipitation Seasonality (Coefficient of Variation)	worldclim.org bio_15
Precipitation of Wettest Quarter (mm)	worldclim.org bio_16
Precipitation of Driest Quarter (mm)	worldclim.org bio_17
Precipitation of Warmest Quarter (mm)	worldclim.org bio_18
Precipitation of Coldest Quarter (mm)	worldclim.org bio_19
Elevation (m)	USGS DEM
Slope	USGS DEM
Roughness	USGS DEM
Proportion Cropland within 150m	Landfire
Proportion Marshland within 150m	Landfire
Proportion Grassland within 150m	Landfire
Proportion Development within 150m	Landfire
Proportion Sagebrush within 150m	Landfire
Proportion Shrubland within 150m	Landfire

For future climate projections, we used the same top MaxEnt model, but applied future climate model data instead of recent climate data. Future climate data were derived from the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC AR5) using the Hadley Centre Global Environment Model version 2 and Representative Conservation Pathway 4.5 projected to the year 2070 (RCP4.5; Moss et al. 2008). This dataset assumes a radiative forcing value of +4.5 in the year 2100 relative to pre-industrial values, a conservative model that assumes considerable reductions in the rate of growth in current greenhouse gas emissions. For the future projections, we held the habitat variables at their current level, an assumption that is not likely to hold true as changes in climate will likely result in changes in habitat available.

We present graphical representations of estimated effect size with 95% confidence intervals to align with the majority of scientific literature, whereas, we present abundance estimates with 80% confidence intervals to more closely align with local management objectives. We conducted all statistical analyses in Program R and Program Mark (White and Burnham 1999, R Core Team 2017). We used the R package “RMark” to interface between Program R and Program Mark for the multi-scale occupancy modeling (Laake 2014). We used R package “AICcmodavg” to rank all models (calculating AIC_c), and to perform model averaging (Mazerolle 2015). We used R package “dismo” (Hijmans et al. 2017), interfacing with the MaxEnt software engine (Phillips et al. 2017), for all MaxEnt analyses. We used R package “ENMeval” for ranking and evaluating MaxEnt models (Muscarella et al. 2014).

RESULTS

A total of 622 individuals participated in the survey portion of the program (Appendix I & II), contributing 6370 volunteer hours, 1221 non-federal paid hours, and 165 paid federal hours (Table 5). Participants traveled 137,699 miles to complete the surveys (Table 6), some of which presented travel challenges.

Table 5. Hours invested and value of contribution for volunteers, non-federal paid biologists, and federal paid biologists (based on standard volunteer rate for each state - California=$28.46/hr, Idaho=$21.10/hr, Montana=$21.04/hr, Nevada=$21.51/hr, Oregon=$24.15/hr, Utah=$24.27/hr, Washington=$30.04/hr, and Wyoming=$22.13/hr) by state.

State	Participants	Volunteer hours	Volunteer $	Non-fed hours	Non-fed $	Fed hours
California	85	740	$21,046	205	$5,820	84
Idaho	103	961	$20,279	68	$1,435	15
Montana	60	583	$12,266	169	$3,556	32
Nevada	59	300	$6,448	287	$6,163	126
Oregon	83	1151	$27,797	97	$2,343	15
Utah	103	1042	$25,280	106	$2,560	26
Washington	71	1008	$30,291	83	$2,493	32
Wyoming	75	586	$12,957	208	$4,592	11
Total	622	6370	$181,284	1221	$34,750	165

Table 6. Miles traveled and value of contribution for volunteers, non-federal paid biologists, and federal paid biologists (based on standard rate of $0.535/mile) by state.

State	Volunteer Miles	Volunteer $	Non-fed. Paid Miles	Non-fed. Paid $	Fed. Paid Miles	Fed. Paid $
California	11989	$6,414	2,509	$1,342	1,005	$538
Idaho	14,636	$7,830	252	$135	156	$83
Montana	7,522	$4,024	6,312	$3,377	742	$397
Nevada	7,016	$3,753	7,068	$3,781	1,911	$1,022
Oregon	13,979	$7,479	1,995	$1,067	442	$236
Utah	17,246	$9,227	2,599	$1,390	539	$288
Washington	19,997	$10,698	3,106	$1,661	742	$397
Wyoming	12,137	$6,493	4,163	$2,227	380	$203
Total	104,521	$55,919	28,003	$14,982	5,175	$3,165

In 2018, we successfully surveyed 399 total grid cells; which included 368 regular random grid cells and 31 hot-spot grid cells (Table 7). We detected Short-eared Owls on 57 regular and 14 hot-spot grids. The grids where owls were detected were roughly geographically dispersed, but weaker presence in the south and east of the study area (Fig. 4).

Table 7. Total number of regular grids surveyed and grids with detections of owls, broken out by which visit, whether the grid was a random grid (regular) or hotspot grid, and by state.

State	Regular Grids	Regular W/ Owls	Regular Round 1	Regular Round 2	Hotspot Round 1	Hotspot Round 2
California	44	3	3/44	0/39	2/5	0/5
Idaho	58	13	9/58	9/53	2/3	3/3
Montana	42	14	6/42	10/36	1/1	1/1
Nevada	41	7	6/41	3/35	0/8	0/8
Oregon	38	5	3/38	6/36	2/4	2/4
Utah	48	4	2/48	4/44	3/5	4/5
Washington	49	8	4/49	6/45	1/2	0/2
Wyoming	48	3	2/47	2/43	0/3	1/3
Total	368	57	35/367	40/331	11/31	11/31

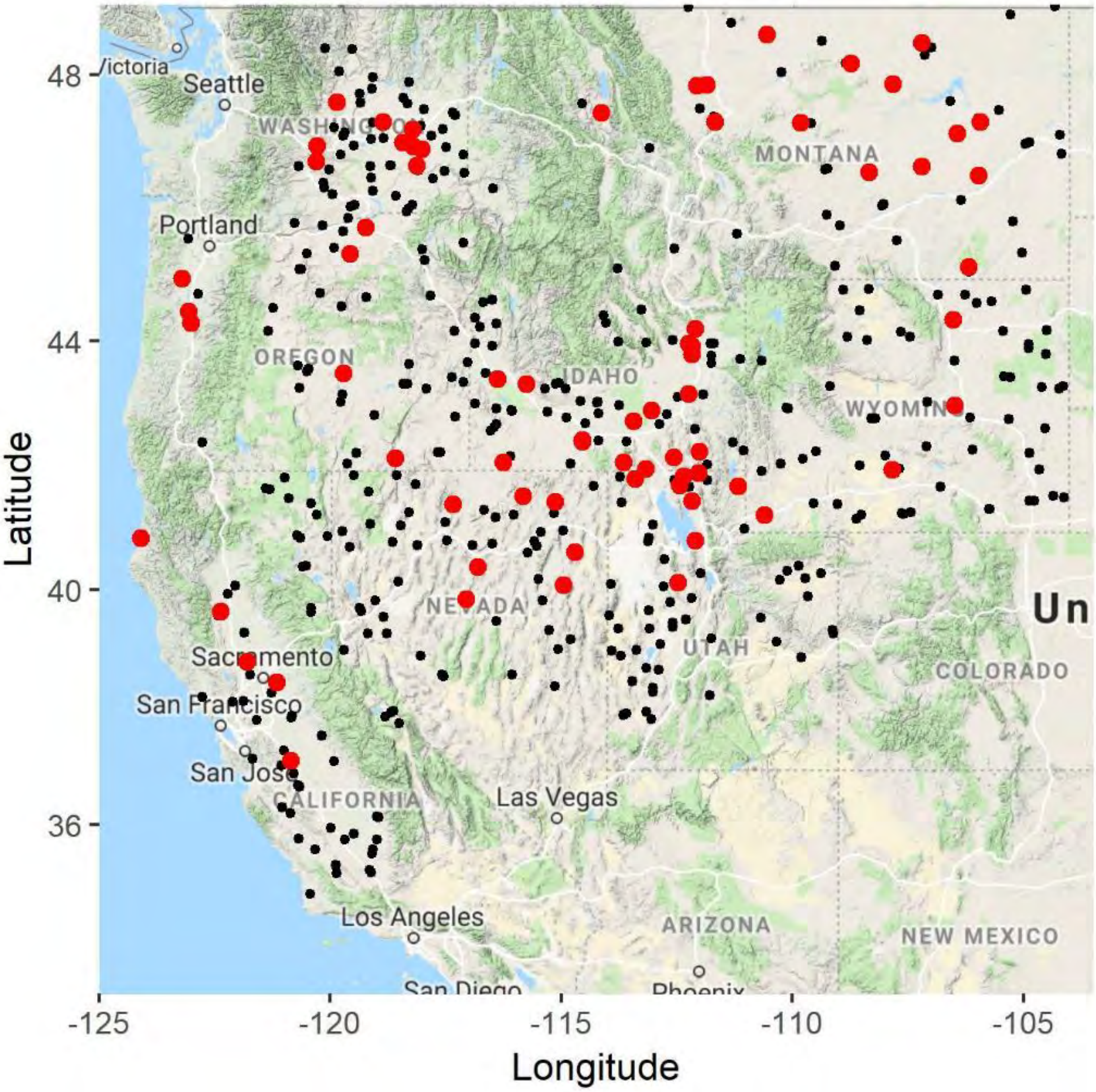

Figure 4. Locations of completed WAfLS surveys (regular and hot-spot) with no Short-eared Owl detections (black), and with Short-eared Owl detections (red).

Multi-scale Occupancy Modeling

The model selection process for the multi-scale occupancy analysis produced seven models falling within two ΔAIC_c of the top model (Table 8). Day-of-year, minutes-before-civil-twilight, and wind appeared in seven, six, and seven models, respectively, influencing the probability of detection of at least one Short-eared Owl, given that at least one owl was present (Table 8, Fig. 5). The square of minutes-before-civil-twilight appeared in three of the models (Table 8, Fig. 5).

Table 8. Top model set, and the null model for comparison (shaded), for multi-scale occupancy analysis predicting the occupancy of transects by Short-eared Owls during the 2018 breeding season. k is the number of parameters in the model, AIC_c is Akaike's Information Criterion adjusted for small sample size, ΔAIC_c is the difference in AIC_c values between individual models and the top model, and w_i is the model weight. We only presented models where $\Delta AIC_c \leq 2.00$, the set used to generate model averaged predictions, and the null model for comparison.

Model	k	AIC_c	ΔAIC_c	w_i
Ψ(crop + crop²) Θ(stubble + stubble²) *p*(wind + minCiv + julian)	10	2248.84	0.00	0.22
Ψ(crop + crop²) Θ(stubble + stubble²) *p*(wind + minCiv + minCiv² + julian)	11	2249.33	0.49	0.17
Ψ(crop + crop²) Θ(graze) *p*(wind + minCiv + julian)	9	2249.36	0.52	0.17
Ψ(crop + crop²) Θ(graze) *p*(wind + minCiv + minCiv² + julian)	10	2249.79	0.95	0.13
Ψ(crop + crop²) Θ(graze + graze²) *p*(wind + minCiv + julian)	10	2249.90	1.06	0.13
Ψ(crop + crop²) Θ(graze + graze²) *p*(wind + minCiv + minCiv² + julian)	11	2250.35	1.51	0.10
Ψ(crop + crop²) Θ(stubble + stubble²) *p*(wind + julian)	9	2250.58	1.74	0.08
Ψ(.) Θ(.) *p*(.)	3	2270.70	21.86	----

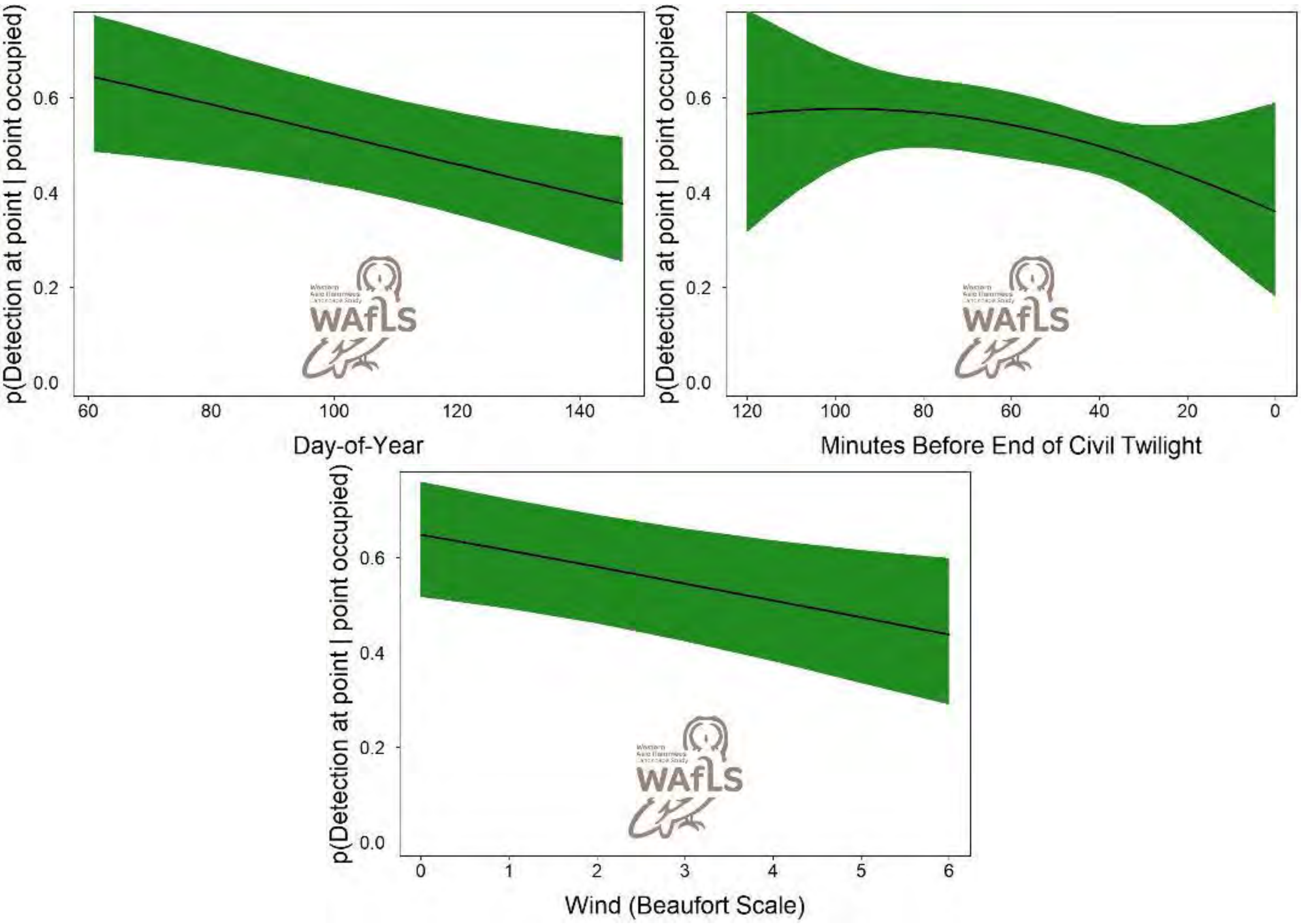

Figure 5. Model averaged prediction generated from multi-scale occupancy top model set for the effect size of a) day-of-year; b) minutes-before-civil-twilight; and c) wind, on the probability of detecting at least one Short-eared Owl at a point given that there was at least one Short-eared Owl at the point during the 2018 breeding season. Black line = model prediction; green area = 95% confidence interval.

The proportion of land within 400m (~50ha) of the survey point that consisted of stubble agriculture or was being, or had previously been, grazed was selected as the variables influencing the probability of at least one Short-eared Owl at a point, given that at least one owl occupied the transect (Table 8, Fig. 6).

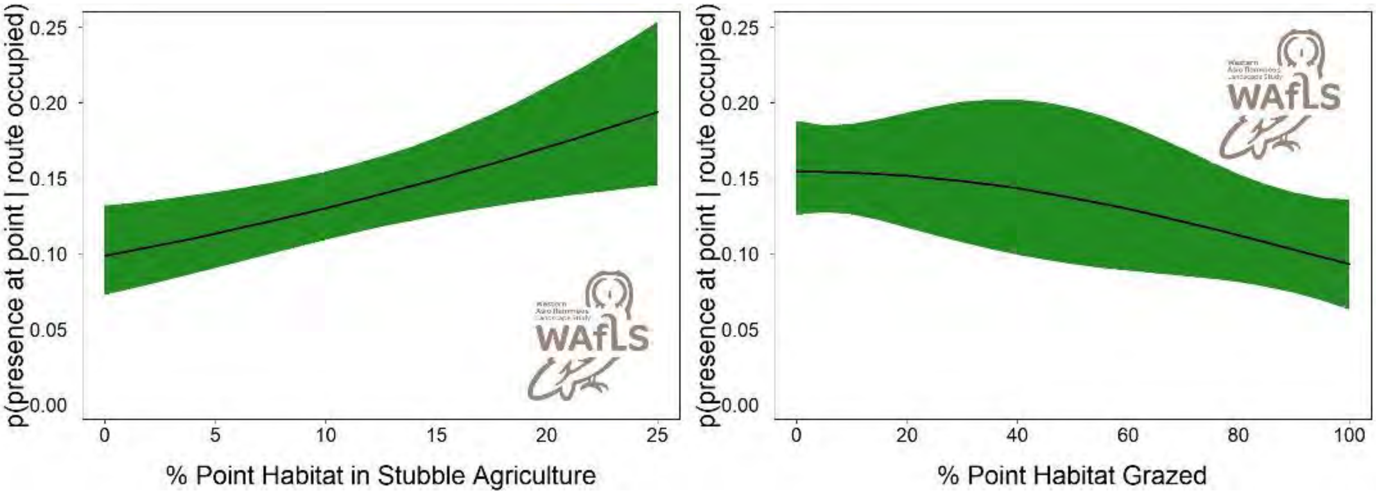

Figure 6. Model averaged predictions generated from multi-scale occupancy top model set for the effect size of the proportion of area within 400m of the surveyed point that is a) in stubble agriculture, and b) that had been grazed, influencing the availability of at least one Short-eared Owl at the point to be sampled given that the transect was occupied by at least one Short-eared Owl during the 2018 breeding season. Black line = model prediction; green area = 95% confidence interval.

Only one variable was selected influencing the presence of Short-eared Owls within the grid itself, cropland (Fig. 7). The effect was quadratic in nature.

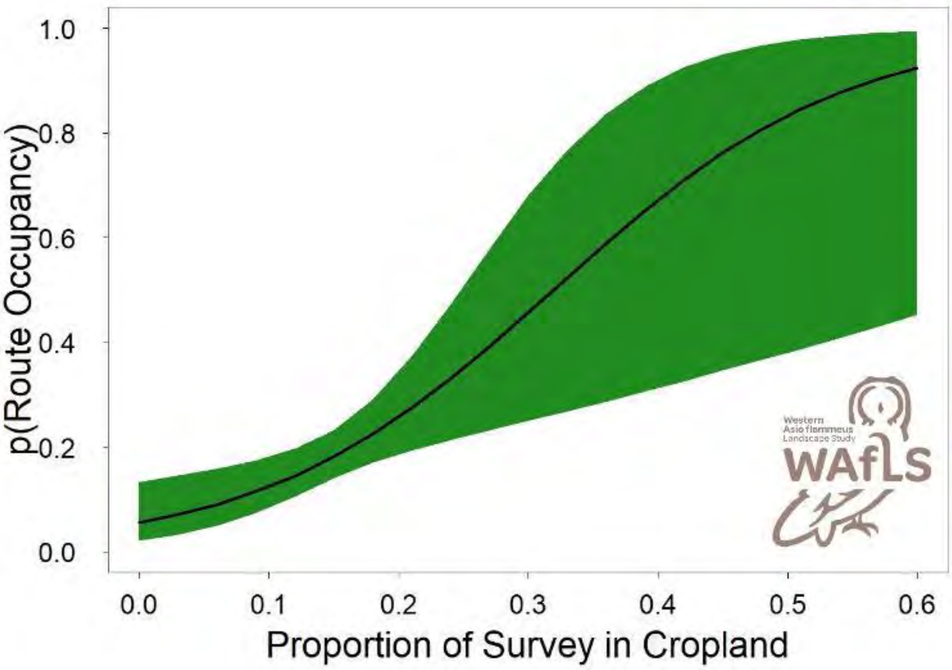

Figure 7. Model averaged predictions generated from multi-scale occupancy top model set for the effect size of the proportion of area within 1km of all surveyed points that is classified as cropland, influencing the probability of at least one Short-eared Owl occupying the survey area during the 2018 breeding season. Black line = model prediction; green area = 95% confidence interval.

The various states have participated in Project WAfLS for differing lengths of time, with Idaho being the longest. Calculated grid occupancy, a surrogate for abundance, shows occupancy rates for Idaho increasing since 2017, but still lower than 2015 and 2016 (Fig. 8). Estimated occupancy rates in Nevada similarly increased in 2018 as compared with 2017 (Fig. 8). Occupancy rates in Utah and Wyoming remained low, declining slightly by similar margins (Fig. 8). We generated first year occupancy rates in the other states.

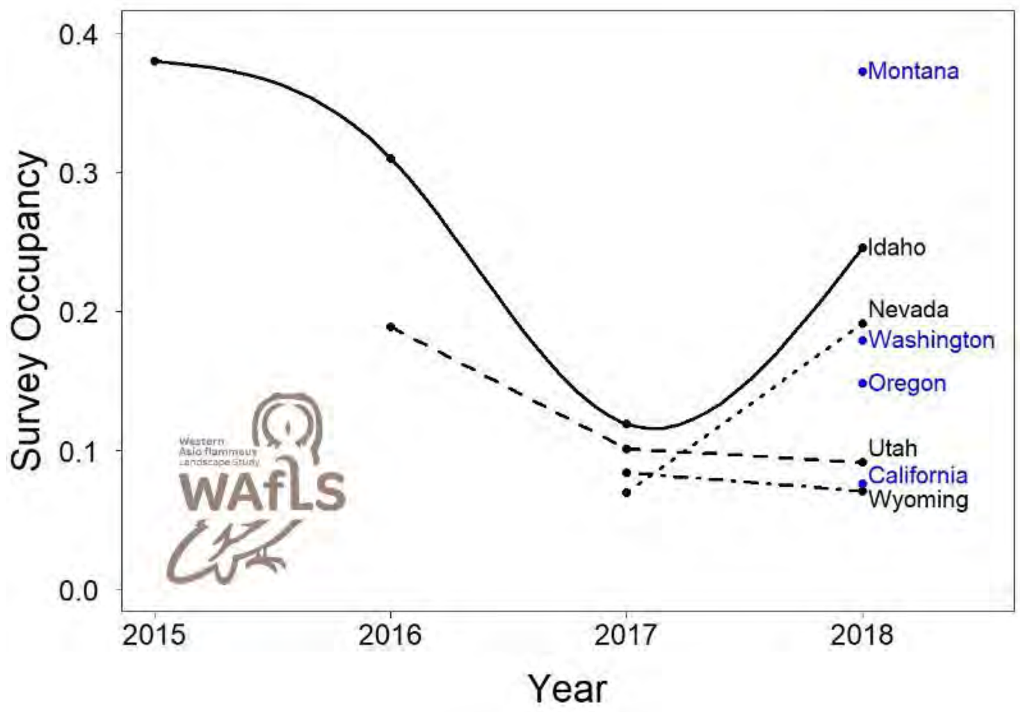

Figure 8. 2018 Estimated survey occupancy rates (surrogate for abundance) among the eight states with varying levels of historical participation.

Maximum Entropy Modeling

The top MaxEnt model as evaluated with AIC_c was a linear-quadratic-hinge model with regularization parameter 3.0 (LQH3). The regularized training gain for the LQH3 model built with all presence records was 0.34, and the Area Under the Curve of the receiver operating characteristic plot (AUC) was 0.78. From the jackknife test of variable importance, the single most important predictor variable, in terms of the gain produced by a one-variable model, was Mean Diurnal Temperature Range (worldclim.org bio_2), followed by Precipitation of Wettest Month (worldclim.org bio_13), Mean Temperature of Warmest Quarter (worldclim.org bio_10), Annual Precipitation (worldclim.org bio_12), and slope. Slope and Mean Temperature of Wettest Quarter (worldclim.org bio_8) decreased the gain the most when they were omitted from the full model, which suggests they contained the most predictive information not present in the other variables.

The effect sizes, direction, and shape of the climate variables implemented in the MaxEnt model varied among variables (Fig. 9). Note that the effect sizes as reported individually are exaggerated when multiple correlated variables are included in the analysis. Since the climate variables are correlated, attention should focus on the direction and shape of the curves and not the absolute values. Additionally, the effect sizes should be considered in aggregate, instead of too much individual attention.

Short-eared Owls within our study area were more likely found in locations where the temperature range, both daily and seasonally, is more restricted, annual temperatures are not too extreme (Fig. 9). With regards to precipitation, Short-eared Owls were more likely found in locations with comparatively higher annual precipitation, available throughout the year (not simply in the wettest month, but also in the driest month), but not too evenly spread (moderate seasonality; Fig. 9).

Regarding the geographic and habitat features, there was less correlation among prediction variables, so the interpretation was easier. We found that Short-eared Owls were more likely to be detected at lower elevations, but not the lowest within our study area (Fig. 10). Short-eared Owls appeared to favor cropland, shrubland, and marshland, over grassland environments, both monotypic cheatgrass and more complex grasslands (Fig. 10).

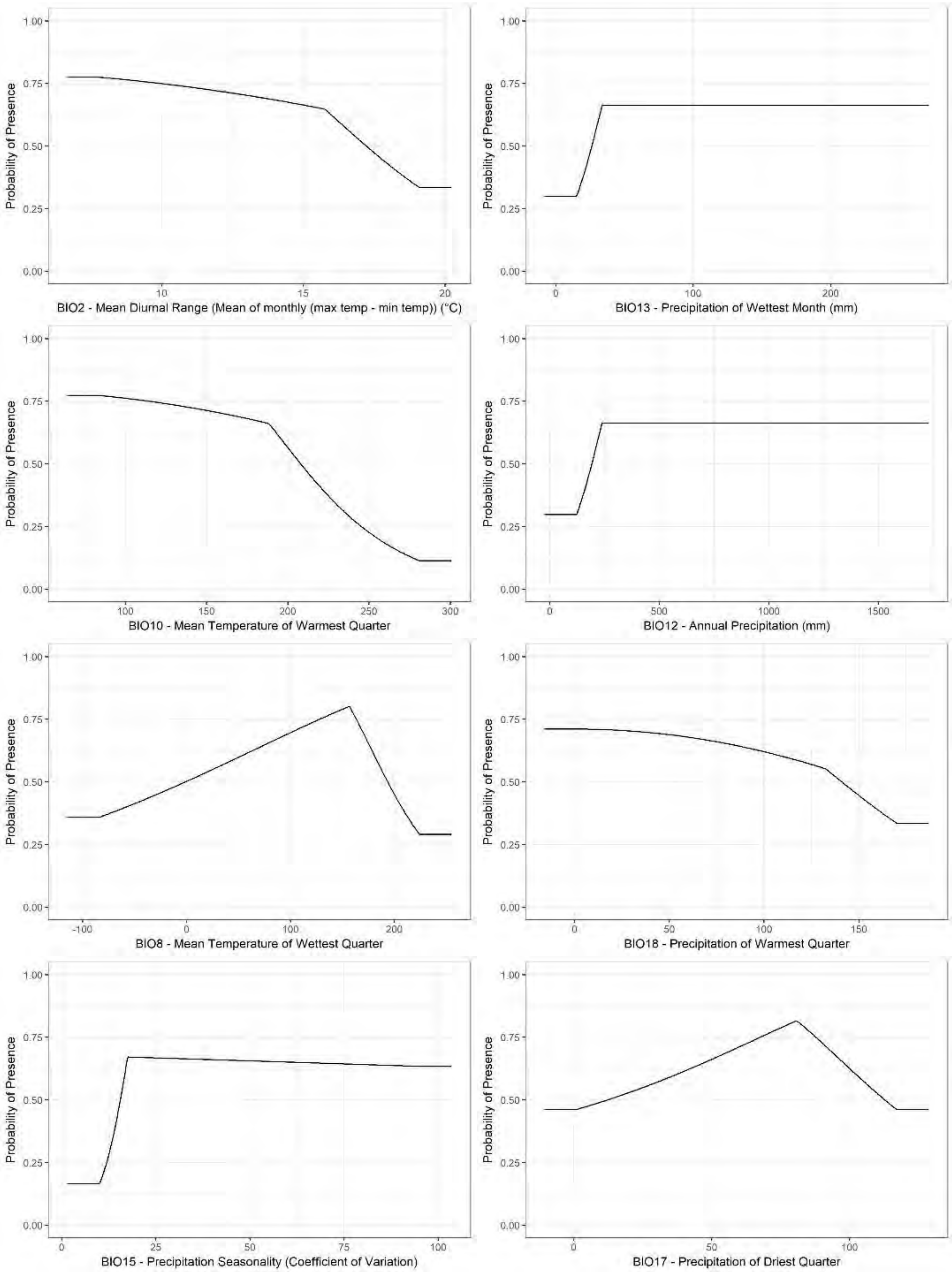

Figure 9. Response variable effect sizes for eight climate variables influencing Short-eared Owl presence, derived from MaxEnt model LQH3 using presence and pseudo-absence data from project WAFLS 2015, 2016, 2017, and 2018. Ranked in general relative importance. Note: effect sizes may be amplified as a result of including highly correlated variables such as multiple climate related variables.

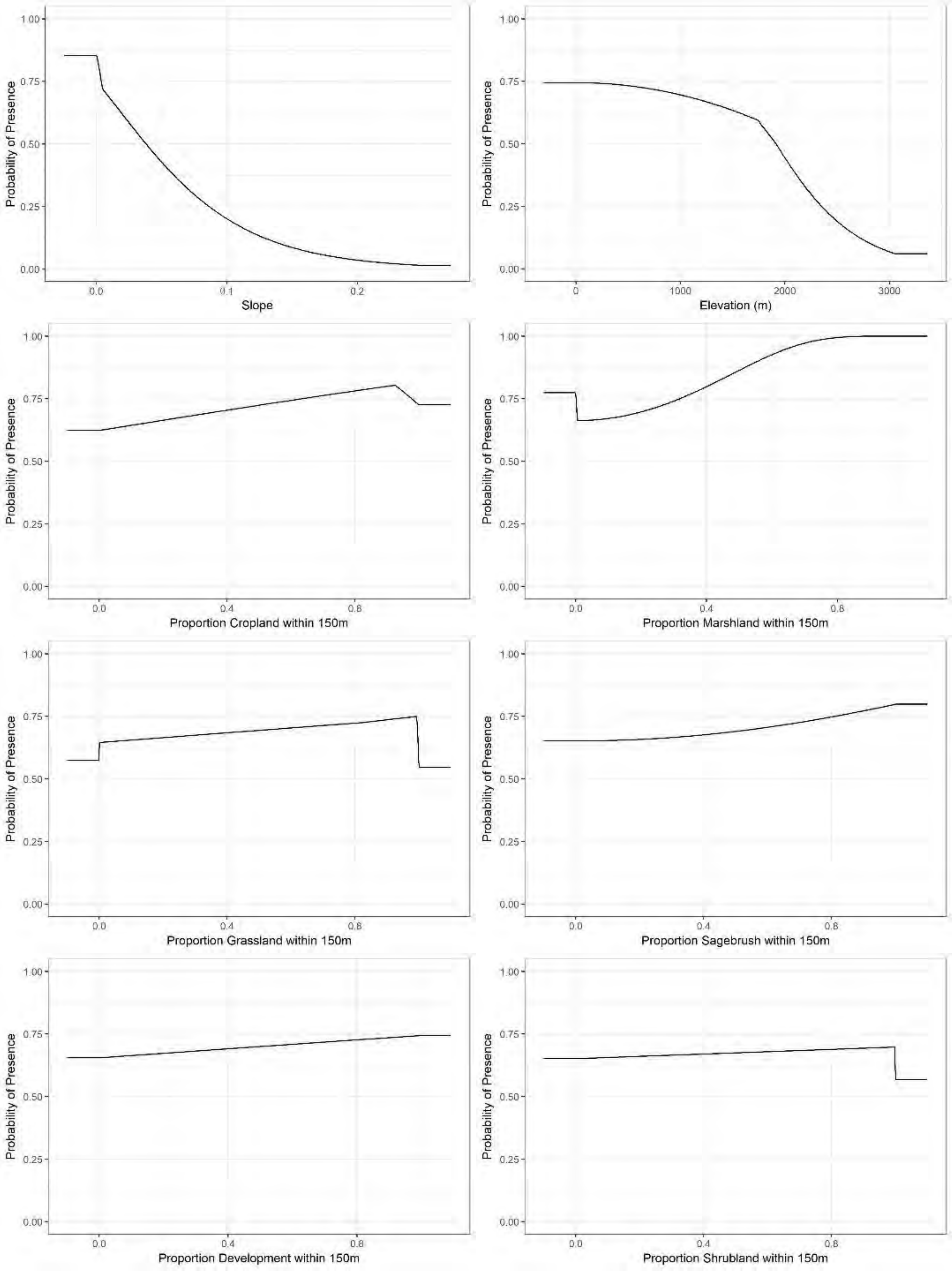

Figure 10. Response variable effect sizes for geographic and habitat features influencing Short-eared Owl presence, derived from MaxEnt model LQH3 using presence and pseudo-absence data from project WAFLS 2015, 2016, 2017, and 2018.

Using the full combination of climate, geographic, and habitat variables described in Figures 9 and 10, we were able to plot the likelihood of Short-eared Owl occurrence across the study area (Fig. 11). Furthermore, replacing only the climate variables within the model with future climate variable projections for the year 2070, we were able to project the future likelihood of Short-eared Owl occurrence across the study area (Fig. 11). This climate view is considered conservative as it assumes no change in land cover, only in climate. We expect the land cover to also change with a change in climate, which could make the change in likelihood of presence even more dramatic.

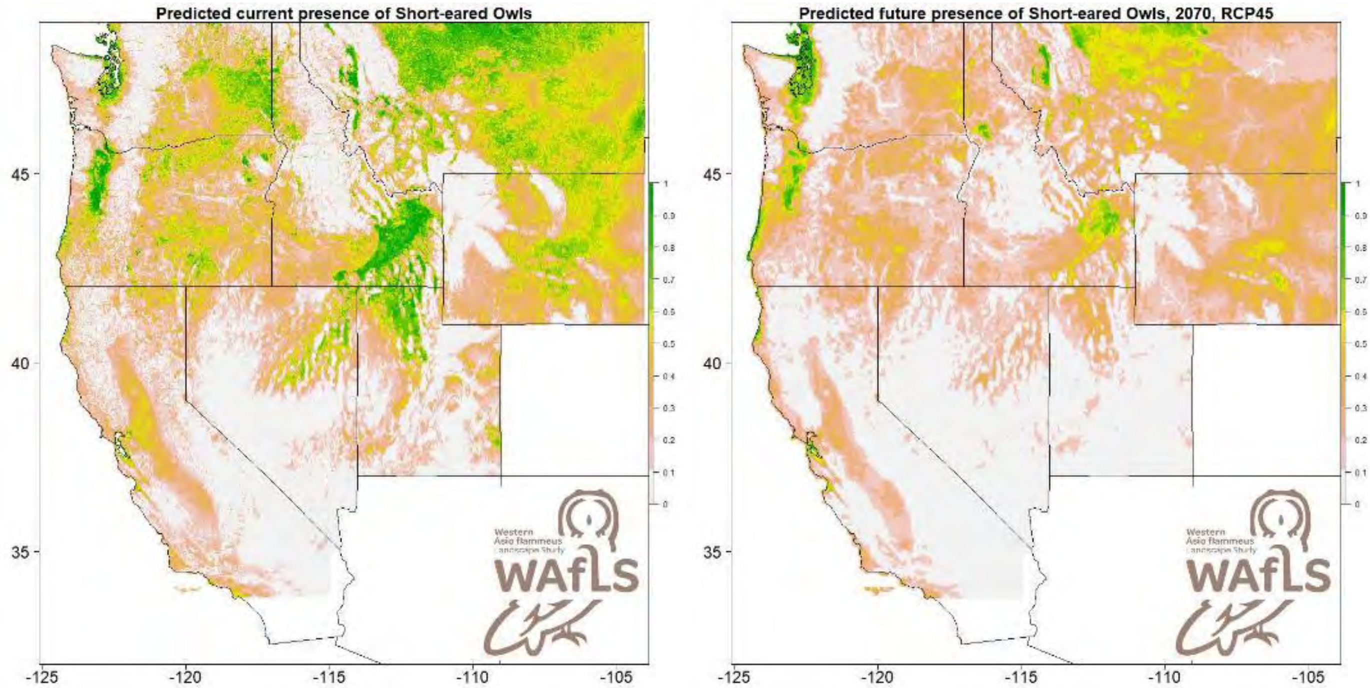

Figure 11. Study-wide predicted habitat suitability for Short-eared Owl presence, using current and future climate scenarios, derived from MaxEnt model LQH3 using presence and pseudo-absence data from project WAFLS 2015, 2016, 2017, and 2018. Future climate is projected to the year 2070 using the Representative Conservation Pathway 4.5 assumptions generated by Hadley Centre Global Environment Model version 2.

DISCUSSION

We successfully engaged a large group of participants, mostly citizen-scientist volunteers, to survey for Short-eared Owls across a broad geographic region in the western United State. The continued participatory expansion from four states to eight states further increased the strength of this study. We believe this to be the largest species-specific survey for Short-eared Owls in the world. The analysis identified important Short-eared Owl habitat associations, providing insight into which habitats in the region may be most important for conservation and further study. The results will be integrated in the various state-wide action plans to address the conservation concerns for this species.

The study is most informative in Idaho and Utah, the states that have been consistently surveyed for the longest period of time. With two years of data in Nevada and Wyoming, we can begin to see patterns of changes in these states, especially when augmented with the trends observed in Idaho and Utah. Equally important for the future, we now have initial occupancy estimates for the four newest states. We acknowledge a lack of understanding about expected patterns of occurrence or abundance of this species. Given their known irruptive behavior (Clark 1975, Korpimäki and Noordahl 1991, Wiggins et al. 2006, Booms et al. 2014), likely in response to changes in prey populations (Clark 1975, Korpimäki and Noordahl 1991, Johnson et al. 2013), the patterns that appear to be emerging in our data will likely change across the study area through time. Our hope is that this study will provide the framework for continued collection of data to support longer-term assessments of region-wide changes if they occur.

The predicted occupancy rates of the states point to the importance of long-term and broad geographic study of this species. The Short-eared Owl populations in Idaho and Nevada increased at similar rates from the low of 2017 (using Idaho as the standard). However, the occupancy rates in Utah and Wyoming continued to decline, by similar amounts but not as steeply as Utah dropped between 2016 and 2017. These shifts may be the result of population movements from the eastern states toward the western states or could be independent numerical responses resulting from conditions within the two states. Both theories are supported by the known biology of the species. Short-eared Owls are known to have low breeding site fidelity and be highly nomadic, enabling them to move across broad geographies to breed in areas with the most favorable conditions (Clark 1975, Korpimäki and Noordahl 1991, Wiggins et al. 2006, Booms et al. 2014). In addition, the species is known to be highly responsive numerically to prey availability (Clark 1975, Korpimäki and Noordahl 1991, Johnson et al. 2013). Wiggins et al. (2006) and Johnson et al. (2013) each suggest that consistent surveying over a time span exceeding multiple prey cycles is required before conclusions about trend estimation should be made.

Our multi-scale occupancy analysis provides insight into detectability of owls, local habitat preferences, and geographical habitat preferences. From a detectability perspective, our results are reasonably consistent with the known biology of the species and the challenges of observing and identifying birds near dusk. Detectability is defined as the probability of identifying at least one owl given that there is at least one present. We see this rate declining later in the season. This is likely the result of fewer courtship flights after nesting has begun. Our results show that detectability peaks about 90 minutes before the end of civil twilight and decreases as we approach darkness. In general, we would predict owl activity to increase over this time period, increasing detectability, but low light conditions make it more difficult to positively identify owls at a distance. Our 2018 results are consistent with our 2016 results, but in 2017 we had an opposite effect of survey time, suggesting that there are likely other important factors related to this timing. Increasing wind decreased detectability in our study. We expect this is the result of dual forces - decreased owl activity in windy conditions and decreased observer effectiveness in windy conditions. Wind has been a strong negative factor on detectability for every year of our study and why we emphasize to participants to choose the calmest conditions possible. The greater the alignment of our results with the known biology of the species, the higher confidence we have in the overall occupancy estimates. These detectability estimates provide strong support for the overall model.

The middle level of our occupancy analysis estimates the factors influencing an owl to occupy a survey point given that there is at least one owl somewhere on the survey. We found a very strong correlation of owls with stubble agriculture with occupancy rates nearly doubling when stubble agriculture was present. Stubble agriculture was similarly selected in our 2016 study, but narrowly missed as a top predictor variable in the 2017 model. Grazing once again influenced point-scale occupancy in our models. Similar to 2017, the response showed some tolerance to grazing as long as it was not pervasively surrounding the point. However, the effect was more negative at higher levels of grazing in 2018 than in 2017. Our 2018 results are more consistent with the results of Larson and Holt (2016) who found a strong negative association with grazing. This dovetails nicely into our partner program evaluating specific impacts of various grazing regimes on Short-eared Owl occupancy. This partnership with the Grouse and Grazing project led out of the University of Idaho, is a manipulative landscape study expected to provide high-resolution measurement of the sensitivity, or lack thereof, of Short-eared Owls to various grazing practices. Results of that effort will be presented elsewhere.

At the highest level of our occupancy model we found that cropland was the top cover type predictor of Short-eared Owl occupancy on the survey. However, only stubble agriculture was chosen at the point scale and we seldom found stubble agriculture in high abundance. This may suggest that a combination of agriculture types and agriculture combined with non-agriculture may be preferred by this species. Agricultural lands may provide higher prey density (Moulton et al. 2006), attracting owls to occupy these areas over more native landscape or may compliment the advantages of native landscapes.

The Maximum Entropy modeling was chosen as a more effective way to make predictions based upon habitat associations. MaxEnt models can deal with many highly correlated variables such as climate variables and habitat variables influenced by climate. MaxEnt modeling is generally more comprehensive in its variable selection, allowing a more complex set of variables that more closely resemble the complexity of the study area. This is evidenced by the 28 variables that we report on as compared to the more limited set passing the threshold in our occupancy models.

The climate data included in the MaxEnt analysis allowed us to explore the risk to this species of predicted climate change. The predicted distribution of Short-eared Owls is projected to significantly decrease over the next 50 years and the decrease is predicted to occur in all states participating in this program (Fig. 11). The variables chosen and their impacts clearly illustrate this risk. The owls are associated with habitats where precipitation occurs throughout the year with only a moderate level of seasonality, and the temperatures are not too warm. Climate predictions for our region suggest that annual precipitation may remain constant or slightly increase, but when that precipitation occurs during the year is expected to shift. Seasonality is predicted to increase with summers continuing to become drier. This is the primary factor influencing the range contraction illustrated in the future study-wide predictions. It is worth emphasizing that the climate projection we used (RCP4.5) is a conservative model based upon assumptions that the world significantly reduces greenhouse gas emissions. The current trajectory of gas emissions would produce a much less optimistic future for the owls than the fairly negative prediction that we present.

The habitat components of the MaxEnt models suggest a positive association with shrubland, cropland, marshland, and grassland. In the case of cropland, grassland, and shrubland, the probability does drop off when the composition reaches 100% of those classes, supporting our earlier observation that they may favor diverse landscapes. In many parts of its range, the Short-eared Owl is considered a grassland species (Clark 1975, Holt et al. 1999, Swengel and Swengel 2014). However, much of the Intermountain West has been converted to invasive cheatgrass (*Bromus tectorum*) and other invasive annual plants (West 2000). Swengel and Swengel (2014) note that in the Midwest, Short-eared Owls most often nest in large areas of contiguous grassland, with heavy litter or “rough grassland”. The structure of the grassland in their study is quite different from the more homogenous, low litter grass found in invasive grasslands in the Intermountain West. Short-eared Owls in other studies appear to occur less often in landscapes similar to the invasive grasslands of the West (Clark 1975, Fondell and Ball 2004). In the Intermountain West, shrubland habitats usually provide more structural complexity than grasslands, which may explain the association of the owls with this primary habitat type in our area. However, because much of the Intermountain West has been converted to invasive grasslands, and these are lumped together with native grasslands within our chosen Landfire classification system, the importance of intact, native grasslands may be masked by the overwhelming presence of invasive grasses within our study area. We will work to better distinguish these classes in future analyses.

Another surprise from the model is the slight positive association with development. In our current modeling, all development, from a farmhouse and barn to an urban or suburban landscape, is grouped together. Yet, we are only really surveying the more rural development. Thus, the prediction may over emphasize the viability of owls in those suburban or urban landscapes. We will continue to work to distinguish these habitat types in future analyses.

The association with agricultural lands could be the result of a number of factors or combination thereof. Agricultural lands may provide higher prey density (Moulton et al. 2006), attracting owls to occupy these areas over more native landscape. Some agricultural lands may also provide plant structure more similar to the owl’s native prairie landscape that they use in the Midwest. As our surveys were limited to roads and many of the roads were built to support agriculture, we may not have adequately sampled undisturbed natural habitat (Gelbard and Belnap 2003), which is becoming increasingly rare in the region. Conversely, owls could be pushed to agricultural lands as a result of habitat degradation occurring in the non-agricultural landscape as a result of cheatgrass invasion, development, and fire (West 2000, Fondell and Ball 2004).

Our study had several potential sources of bias, which was one reason we performed multiple analyses. Potential sources of bias that could have increased our occupancy estimates included placement of the survey route along the best habitat within the grid, misidentifying species (e.g., counting a distant Northern

Harrier or a Barn Owl as a Short-eared Owl), and identifying owls further than 1km from the survey point. Potentially biasing our results lower included not detecting birds less than 1km due to obstructions or local landscape relief, not sampling the areas that fell outside of our stratum (e.g., grids with only 68% of target habitat instead of >70% target habitat), and the potential influence of road based surveys. Roads enable land use that can result in fragmented landscapes which have been shown to have a negative association for Short-eared Owls in the Midwest (Swengel and Swengel 2014). Additionally, Short-eared Owls could be negatively affected by road noise, which has been shown for other avian species (e.g., Ware et al. 2015). As these biases act in opposite directions, and we have invested significantly in training to remove the biases, we trust that the resulting bias is less than the width of our confidence intervals.

This project was only viable with the generous support of our participant base (mostly volunteers, but many partner organization employees). However, the volunteer base was likely the largest variance introduced to our project. The skill set of our volunteers ranged from expert to beginner. We emphasized training during the project, but volunteers were not evaluated on their skills; a process more often performed on professional surveys. However, checking datasheets for quality and completeness confirmed that most of our volunteers were very diligent in completing the assigned tasks, very often exceeding the detail provided by professional biologists. The biggest unknown we had pertained to the correct identification of Short-eared Owls. We provided training materials for proper identification and emphasized to volunteers to only record owls that they were certain were Short-eared Owls, as our methods were more robust to false negatives. Within our study area, the Long-eared Owl and Northern Harrier would be the most likely species' to confuse with a Short-eared Owl. We focused on that distinction within our training materials. In an effort to mitigate species confusion, we asked volunteers to record the number of Long-eared Owls and Northern Harriers, and to record the number of birds that they believed to be Short-eared Owls, but could not fully confirm. Our volunteers reported 131 instances of possible Short-eared Owls that could not be fully confirmed, suggesting that we were effective in mitigating this risk. As with most programs, quantifying the magnitude of the bias from each factor is not feasible. We do believe that these biases have been managed as best as possible within the program and that the actual population and effect sizes fall well within our confidence intervals.

Our study has primarily focused on the landscape and land cover aspects of Short-eared Owl presence. However, there are a number of threats that Short-eared Owls face, some of which our teams have observed directly, although typically not in association with surveys. This may not represent a comprehensive list, but each has been observed in our study area by WAfLS participants.

Agricultural practices. Our data indicate a positive association between Short-eared Owls and stubble fields. These stubble fields are often tilled during the nesting season for Short-eared Owls. We know of a few instances of fields with known nests being tilled. We have not quantified this threat but believe it to be widespread, although it is unknown if these practices impact the population.

Vehicle strikes. Vehicle strikes are potentially a huge concern for the conservation of this species. Our teams have documented more than 120 such collisions over the past few years. These collisions often occur on straight, flat backroads with little traffic. Some of our mortality hotspots include northern Utah around the Promontory, Howell, Faust Valley, and Snowville areas, and in southern and eastern Idaho northwest of Mud Lake and south of Malta. In a long-term study of Barn Owl mortality along I-84 in southern Idaho, very few Short-eared Owl carcasses were found suggesting that Short-eared Owls may avoid the higher traffic areas (pers. comm. J. Belthoff).

One of 33 dead Short-eared Owls documented in June of 2016 by four-year Project WAfLS volunteers Don and Sheri Weber, northwest of Mud Lake, Idaho

Fence collisions. Collisions with barbed-wire fences is a known threat for Short-eared Owls and other shrubland species. Our teams have documented two mortalities, one in Utah and one in Wyoming, and one injury resulting in a non-releasable rehabilitated bird. We suspect it occurs more often than reported

Short-eared Owl caught on barbed-wire fence, Wyoming (photo by two-year Project WAfLS volunteer, Tina Toth)

Rodenticide. A possible additional source of direct mortality, or indirect mortality contributing to fence or vehicle collisions, is poisoning, particularly by rodenticide. In a California study of raptor mortalities, Kelly et al. (2014) found high levels of ingested rodenticide even when the final cause of death was the result of collisions. In a similar study in Massachusetts, Murray (2017) found a high proportion of raptors had ingested rodenticide. Abernathy et al. (2018) found rodenticide in the blood of migrating raptors in California. Consequently, the Pacific Flyway Council identified addressing rodenticide impacts on raptors as a priority for their Nongame Technical Committee (Pacific Flyway Council 2015). So far, we have tested two Short-eared Owl carcasses collected along roadways (one from Idaho and one from Utah) for rodenticide and both have tested negative. We will look to test additional carcasses.

We will continue to monitor these threats, as opportunity allows, and attempt to investigate the population level impacts of the mortalities that do occur.

We were successful in meeting all of our objectives utilizing a largely volunteer labor force. We suggest that the use of a distributed volunteer labor force resulted in greater efficiency in survey coverage, resulted in more surveys completed, and ultimately resulted in a higher quality inference than would have occurred using only professional staff. In subsequent years we expect to continue promoting the use of citizen scientist volunteers and maintain the same basic structure of the 2015 – 2018 programs.

CONCLUSION

We successfully recruited a large group of volunteers to sample a broad geography within the western United States for Short-eared Owls during the 2018 breeding season. Our results identified specific habitat associations, confirming that habitat use may vary regionally. Our occupancy rates provide a great surrogate for abundance and provide a good comparison for further studies to identify and quantify any trends that may be occurring in the population. We have confirmed that our study design was sufficient to meet our objectives and will only require minor modifications moving forward.

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Appendix I: 2018 Survey Participants

Sorry if we missed anyone…

Aaron Holmes, Aaron Skirvin, Abby Kirkaldie, Adam Henderson, Aden Barbuta, Adriene Holcomb, Aimee Vitateau, Airin Brown, Alex Higgins, Alex Welch, Alexa Armstrong, Alexandra Clifton, Ali Helmig, Alison Nevins, Allan Wylie, Allen Day, Amanda Culpepper, Amanda Holt, Ami Johnson, Amy Blossom, Amy Henderson, Amy Lyons, Amy Seaman, Andie Leuders, Andre Blewett, Andrea Kristof, Andrew Barbuta, Andrew Cliburn, Andrew Jacobson, Andrew Meyers, Andrew Mueller, Angel Correa, Angela Moran, Anika Mahoney, Ann Ratchanee Schoepp, Anna Martin, Annette Boyer, Annie Chang, Art Campbell, Ashleigh Pryor, Aspen Bird, Austin Young, Avery Kane, Azulite Rondeau, Bailey Harris, Barb Gonzalez, Barbara Kelly, Barry Swidler, Becky Lyle, Becky Riley, Ben Sweet, Ben Wishnek, Benjamin Hart, Beth Carpel, Bill McDougal, Bill Robertson, Billie Farley, BishGF, Blake Lamphear, Blake Marsters, Bob Fischer, Bob Tregilus, Bobby Jones, Bonnie Schonefeld, Boo Curry, Brad Henderson, Brandon Gonzalez, Brandon Rossi, Breezy Bird, Brenda Pace, Brett Bunkall, Brian Barber, Brian Fagundes, Brian Maxfield, Brian Miller, Brooke Langle, Brooke Stutz, Brooke Walcroft, Bruce Holt, Bruce Lawson, Bryan Fox, Bryan Hamilton, Bryan Lamont, Bryant Olsen, Buzz Hettick, Cameo Flood, Cari Medeiros, Carie Battistone, Carl Day, Carole Hallett, Cassandra Hughes, Catherine Hamilton, Catherine J. Flick, Cathy Schmidt, Chad Welch, Charlene Burge, Cheryl Huizinga, Cheyenne Stewart, Chris Allen, Chris Fichtel, Chris Howard, Chris Lyle, Chris Schafer, Christian Kessler, Christine Keil, Christine Lamphear, Christy Klinger, Christy Taylor, Cindy Hyslop, Cindy Marlow, Clarisse Landry, Clay Edmondson, Clay Rouse, Cody Byrne, Colby Chinn, Colleen Moulton, Colleen Trese, Collett Olson, Conner Parrish, Connie Holloway, Cordell Peterson, Cory Braastad, Courtney Duchardt, Craig Okraska, Craig Swolgaard, Cris Tomlinson, Cristian Sepulveda-Maldonado, Cynthia Swidler, Cynthia Wise, Damon Noller, Dan Herrig, Dan Stoken, Dan Thiele, Dana Nelson, Daniel George, Daniel Herrig, Daniel Kimball, Daniel Ryan, Dave Davis, Dave Keir, Dave Oleyar, Dave Pace, David Jensen, David Lehman, David Stankewitz, David Vanek, David Wheeler, Dawn Stryhas, Dean Goehring, Deb Drain, Deb Frankenberger, Deb McFarlane, Deborah House, Deirdre Young, Dena Santini, Denise Hughes, Derek Christensen, Diane Davis, Distel, Dixie Brackman, Don Bailey, Don Weber, Donald, Donna Whitham, Doug Hunter,Duantem Phuangsombat, Dustin Garrison, Dustin Terwilliger, Dylan Hopkins, Ed Jones, Eileen Oldag, Elaine Dale, Elizabeth OeDell, Elizabeth Traver, Ellie Armstrong, Emily Chilcoat, Emily Gonzales, Emily Young, Emma Hoskins, Eric Henze, Eric Payne, Eric Stewart, Erika Peckham, Erin Burgess, Erin Fairbank, Erin Flood, Erin Rentz, Erin Stacy, Erin Tennant, Ernie McKenzie, Ethan Chatwood, Ethan Ellsworth, Eva Alza, Evan Buechley, Evan Heisman, Evan Myers, Farrah Rawlins-Petrasek, Fiona Petersen, Frank Jenks, Frank Stetler, Fred Parent, Gared OeDell, Garrett Moss, Gayle B. Poorman, Geniel Simpson, Geoff Grisdale, George Gerdts, Glenn DeVoe,Grant Frost, Gray, Grayson Carlile, Greg Cameron, Greg Carter, Gregory O'Connell, Gretchen Albrecht, Gretchen Vanek, Gwyn McKee, Hailey Pexton, Hayley Calvert, Heather Dove, Heather Nenninger, Helen Harrington, Herb Haley, Hilary A. Turner, Hilde Hamilton, Hunter Nelson, Hunter VanDonsel, Ivana Turner, Izzy Guzman, Jagdeep Deol, Jake Flood, James Castle, James Taylor, Jamie Acker, Jan Walker, Jane Brandt, Jane Van Gunst, Janene Willer, Jared Power, Jason Fidorra, Jason Finkle, Jason Sparks, Jason Sutter, Jazmyn McDonald, Jean Ragland, Jean Robinson, Jeff Crenshaw, Jeff Fleischer, Jeff Frankenberger, Jeff Hallett, Jeff Jones, Jeff Schwilk, Jeff Thompson, Jefferson Anderson, Jen Langevin, Jenni Jeffers, Jennifer Brown, Jennifer Clark, Jennifer Olson, Jeremy Ditto, Jeremy Jirak, Jeremy Telford, Jeremy Welch, Jeri Wood, Jesse Gomez, Jessica Holt, Jessica Van Woeart, Jill Wyatt, Jim Destaebler, Jim DeWitt, Jim Dowling, Jim Francis, Jim Sparks, Jim Spencer, Jim VanArk, Jimmie Yorgensen, Joanie, Joanna Kane, Jody Barbuta, Joe Kipphut, Joe Sandrini, Joel Boros, Joel Turner, John Hamilton, John Harlin, John Herrera, John Lockenvitz, John Meriwether, John Morris, John Schijf, John Westenhoff, John Young, John Young III, John Young Jr, Jon Nystrom, Jonathan Berman, Jordan Straley, Joseph Belli, Joseph Dane, Joseph Savage, Josie Gray, Joyce Hopkins, Joyce Perkins, JP Cavigelli, Judeen Theis, Judi Zuckert, Judy Bendix, Judy Tsiang, Julia Curtis, Julie Eakin,Julie Furber, Julie Hall, Julie Howar, Julie McKinnon, Julie Newman, Kade Olson, Kailea Rasmussen, Kaitlyn Green, Karen Antell, Karen Leibert, Karen Mulcahey, Karen Steenhof, Karen Yates, Kari Prassack, Kasia Crabiec, Kate Grandison, Kate Keiser, Kate Koughan, Kate Owens, Kate Yates, Katharine Cook, Katherine Thompson, Kathleen Rittle, Kathy Bradshaw, Kathy Cadigan, Kathy Griffin, Kathy Lopez, Kathy McCarthy, Kathy Paulin, Katie Guntly, Katie Knox, Katy Savage, Kaycie Adams Deem, Keeli Marvel, Keith Bagnall, Keith Rittle, Kellie Carter, Kelly Keenan, Ken Harris, Ken Olson, Ken Plourde, Kendra David, Kenna Holt, Kenneth P. Able, Keo Markwell, Kevin Hintze, Kevin Ward, Kiauna Canada, Kim Brandt, Kim Quayle, Kimberli Conrad, Kole Stewart, Kris Day, Kris Singletary, Kristen Lynch, Kristin Howard, Kristin Szabo, Kristin Telford, Kristin Terwilliger, Kristina Smucker, Kyle Ebenhoch, Kyra Walton, Lana Taylor, Lara Enders, Lara Sparks, Larry Hyslop, Laura Cotts, Laura Guptill, Laura Lockhart, Laura Mahrt, Lauren Connell, Lauren Sopata, Lauri Taylor, Laurie Averill-Murray, Leah Lewis, Leah Richardson, Lee Knox, Leslie Koenig, Leslie Nelson, Leslie Rouse, Levi Souza, Libby Burtner,Linda Hanson, Linda Tunnell, Lindsay Hooker, Lindsay Messett, Lindsey Lesmeister, Lindsey Smith, Lisa Cox, Lisa Jasumback, Lisa Trankley, Liz Taylor, Lori Nussbaum, Lourdes Cameron, Luis Alza, Lynn Gemlo, Lynn Goddard, Lynne Kelly, Mackenzie Jeffress, Maggie Jones, Maggie Wright, Makensie Forsyth, Mara Burstein, Marcia Kamin, Margaret LaFaive, Marian Eason, Marilyn Olson,Marilyn Wright, Marjorie Chase, Mark Chynoweth, Mark Dale, Mark Enders, Mark Jasumback, Mark Matheny, Mark Owens, Mark Whitham, Marsha White, Martin Edwards, Martin Hicks, Mary, Mary Maj, Mary Pendergast, Mary Pitz, Mary Williams,Mary Wylie, Matt Howard, Matt Larson, Max Malmquist, Max von Zastrow, McKaden Manderbach, Meg Glaser, Meg Horner, Meg Tracy, Melinda DeVoe, Melissa Foster, Melissa Jensen, Melissa Nissonger, Melissa Odell, Meredith Geissinger, Merri Melde, Michael Chinn, Michael Frazier, Michael Hobbs, Michael Lesnik, Michael Mahoney, Michael R. Harris, Michelle Cepello, Michelle Cordier, Michelle Dewey, Michelle Jeffries, Mike Bogar, Mike Chesnut, Mike Kane, Mike King, Mike Lesnik, Mike Malmquist, Mike McDonald, Mike Santini, Mike Schijf, Mike Thorson, Mike Toth, Mike Yates, Moira Kolada, Molly Todd, Molly Wright, Monica Morales, Nancy DeWitt, Nancy Edmondson, Nancy Herms, Nancy Hoffman, Nancy Kiser, Nancy Light, Natasha Hadden, Neil Paprocki, Neysa Jensen, Nichole Rubeck, Nick Eason, Nick Todd, Norm Engeland, Norma Johnson, Norma Trefry, Orlando Hiller, Pam Knowles, Pat Nyquist, Pat Weber, Patricia Edwards, Patricia Hettick, Patrick Lynch, Patti Gregor, Patty Wise, Paul Miller, Paul Poorman, Pete Zimowsky, Phil Damm, Pine Irwin, Rachel Freund, Rachel Williams, Randa Tang, Randy Harrison, Randy Smith, Rebecca Bonebrake, Rebecca Galloway, Rebecca Heisman, Rebecca Ward, Reid Olson, Rhett Boswell, Richard Nelson, Rick Rottman, RJ Baltierra, Rob Lowry, Rob Shipe, Robbette Schmit, Robert Burdick, Robyn Smith, Rochelle Renken, Roger Baker, Roger Perkins, Ros Bass-Fournier, Rosalie Salisbury, Rose Leach, Rosie Yacoub, Roy Averill-Murray, Russ Humphrey, Russ Lawrence, Ryan Byrnes, Ryan Greenberg, Ryan Karren, Ryan Williamson, Sally Friou, Sam Phillips, Sarah Chatwood, Sarah Harris, Sarah Owens, Sarah Thomas, Scott Farkas, Scott Gibson, Scott Hardage, Scott Heidebrink, Scott Ramos, Sean Young, Shaila Hood, Shannon Gonzalez, Sheri Weber, Sherree Sheide, Stacy Cepello, Stephanie Danyi, Stephanie Winters, Stephen Chase, Steve Antell, Steve Davis, Steve Flood, Steve Heinrich, Steve Marx, Steve Smith, Steve Williams, Steve Yates, Steven Baker, Steven F. Kahl, Stewart Fletcher, Sue Braastad, Susan Burchardt, Susan Cooper, Susie Carlson, Suzanne McDougal, Suzi Holt, Tana Hunter, Tanner Pearson, Tanya Davalos, Tayton Gerlach-Duby, Ted Williams, Terri Pope, Terry Crawford, Thea Yacoub, Theodore Rittle, Theresa Gulbrandson, Thi Markwell, Thomas Boyer, Tia Adams, Tim Bowden, Tim Demers, Tina Blewett, Tina Toth, Todd Caltrider, Tom Neale, Tom Pehrson, Tommy Thompson, Tonya Kieffer, Tori Steely, Tosca Humphrey, Toyia Hatten, Trevor Welch, Troy Achterhof, Troy Fieseler, tubne, Tyler Boston, Vanessa Wall, Vern Tunnell, Veronica Young, Vicki Allen, Vicki Olson, Visnja Turner, Vivian Schneggenburger, Wallace Keck, Wayne Crawford, WD Robinson, Wendy King, William Gonzalez, Willow Bish, Zachary Kermitz, and Zenn Hamilton.

Appendix II: 2018 Participant Affiliations

American Eagle Research Institute, American Prairie Reserve, American River College, Audubon Society - Bristlecone Chapter, Bird Conservancy of the Rockies, Birding in Utah, Birds of Prey NCA Partnership, Blue Mountain Audubon Society ~ Walla Walla, Bureau of Land Management, Bureau of Land Management - Ely District, California Department of Fish and Wildlife, California Natural Diversity Database, Central Oregon Community College, City of Rocks National Reserve, Crane Hill Birders, Department of Defense, Earthspan.org, East Cascade Audubon Society, Eastern Oregon University, Five Valleys Audubon, Friends of Great Salt Lake, Friends of Nevada Wilderness, Golden Eagle Audubon Society, Great Basin Institute, Great Basin National Park, Great Plains Wildlife Consulting, Inc, Great Salt Lake Audubon, Hawk Watch International, Idaho Birding, Idaho Department of Fish & Game, Idaho Department of Parks and Recreation, Idaho Master Naturalist, Idaho Master Naturalist - Deer Flat Chapter, Idaho Master Naturalist - Henry's Fork Chapter, Idaho Master Naturalist - McCall Chapter, Idaho Master Naturalist - Snake River Chapter, Idaho Master Naturalists - Sagebrush Steppe Chapter, Idaho Master Naturalists - Upper Snake Chapter, Inland NW Birders, Intermountain Bird Observatory, Janelle Nolan & Associates Environmental Consulting, Klamath Bird Observatory, Laramie Audubon Society, LCSC Wildlife Society, McCormick Biological Inc, Moab Bird Club, Montana Audubon Society, Montana Fish Wildlife and Parks, Montana Master Naturalist, Murie Audubon Society, National Audubon Society, National Park Service, Nevada Department of Wildlife, Nevada Natural Heritage Program, Oregon Adopt-A-Lek Program, Oregon Birders Association, Owl Research Institute, Pacific Gas and Electric Company, Padre Associates, Inc., Point Blue Conservation Science, Portland Audubon Society, Prairie Falcon Audubon, Precision Wildlife Consulting, Psomas, Red Cliff Audubon Society, Red Desert Audubon Society, Sacajawea Audubon Society, Sacramento River Preservation Trust, Salt Lake Audubon, Sierra Club - Toiyabe Chapter, Sierra Foothill Conservancy, Snake River Audubon Society, Soil and Water Conservation Districts of Montana, Southwestern Idaho Birders Association, Stell Environmental - Yakima Training Center, Swaim Biological, Inc. , Terra Verde Environmental Consulting, Teton Raptor Centre, The Nature Conservancy, The Wildlife Society - Sac-Shasta Chapter, The Wildlife Society - San Joaquin Valley Chapter, The Wildlife Society - Western Section, Tracy Aviary, U.S. Air Force, United States Forest Service, University of Idaho, University of Wyoming, University of Wyoming Biodiversity Institute, Upper Snake Audubon Society, US Fish and Wildlife Service, US Fish and Wildlife Service - Bear Lake NWR, US Fish and Wildlife Service - Camas NWR, Utah County Birders, Utah Department of Transportation, Utah Division of Wildlife Resources, Utah State University, Wallowology Natural History Discovery Center, Wallowology Natural History Museum, Washington Department of Fish and Wildlife, Western Watersheds Project, Wild Utah Project, Wildlife Management Institute, Woodland Park Zoo, WOS, Wyoming Game & Fish Department, Yakima Training Center, Yosemite Area Audubon Society

Appendix III: 2018 Protocol

Western Asio flammeus Landscape Survey (WAfLS) Protocol

Protocol Version: 2018a

Equipment Needed:

1) GPS unit or Smartphone. We will use "decimal degrees" for all coordinates (e.g., IBO Offices are located at 43.605187°, -116.211022°). There are many free smartphone apps to provide you with GPS coordinates. Here are some suggestions:

> Android: "GPS Coordinates" app by Woozilli, Inc. It is free, easy to use and does not require cell service to operate. Decimal degrees shown by default.
>
> iPhone: Try "Current Altitude Free" from Hearn Apps, LLC.
> or: "Easy GPS" from 2kit consulting
> or: "Free GPS" from CodeBurners

2) datasheet and map
3) Civil twilight times for your grid (Please download from program website for official times)
4) clipboard (or hard surface to write on) and writing utensil (pen preferred)
5) binoculars
6) Stopwatch or clock to keep track of minute-by-minute intervals of the survey.
7) survey partner (optional… but its easier and more fun with two people; record # of observers)
8) This survey protocol (for reference)
9) Flashlight for reading datasheet at last point

Dates of Surveys:

Surveys should be conducted during the period of short-eared owl (SEOW) pair formation. These dates vary by state and by elevation so check the information for the grid you signed up for. Surveys must be done between these dates. Each survey route assigned to you should be surveyed twice during this period – once during the first 3-week visit window, and once during the second 3-week visit window. We prefer to have at least one week between the two visits, but this is not required.

Timing of Surveys:

Surveys should be conducted during the time of day when Short-eared Owl courtship is occurring and can be seen by a human observer. Therefore, surveys must be performed over 90 total minutes, between 100 minutes and 10 minutes before the end of **civil twilight** (later than sunset, defined to be when the sun is 6 degrees below the horizon) for the township you are in. We have created an online table for each survey route and date. Please look up survey start time and end time prior to leaving for your survey. These times are specific for your route and for your day of survey. If you survey outside of these times, we cannot use your data.

Weather:

Your survey should be completed during periods of good or fair weather. Clouds are fine, but you should avoid any steady rain or snow. Breezy conditions are also ok, but strong winds should be avoided. Previous survey results have found that detection rates of Short-eared Owls decrease with higher winds, probably due to observer effects and that wind may discourage owls from performing courtship flights.

Choosing Route:

If you are choosing your own route within a grid, please remember that you will need a five mile stretch of road, with as few turns as possible. The grids are 6.2 miles square, so your survey will need to span most of the grid. Choose a road with little traffic, where you can safely pull off of the road to survey. Choose a road with as much diversity as you can find (e.g., combinations of shrubland, grassland, and agriculture; the free Google Earth software is very useful for this). Zoomed in single grid maps are available on the portal. If uncomfortable with laying out the points, just ask your state volunteer coordinator for help. If your route includes a sharp turn, you will have to travel ¾ of a mile to the next point to ensure that the points are at least ½ mile apart. If you find that your route in inaccessible due to private land access, muddy roads, or other issues, just notify us. We expect to have a few failed routes. Unfortunately, we are not able to preview all routes across all states. Note: you will survey the same points on each of your two visits.

Mileage, Hours and Affiliation:
The datasheet asks for your total round trip mileage to complete the survey (estimates are fine). These are vehicle miles and are not duplicated per person. There are three fields, one for volunteers, one for miles being paid by a non-federal agency, and the last for miles paid for by a federal agency. State and federal employees may still be volunteers if they are on their own time and in a personal vehicle. We also want to know your total time investment (please include initial sign-up, studying, and preparation in your first visit, surveying, and data entry). Please add this up for all people participating (e.g., 2 people for 4 hours = 8 hours total). Hours are also split by whether the hours are volunteer hours or being paid by an agency (non-federal and federal). This will be used to report on the overall volunteer contribution. Affiliation refers to which birding, volunteer, or professional group(s) you heard about this opportunity through or participate in. This may include online groups. We want to recognize those organizations as well (e.g., Golden Eagle Audubon, Southwestern Idaho Birders, McCall Master Naturalists, Professional (BLM), Professional (IDFG), Idaho Birding, IBLE, …).

Survey Procedure:
Each survey consists of *at least* 8 observation points, spaced 800 meters (0.5 miles) apart, but may extend up to 11 survey points. Active surveying is performed at each point for 5 minutes. *Arrive at the first point at least 5 minutes in advance of the beginning of the survey to organize data sheets, record weather conditions, etc.* We also suggest visiting the points and collecting habitat data prior to the survey so to maximize the available time during the survey window.

1) Locate a start point of the survey (surveys can begin at either end of the established route) using a GPS unit or smartphone. There are many free smartphone applications that will provide you with coordinates. We will use "decimal degrees" for all coordinates (e.g., IBO Offices are located at 43.605187°, -116.211022°). Please record at least 5 digits to the right of the decimal point. This may require a settings change on your GPS or Smart Phone. Some units may report the longitude as 116.211022 **W** instead of **-**116.211022. That is fine, we will drop the "W" and add the "-" later.

2) Identify the best vantage point within approximately 50 meters of the survey point. This vantage point may be a slight mound off the roadway, or it may be the bed of your truck, or if terrain is relatively flat, it may be the roadway in front of or behind your vehicle. Wherever you end up, make sure you have a good view of the surrounding landscape. **Please do not survey from within your car and do not trespass on private land to gain an optimal vantage point unless you have explicit permission from that landowner!**

3) At the beginning of each 5 minute survey period, begin scanning the surrounding area, including ground and sky, for any SEOW presence. Surveys should be done using a combination of scanning with binoculars and scanning with the naked eye (and, of course, listening). All SEOW observations should be recorded on the data sheet. Best efforts should be made to avoid double-counting SEOWs within each 5-minutes survey, however, please note any observations at the next point if the bird is still visible.

For each Short-eared Owl detected, note how the bird was initially detected (sight or sound), which of the five minutes within the survey it was detected (indicate all minutes observed; e.g., a bird may be observed in the second, fourth and fifth minutes, but not in first or third – three checks), the general direction of the bird from your location (to nearest N, NE, E, SE, S, SW, W, NW), the estimated distance to nearest 200m (roadside power pole are roughly 100m apart), the behaviors observed, the sounds heard, and the type of habitat over which the bird was located. Only mark birds that are ***positively*** identified. If you are unsure, there is a separate area on the datasheet top record that.

How SEOW detected (sight/sound)	Minutes Observed (Check all ☑)					Initial Direction	Initial Distance ☑				Behavior (list all - perched, foraging, direct flight, agonistic, courtship)	Vocalizations/Sounds (list all - hoots, barks, screams, wing clip, bill snap)	Habitat where observed (shrub, grass, ag, marsh, other)
	1	2	3	4	5	N, NE, E,…	< 200m	200 – 400m	400 – 600m	> 600m			

4) When 5 minutes of survey at a point are complete, quickly finish recording SEOW observations, recalling and recording any other positive raptor identifications you made, record the habitat (if not done prior, spend no more than 1 minute), and travel to your next survey point – 800 meters (0.5 miles) down the survey route. If you must turn a sharp corner, then travel 0.75 miles to the next point. These points should be determined by simply driving 0.5 miles in your car (or 0.75 miles if you turned a corner), stopping, and determining the best vantage point within 50 meters of your vehicle. At least 8 survey points should be completed within the 90 minute period allotted, but complete as many as you can up to 11.

<u>Note:</u> To complete at least 8 survey points in 90 minutes, you will have approximately 7 minutes between survey points. This is a suggestion but not necessarily a requirement. It does not matter if you only take 6 minutes between one, and then take 8 minutes between another set of points, as long as at least 8 points are completed in the 90 minute window. If road conditions do not permit the completion of all 8 points in the 90 minutes allotted, just complete a many as you can.

5) The survey is complete after 90 minutes have elapsed since the first survey began. Again, if for some reason you were unable to complete 8 points in 90 minutes, please make a note of this in the datasheet. The provided online time schedules indicate start time and the latest time to begin a point for each survey grid. After surveys are complete, **review the datasheet for completeness**.

<u>Datasheet and Variables:</u>
The provided datasheet has blanks for all the required survey information. Below are guidelines for each variable.

Air Temperature – measured in degrees Fahrenheit (F), to nearest 5 degrees is fine.

Wind Classification – measured using the Beaufort Wind Scale at the start point only. If wind conditions change dramatically during the survey, please make a note of this. See scale below:

- 0 = Calm: smoke rises vertically
- 1 = Light Air: Smoke drift indicates wind direction, still wind vanes
- 2 = Light Breeze: Wind felt on face, leaves rustle, vanes begin to move
- 3 = Gentle Breeze: Leaves and small twigs constantly moving, light flags extended
- 4 = Moderate Breeze: Dust, leaves, and loose paper lifted, small tree branches move
- 5 = Fresh Breeze: Small trees in leaf begin to sway
- 6 = Strong Breeze: Larger tree branches moving, whistling in wires (<u>not recommended to survey</u>)
- 7 = Near Gale: Whole trees moving, resistance felt walking against wind (<u>not recommended to survey</u>)
- 8-12 = Gale – Hurricane (<u>DO NOT conduct survey in these conditions</u>): Twigs breaking off trees, generally impedes progress.

Cloud Cover Classification – measured at start point only. Classified as **cloudy** (100% cloud cover), **mostly cloudy** (50-99% cloud cover), **partly cloudy** (1-49% cloud cover), and **clear** (0% cloud cover).

Owl Behavior Classification – recorded at initial detection of each individual owl (i.e. if same individual owl is re-sighted, do not change the behavioral classification) classified as **perched, foraging, direct flight, agonistic, or courtship** (Holt and Leasure 1993).

Owl Vocalizations/Sounds – any sound produced by a Short-eared Owl should be classified as **hoots, barks, screams, wing clapping, bill clapping** (Holt and Leasure 1993).

Initial Direction – Record the general direction (e.g., N, NE, E, …) of where the bird was *first* detected.

Initial Distance – estimated distance to where the bird was first detected. This is rounded to nearest 200 meters. Roadside power poles are typically 100 meters apart. The categories are roughly less than 2 power poles, 2 – 4 power poles, 4 – 6 power poles, or greater than 6 power poles away. This is an estimate, so do you best but don't worry if it is not accurate. You can practice your distance estimation prior to the survey in case your route does not have power poles.

Habitat where owl observed – The general classification of habitat where the owl was initially observed. For example, the point habitat might be 90% shrubland and 10% riparian, but the owl was observed in the riparian vegetation. If the bird is flying, what habitat was it flying over when initially observed.

Vegetation Cover Classification – measured at *each survey* point. This should be recorded for each survey visit. For most points the values may not change, but agriculture could change from stubble to dirt if the field has been tilled since the last visit. This is a quick assessment. Do not spend more than about 1 minute determining habitat. If you prefer to be less rushed, you may travel the route prior to your survey to establish points and record vegetation (recommended!).

Record values to the nearest **10%**. Recorded as percentage of various land types within approximately 400 meters/yards (1/4 mile) of each survey point (half distance between points). Values should total to 100%. **Shrubland** may include grass, but is determined by at least a regular distribution of shrubs. Shrubland is split into two categories – **low** = knee height or shorter, and **high** = greater than knee height. **Grassland** may include a few shrubs, but there should not be many and should not be regular on the landscape. Grassland has two possible categories – **cheatgrass monoculture** (dominated by short cheatgrass), and **complex grassland** (taller grasses, bunch grasses, diverse species [may also include cheatgrass]) **Agriculture** is broken down into four classes including **fallow** (land has not been used for at least a few years and is over-run by grass, weeds, and shrubs), **dirt** (ground has been tilled to bare dirt or very short stubble, not high enough to provide shelter for mice or voles), **stubble** (last year's growth is still present and is at least a few inches tall – enough to provide some shelter and refuge for mice and voles), and **green** (new growth for this year). Pasture is considered agriculture and should be put into nearest agriculture category. **Marsh/riparian** indicates the presence of water, riparian vegetation, reeds, or cattails.

Examples:

Tall Shrub (Photo: Jimmie Yorgensen)	**Low Shrub** (Photo: Von Welch)
 **Cheatgrass Monoculture** (Photo: nature80020, Creative Commons License)	 **Complex Grassland** (Photo: BLM)
 **Agriculture – Green** (foreground, Photo: Elizabeth Burtner)	 **Agriculture – Dirt** (Photo: Elizabeth Burtner)
 **Agriculture – Fallow** (Photo: Rob Miller)	 **Agriculture – Stubble** (Photo: Rob Miller)

Marshland (Photo: Don and Sheri Weber)

Grazing and livestock – Does the habitat around the point look grazed (very short grass, trimmed shrubs, cow-pies etc.) and how much of the landscape appears grazed? If you are unsure, put zero. If animals are present, how much of the landscape do they have access to? Also, count the number of livestock within ¼ mile (it is ok to estimate of there are large numbers).

Other Observations – At the conclusion of each 5-minute point count, record the number of Long-eared Owls, Northern Harriers, Ferruginous Hawks, Burrowing Owls, or Long-billed Curlews seen or heard during the 5-minute point count. Please record the number observed, or zero if none were observed. A separate line is provided for any other raptors observed that were not specifically called out.

Data Submission:
We ask that you submit all data into the online data portal. This can be done after each visit of the survey (preferred) or after you complete both visits (two data submissions)

Please submit your data via the online project portal no later than **May 30th**.

THANK YOU, THANK YOU, THANK YOU for contributing to this project!

Preble's Meadow Jumping Mouse Recovery Goals

INTERIM REPORT, 2018

Prepared by:

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Prepared for:
Wyoming Game and Fish Department
Nongame Program

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Table of Contents

Introduction

Preble's meadow jumping mouse (*Zapus hudsonius preblei)* (Preble's hereafter) is found exclusively in riparian and adjacent upland habitats. The suspected range of the subspecies is restricted to the eastern slope of the Rocky Mountains from Colorado Springs, Colorado north to east-central Wyoming. Within its range, the availability of suitable riparian habitat is declining due to agricultural, residential, and commercial development. In 1998, Preble's was listed as Threatened under the Endangered Species Act. Subsequent actions by the United States Fish and Wildlife Service (USFWS) have modified details of the status and management of the subspecies. Currently, Preble's is listed as Threatened in Wyoming and Colorado. Management of Preble's is a high priority for management agencies but effective management has been complicated by taxonomic and distributional uncertainty.

The most recent and most widely accepted taxonomic paradigm regarding the taxon supports the subspecific designation of Preble's as a subspecies of meadow jumping mouse (*Z. hudsonius*). While these investigations have clarified taxonomic confusion to a degree, there remains considerable uncertainty about the distribution of the taxon, particularly in the northern part of its range. Specifically, *Zapus* in the North Platte River basin bear morphologic and genetic similarities to western jumping mouse (*Z. princeps*). It is unclear if individuals in this area are Preble's or western jumping mouse. Others suggest species-level hybridization.

In 2016, the USFWS issued a Draft Recovery Plan which includes recommendations for recovering the subspecies to the point where it can be removed from the Endangered Species List. The objective of the proposed study is to address goals highlighted in this plan. Specifically, the primary goal of this study is to identify three Preble's populations within each of three different Recovery Units in Wyoming that can be targeted for recovery actions by the Wyoming Game and Fish Department (WGFD) and USFWS.

Methods

Following the Draft Recovery Plan, we identified Recovery Units in coordination with WGFD in which to locate Preble's populations. Recovery Units are defined as 10-digit hydrologic units. We conducted live-trapping surveys in the Glendo Reservoir, Lower Laramie, and Horse hydrologic units in southeast Wyoming (Figures 1 and 2). Specific live-trapping sites were first identified using aerial imagery and then ground-truthed to ensure suitable habitat for Zapus existed.

We live-trapped small mammals in riparian habitats suitable for jumping mice between 6/13/2018 and 9/14/2018. All procedures followed methodologies laid out in the USFWS's "Prebles's Meadow Jumping Mouse (*Zapus hudsonius preblei*) Survey Guidelines" (2004). Additionally, all live-trapping and capture processing procedures followed guidelines for trapping and handling small mammals published by the American Society of Mammalogists (Sikes et al. 2011) and were approved by the University of Wyoming's Institutional Animal Care and Use Committee. We used foldable metal small mammal live-traps (Sherman live traps; H. B. Sherman Traps, Inc., Tallahassee, Florida) to capture animals. Traps were set and checked for four nights at each site. Traps were placed within 10 m of the high water mark of streams and arranged in transects with traps spaced approximately 5m apart. Each trap contained polyester bedding material and was baited with 3-way horse feed. Traps were opened at dusk and checked beginning at dawn the following morning. Captures were processed immediately at the site of capture. Traps were closed during the day so that no animals risked overheating inside traps during the day. Captured animals remained in traps until processed individually. All small mammal captures were released after processing at the site of capture.

To process small mammals, we gently shook each animal out of its trap into a heavy duty plastic bag with air holes, identified the individual to species (whenever possible), identified the sex, obtained mass, tail length, body length, and total length. We collected one minimally invasive tissue sample (i.e. ear punches) from all captured *Zapus*; ear punches were not obtained from other species captured (King et al. 2006, Sikes et al. 2011). Tissue samples were placed in microcentrifuge tubes filled with 95% ethanol. Once the animal was fully recovered and properly oriented, it was immediately released at the capture site.

Results

In 2018, we sampled seven sites across three hydrologic units (Table 1; Figure 2). We captured a total of 49 *Zapus*, including 35 unique individuals in 2018 (Tables 1 and 2). Genetic results from tissue samples collected from these individuals are pending analysis at the University of Nevada, Reno's Nevada Genomics Center. These data will inform us if captures belong to *Z. hudsonius* or *Z. princeps* and will be included in the final report submitted to the USFWS as soon as possible (Nixon et al. 2009).

Site Descriptions

Horse Creek: We surveyed the Horse Creek Site (Figure 3) from 6/13/2018 – 6/16/2018. The survey location was located near the headwaters of this small permanent creek where it is characterized by a fairly wide flood plain created by an extensive network of active beaver dams. Vegetation is comprised of dense tall grass and forb and relatively tall, dense willow. Portions of the transect occurred in early successional stage forest with aspen, ponderosa pine, Engelmann spruce, and subalpine fir.

Horseshoe Creek: We surveyed Horseshoe Creek (Figure 4) from 7/24/2018 – 7/26/2018. This site has moderately dense, moderately tall grass and forb cover in the understory. Dense willow and chokecherry line a narrow stream channel. The survey location is boarded by a major road to the east and there are a number of unmaintained two track roads and dispersed camping sites that create substantial surface disturbance.

Soldier Creek: We surveyed Soldier Creek (Figure 5) from 7/31/2018 – 8/2/2018. This site appears to be an ephemeral stream though with sufficient moisture to support dense riparian vegetation that supports Zapus. The riparian area is dominated by dense willow with tall, dense, grass and forb cover in open areas. A major road crosses Soldier Creek but it influence is fairly limited.

LaBonte Canyon: The LaBonte Canyon site was surveyed from 8/7/2018 – 8/10/2018 (Figure 6). We surveyed the South Fork of LaBonte Creek near its confluence with Big Bear Creek and LaBonte Creek. The South Fork of LaBonte Creek has a broad riparian area with a mixture of grasses and sedges and willows. The landscape in general is a mix of ponderosa pine forest and sagebrush steppe. There is a major road along LaBonte Creek and an ATV trail along Big Bear Canyon.

We surveyed at the Wyoming Game and Fish Department's Thorne Williams Research Center from 8/14/2018 – 8/17/2018 (Figure 7). Sybille Creek runs through the property creating suitable habitat for Zapus. The portion of Sybille Creek surveyed was characterized primarily by dense, tall grass with segments of the stream with willow and deciduous trees (e.g. boxelder, green ash, cottonwood). The area is heavily impacted by human structures including Highway 34, and numerous outbuildings and roads on the property. We were also informed by WGFD personnel that an adjacent landowner supports numerous feral cats which may predate upon small mammals in the area.

Johnson Creek: We surveyed Johnson Creek (Figure 7) from 9/4/2018 - 9/7/2018. The portion of Johnson Creek surveyed is located on the Tom Thorne / Beth Williams Wildlife Habitat Management Area. This area receives heavy human use and includes a small reservoir and associated infrastructure. However, this site was located upstream of the reservoir on a gated service road. The creek in general is a small permanent stream with dense, tall, grass and forb understory, dense willow and other riparian shrubs, and in portions cottonwood galleries. Surveyors noted high densities of prairie rattlesnakes which may predate upon small mammals including Zapus.

Brush Creek: We surveyed Brush Creek from 9/12/2018- 9/15/2018 (Figure 8). Brush Creek is a very narrow stream that only supports surface water in certain reaches along its length. Portions of the stream support active beaver dam complexes. The portion we surveyed was very narrow and contained dense, tall grass and sparse willows.

Conclusions

We located Zapus populations in five of the seven sites surveyed in 2018. This includes at least one population in each HUC. We plan to continue surveys in 2019 and plan to focus primarily in the Horse HUC. However, accessible sites with suitable habitat are limited. Genetic samples obtained from jumping mice will be analyzed and assigned to species. These data will then be used to update maps and assessments of *Zapus* in Wyoming currently presented in Bowe and Beauvais (2012). Populations of Preble's will be targeted for future management actions to promote recovery. These tasks directly address goals established in the draft recovery plan prepared by the USFWS in 2016.

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Figures

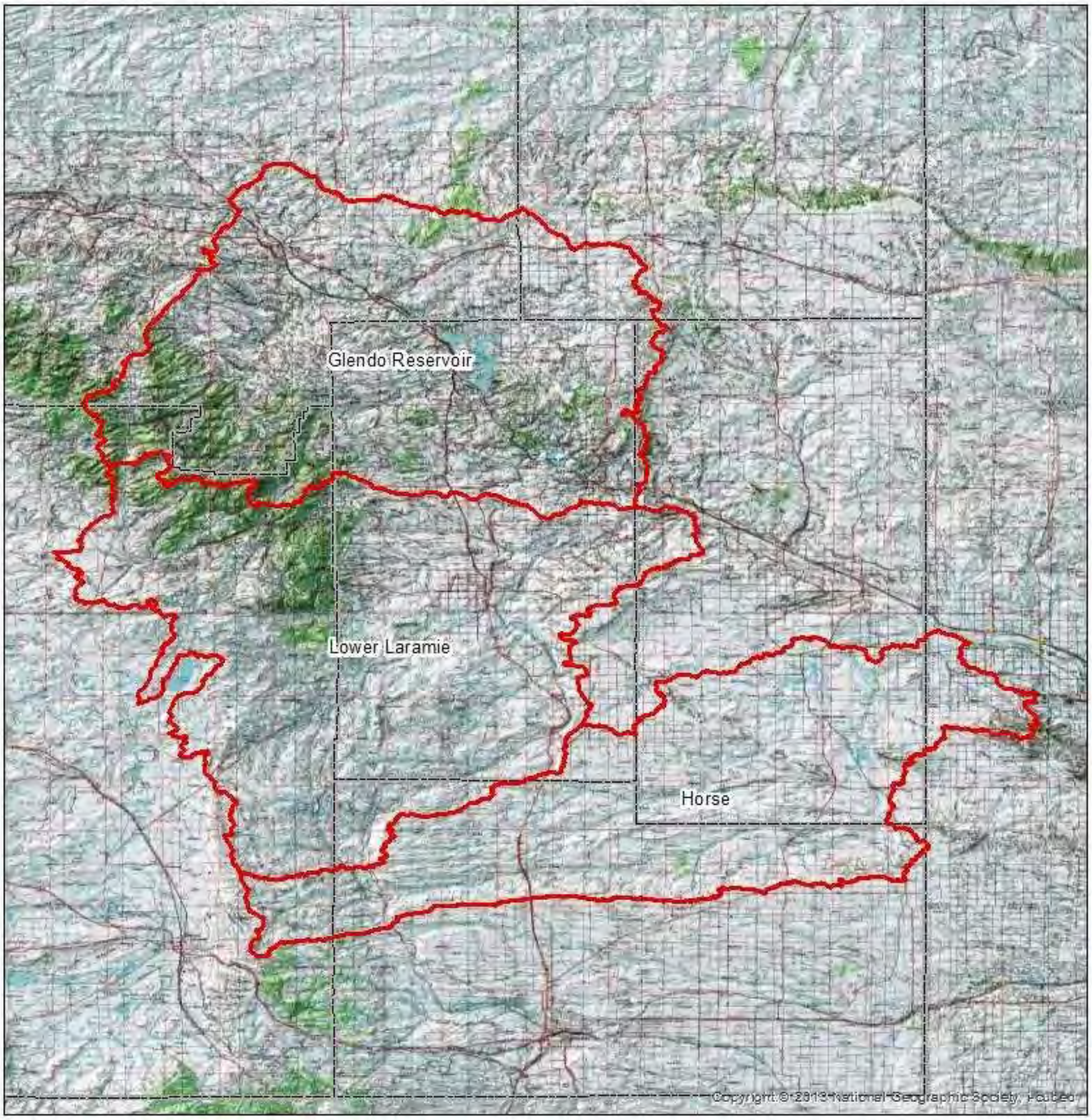


Figure 1. Hydrologic units in southeast Wyoming identified in the Draft Recovery Plan targeted for Preble's surveys in 2018.

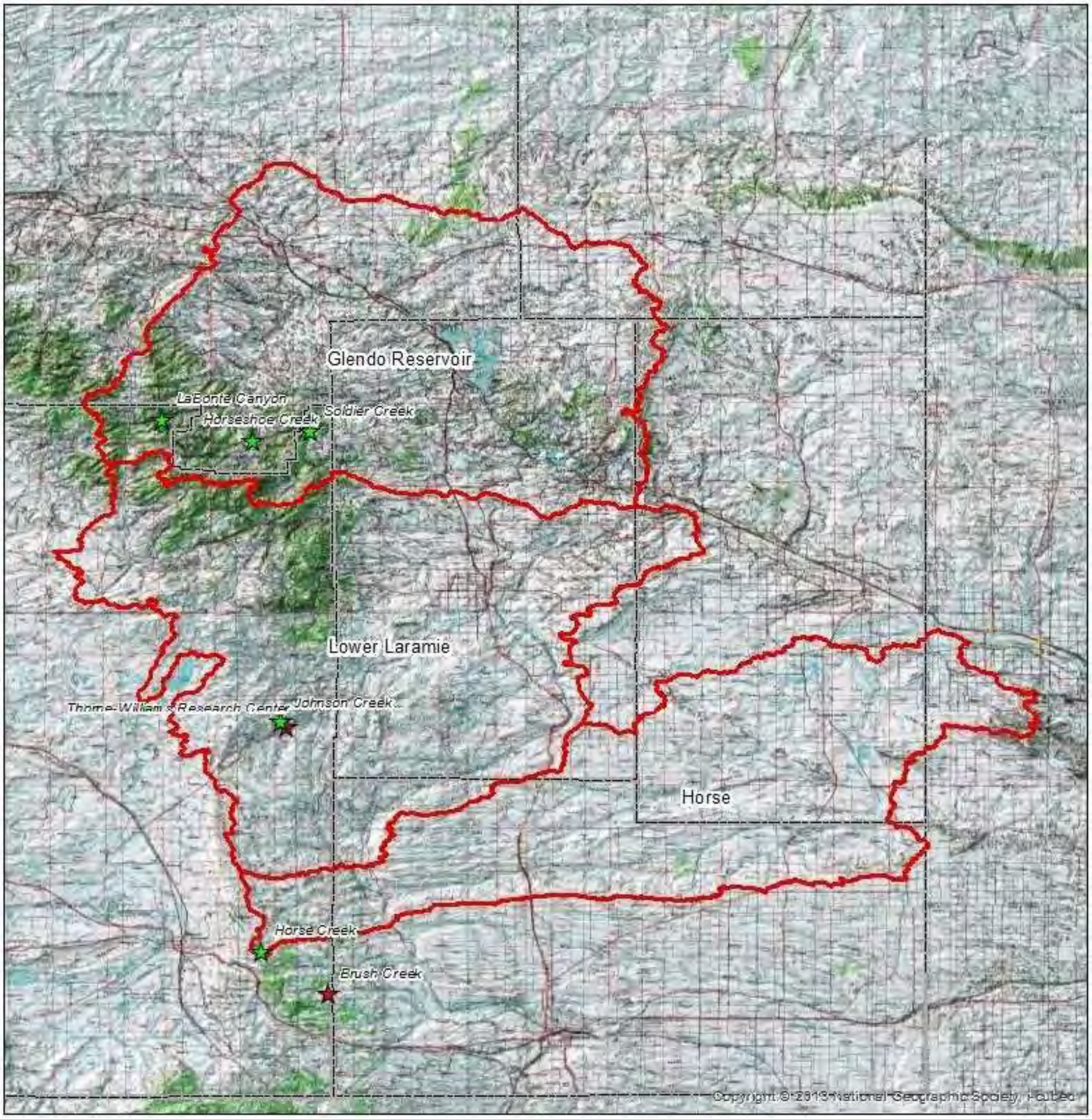
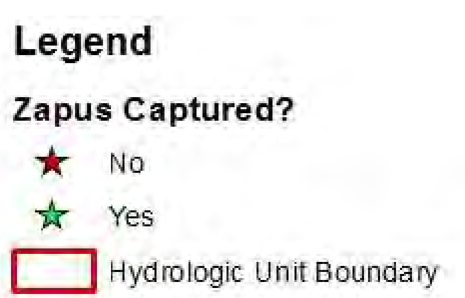


Figure 2. Live-trapping sites surveyed for Zapus in 2018.



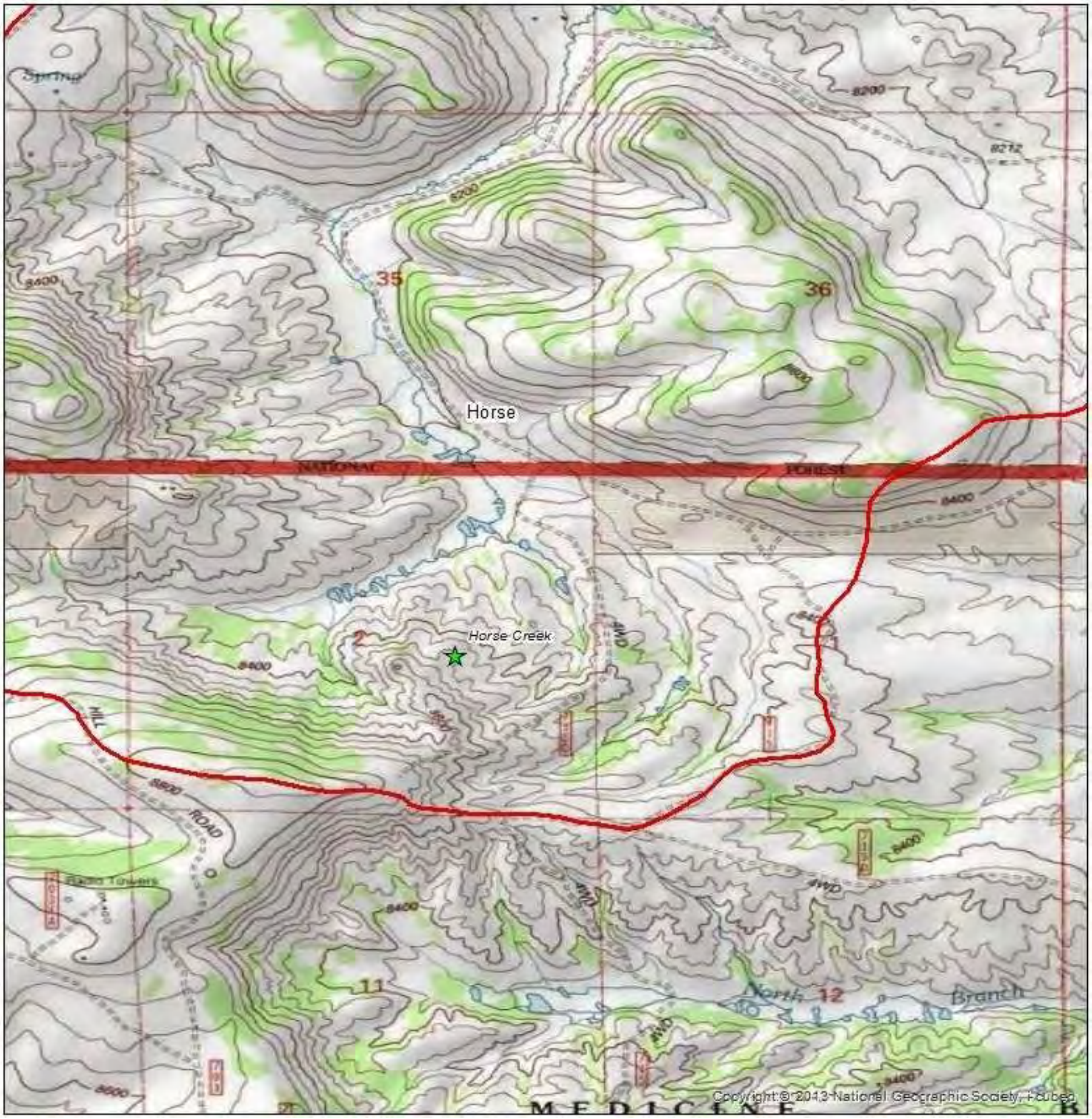
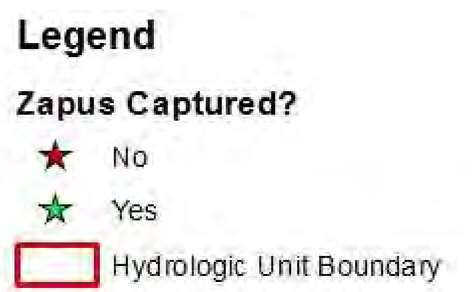


Figure 3. Live-trapping site at Horse Creek in the Horse hydrologic unit surveyed for Zapus in 2018.



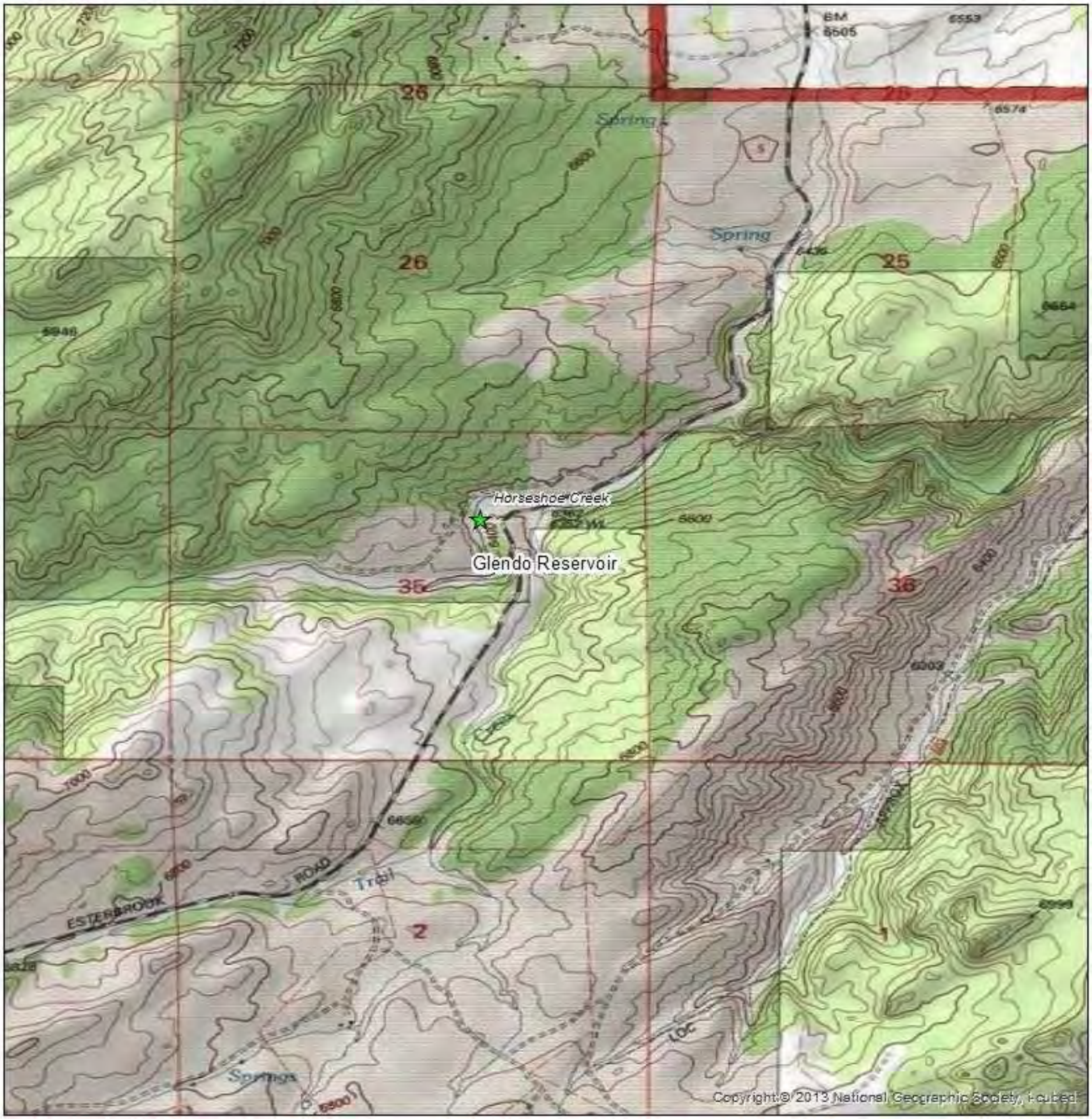
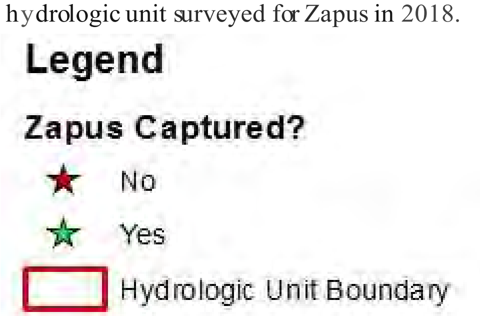


Figure 4. Live-trapping site at Horseshoe Creek in the Glendo Reservoir hydrologic unit surveyed for Zapus in 2018.



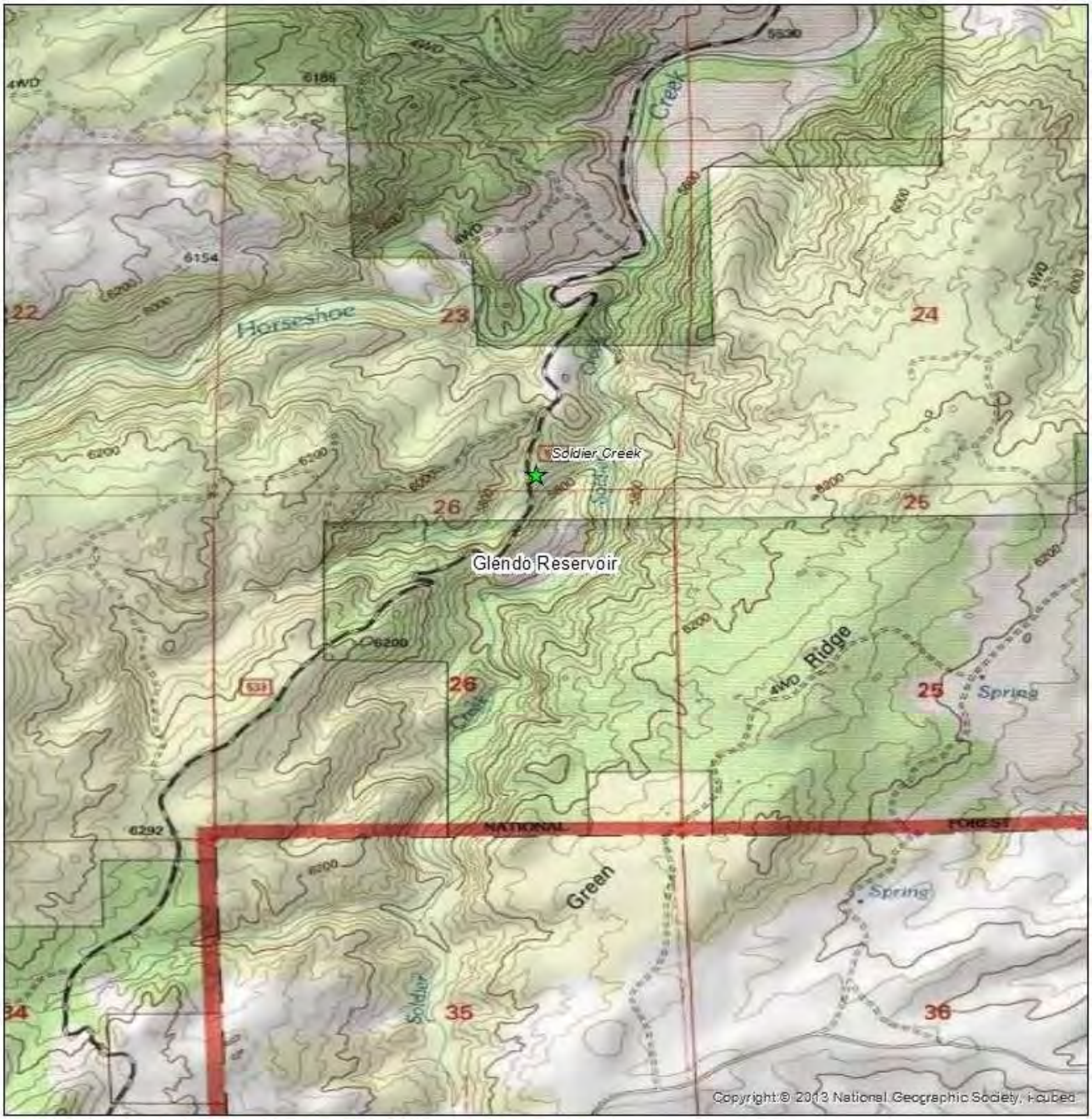


Figure 5. Live-trapping site at Soldier Creek in the Glendo Reservoir hydrologic unit surveyed for Zapus in 2018.

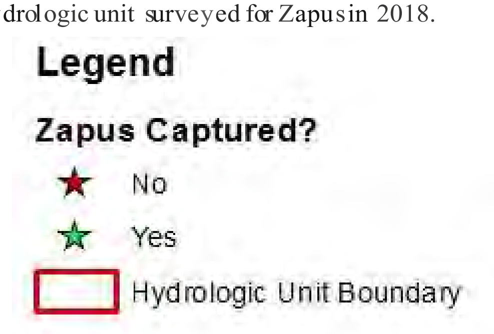
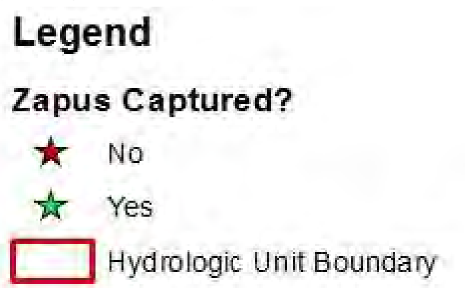


Figure 6. Live-trapping site at LaBonte Canyon in the Glendo Reservoir hydrologic unit surveyed for Zapus in 2018.



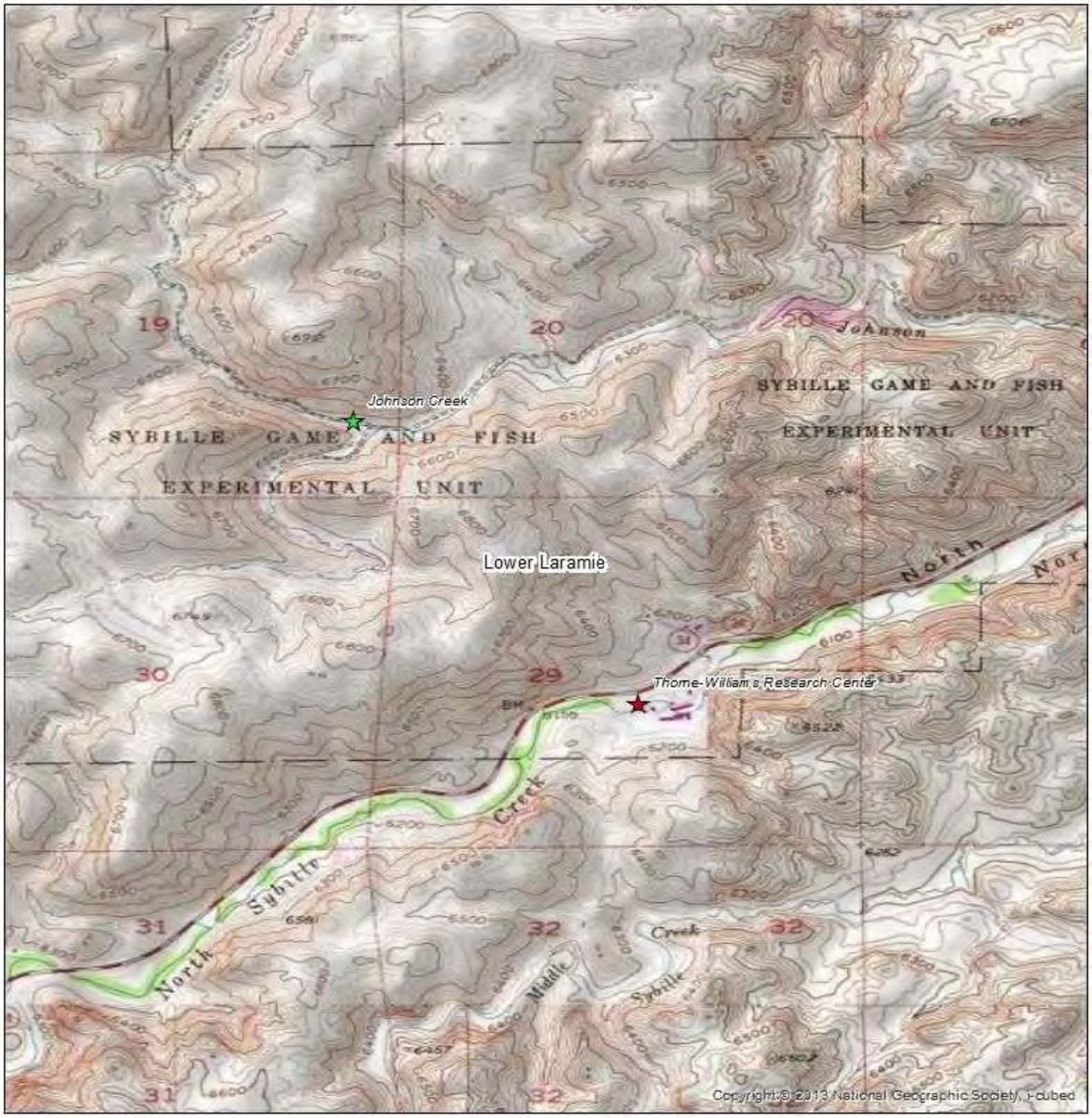
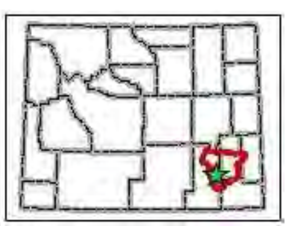
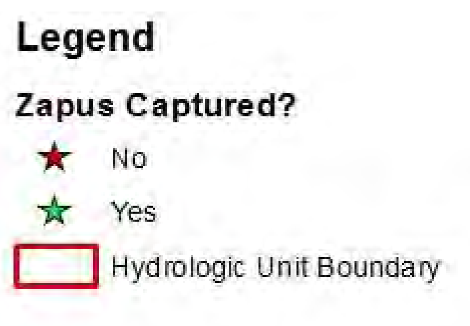


Figure 7. Live-trapping sites at the Thorne Williams Research Center and Johnson Creek in the Lower Laramie hydrologi c unit surveyed for Zapus in 2018.





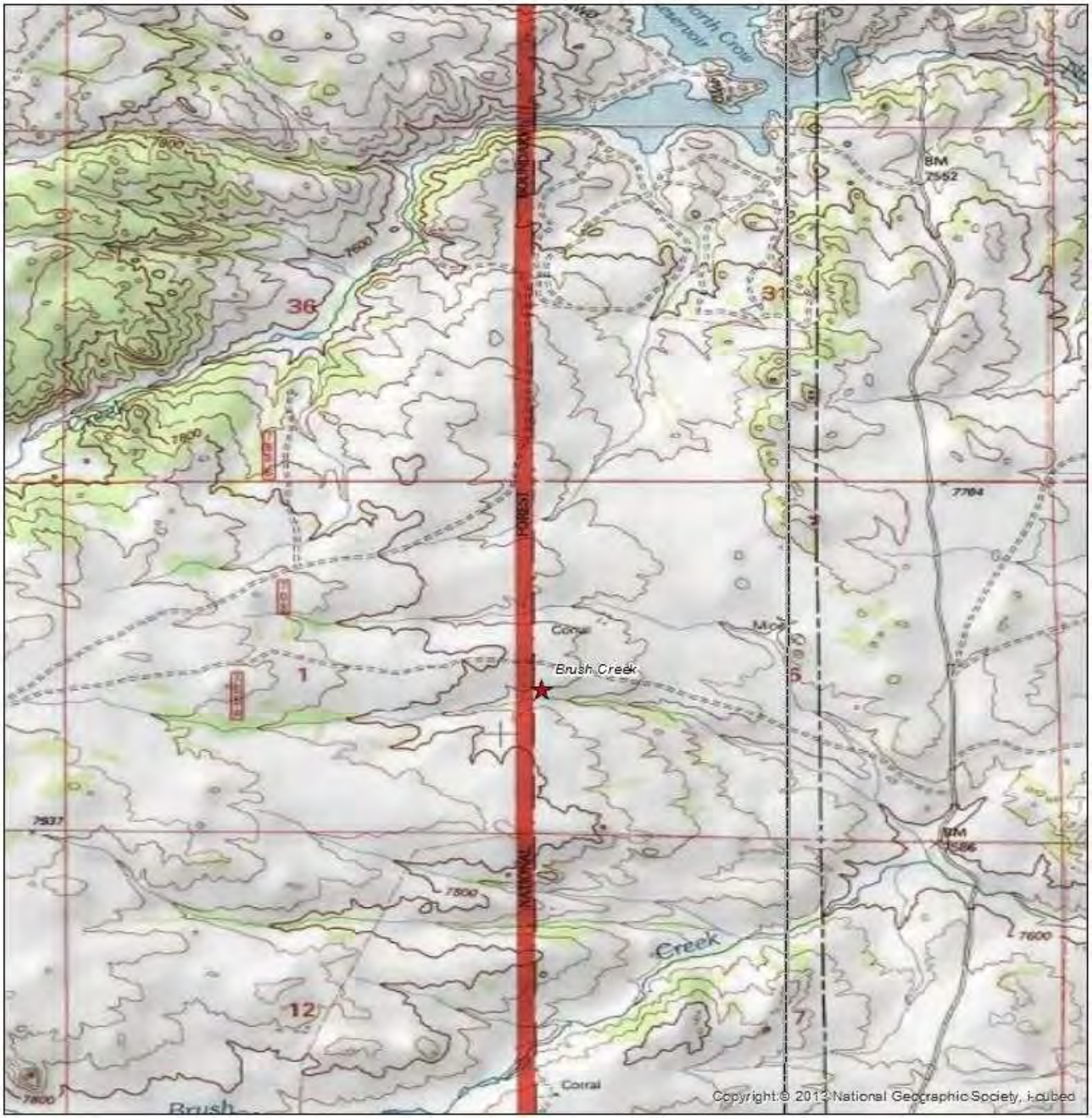
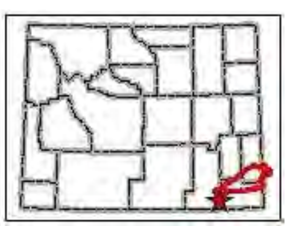
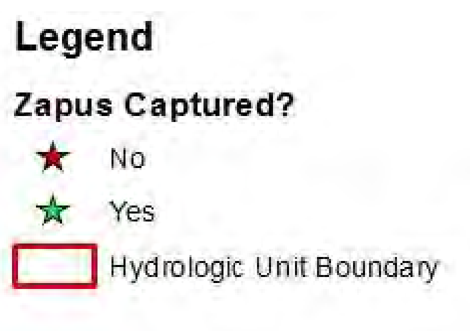


Figure 8. Live-trapping sites at Brush Creek south of the Horse hydrologic unit surveyed for Zapus in 2018.





<u>Tables</u>

Table 1. The number of *Zapus* captured, total trapping effort corrected for sprung traps, and location of transects sampled in 2018.

Transect ID	Total Number of *Zapus* Captures	Unique *Zapus* Captures	Raw Trap Nights	Corrected Trap Nights	UTM Zone	UTM Easting	UTM Northing
Brush Creek	0	0	1000	784.5	13	475652	4562130
Horse Creek	14	12	1000	971.5	13	464002	4571920
Horseshoe Creek	2	2	1000	975.5	13	463194	4689610
Johnson Creek	4	1	1000	891.5	13	467593	4624750
LaBonte Creek	27	19	1000	880	13	447799	4694470
Soldier Creek	1	1	1000	967.5	13	472894	4691710
Thorne Williams Research Center	0	0	1000	946	13	468555	4623460
TOTAL	**49**	**35**	**7000**	**6416.5**	**-**	**-**	**-**

Table 2. Capture data for individual Zapus captured in 2018.

Locality	Survey Date	Genus	Species	Sex	Recapture?	x	Y
Horse creek	6/14/2018	Zapus	Unknown	Male	No	-105.421	41.299
Horse creek	6/14/2018	Zapus	Unknown	Male	No	-105.422	41.296
Horse creek	6/14/2018	Zapus	Unknown	Female	No	-105.42	41.298
Horse creek	6/15/2018	Zapus	Unknown	Male	No	-105.423	41.295
Horse creek	6/15/2018	Zapus	Unknown	Male	No	-105.423	41.295
Horse creek	6/15/2018	Zapus	Unknown	Female	No	-105.421	41.298
Horse creek	6/15/2018	Zapus	Unknown	Female	No	-105.422	41.300
Horse Creek	6/16/2018	Zapus	Unknown	Female	No	-105.423	41.295
Horse creek	6/16/2018	Zapus	Unknown	Female	No	-105.422	41.296
Horse creek	6/16/2018	Zapus	Unknown	Male	Yes	-105.419	41.295
Horse creek	6/16/2018	Zapus	Unknown	Female	No	-105.421	41.297
Horse creek	6/16/2018	Zapus	Unknown	Female	Yes	-105.42	41.298
Horseshoe Creek	7/24/2018	Zapus	Unknown	Male	No	-105.447	42.358
Soldier Creek*	7/31/2018	Zapus	Unknown	Female	No	-105.327	42.381
Horseshoe Creek	7/26/2018	Zapus	Unknown	Female	No	-105.449	42.355
LaBonte Creek	8/7/2018	Zapus	Unknown	Female	No	-105.634	42.400
LaBonte Creek	8/7/2018	Zapus	Unknown	Male	No	-105.635	42.399
LaBonte Creek	8/7/2018	Zapus	Unknown	Female	No	-105.637	42.398
LaBonte Creek	8/8/2018	Zapus	Unknown	Male	No	-105.634	42.401
LaBonte Creek	8/8/2018	Zapus	Unknown	Male	No	-105.635	42.399
LaBonte Creek	8/8/2018	Zapus	Unknown	Male	No	-105.635	42.400
LaBonte Creek	8/8/2018	Zapus	Unknown	Female	No	-105.635	42.400
LaBonte Creek	8/8/2018	Zapus	Unknown	Female	No	-105.635	42.399
LaBonte Creek	8/8/2018	Zapus	Unknown	Male	No	-105.636	42.398
LaBonte Creek	8/8/2018	Zapus	Unknown	Female	No	-105.637	42.398
LaBonte Creek	8/8/2018	Zapus	Unknown	Female	Yes	-105.637	42.396
LaBonte Creek	8/9/2018	Zapus	Unknown	Female	No	-105.634	42.400
LaBonte Creek	8/9/2018	Zapus	Unknown	Female	No	-105.635	42.400
LaBonte Creek	8/9/2018	Zapus	Unknown	Male	No	-105.635	42.400
LaBonte Creek	8/9/2018	Zapus	Unknown	Female	Yes	-105.635	42.400
LaBonte Creek	8/9/2018	Zapus	Unknown	Male	No	-105.635	42.399
LaBonte Creek	8/9/2018	Zapus	Unknown	Male	Yes	-105.635	42.399
LaBonte Creek	8/9/2018	Zapus	Unknown	Female	No	-105.636	42.399
LaBonte Creek	8/9/2018	Zapus	Unknown	Male	No	-105.636	42.398
LaBonte Creek	8/9/2018	Zapus	Unknown	Female	Yes	-105.636	42.398
LaBonte Creek	8/10/2018	Zapus	Unknown	Female	No	-105.634	42.400
LaBonte Creek	8/10/2018	Zapus	Unknown	Male	Yes	-105.635	42.399
LaBonte Creek	8/10/2018	Zapus	Unknown	Female	Yes	-105.636	42.399
LaBonte Creek	8/10/2018	Zapus	Unknown	Female	Yes	-105.636	42.399
LaBonte Creek	8/10/2018	Zapus	Unknown	Male	No	-105.636	42.399
LaBonte Creek	8/10/2018	Zapus	Unknown	Female	Yes	-105.637	42.398

Locality	Survey Date	Genus	Species	Sex	Recapture?	x	Y
Johnson Creek	9/4/2018	Zapus	Unknown	Male	No	-105.386	41.774
Johnson Creek	9/5/2018	Zapus	Unknown	Male	Yes	-105.386	41.774
Johnson Creek	9/6/2018	Zapus	Unknown	Male	Yes	-105.386	41.774
Johnson Creek	9/7/2018	Zapus	Unknown	Male	Yes	-105.386	41.774

*Denotes incidental Zapus mortality

Distribution and genetic differentiation of spotted skunks

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Eastern spotted skunks

FUNDING SOURCE: Western Association of Fish and Wildlife Agencies
Wyoming Game and Fish Commission Funds
Wyoming Governor's Endangered Species Account Fund

PROJECT DURATION: 15 August 2016 – 15 August 2020

PERIOD COVERED: 1 May 2016 – December 31 2018

PREPARED BY: Merav Ben-David, Professor
Robert J. Riotto, Graduate student
Zachariah Bell, Graduate student

ABSTRACT

The plains spotted skunk, a subspecies of the eastern spotted skunk (*Spilogale putorius interrupta*), was petitioned for listing under the United States Endangered Species Act (ESA) due to large, range-wide declines in abundance. Eastern and western spotted skunks are considered distinct based on purported geographic isolation, mitochondrial DNA and differing reproductive traits. However, the two species cannot reliably be distinguished by phenotypic differences. In addition, the validity of the *S. p. interrupta* subspecies is defined largely on geography. Since April 2017 we obtained 75 samples of spotted skunks (eastern and western) from 10 states. DNA was extracted from all samples and shipped for analysis at the University of Maryland Genomics Science Center. We surveyed 250 of 900 sites and detected skunks in 21 of those. In the Granite Mountains, Vedauwoo, Sybille Canyon and Curtis Gulch we caught 28 individuals. Ten adults from the Granite Mountains were fitted with a GPS transmitter and tracked from October 2017 to January 2018. Our tracking suggests that spotted skunks in Wyoming move longer distances than previously reported for other locations. In spring 2018 we will concentrate our camera and live-trapping efforts at the eastern part of the state to target the plains spotted skunks. We will return and survey additional sites on the western side of the state in fall 2018.

INTRODUCTION

The plains spotted skunk is a subspecies of the eastern spotted skunk (*Spilogale putorius interrupta*). It was petitioned for listing under the United States Endangered Species Act (ESA) in July 2011 due to large, range-wide declines in abundance (Gompper and Hackett 2005). The Fish and Wildlife Service has since issued a positive 90-day finding indicating that there is substantial evidence suggesting that listing may be warranted (USFWS 2012).

Both eastern spotted skunk (*S. putorius*) and western spotted skunk (*S. gracilis*) occur in Wyoming (Clark and Stromberg 1987). Due to their cryptic, nocturnal nature, spotted skunks generally require targeted surveys to assess presence, while strong morphological similarities mean that the two species cannot reliably be distinguished by sight (Armstrong et al. 2011), and they were considered the same species until relatively recently (Hall 1981). Eastern and western spotted skunks are now considered distinct based on purported geographic isolation by the continental divide (Kinlaw 1995), mitochondrial DNA (Dragoo et al. 1993) and differing reproductive traits, specifically that *S. gracilis* exhibits delayed implantation while *S. putorius* does not (Mead 1968b, a). However, neither the extent of geographic isolation nor the possibility of hybridization has been thoroughly investigated for these species. Perhaps more importantly, virtually nothing is known about the validity of the *S. p. interrupta* subspecies, which is defined largely on geography.

Central Wyoming is one of few locations along the continental divide where the two species could co-occur (Clark and Stromberg 1987, Verts et al. 2001), leading to the possibility of sympatry and hybridization. If hybridization does occur, it has profound implications for management of spotted skunks in Wyoming and for the validity of the taxon petitioned for ESA protection. Thus, there is a pressing need to clarify the distribution and genetic differentiation of spotted skunks in Wyoming and across their range.

The primary goal of our study is elucidating the conservation status of eastern spotted skunks, particularly the plains subspecies. We will achieve this goal by meeting four primary objectives:

1. Wyoming distribution: Delineate the distribution and habitat associations of spotted skunks in Wyoming.
2. Genomics: Determine the genetic differentiation between eastern and western spotted skunks throughout their range, and assess the distinctness of the plains subspecies of eastern spotted skunk.
3. Taxonomic Mapping: Determine the likelihood of hybridization between the eastern and western species of spotted skunks in Wyoming, estimate the boundary of their ranges, and, if hybridization exists, approximate the zone of introgression.
4. Interstate Collaboration: This project will principally focus on spotted skunks in Wyoming, but we will pursue opportunities to work with other states to increase the scope and robustness of our analyses.

METHODS

Tissue samples – Through the Eastern Spotted Skunk working group and contacts with tribal, federal, and state agencies we obtained 119 tissue samples (Table 1). These include samples from 17 states (Table 1). In addition, we collected samples from 52 individuals captured in Wyoming (See below). Of these, 47 samples have been extracted and amplified. Concurrently, we contacted Dr. Klaus-Peter Koepfli from the Smithsonian Institute who in collaboration with the Broad Institute sequenced and assembled the genome of a western spotted skunk from California. Although this is a contig-only assembly (with a contig N50 of ~60kb), the contigs are of high quality and were assembled using the Broad's Discovar assembler based on a single PCR-free Illumina library. We used this assembly as a scaffold to identify nucleotide diversity among individuals in our first group of samples. Discovery of Single Nucleotide Polymorphism (SNP) is currently underway.

Table 1. Number of samples of eastern and western spotted skunks obtained from museums, trappers, state and federal agencies and the public. Samples from Wyoming were mostly obtained from our live-trapping efforts.

Species	# of samples	Locations
Spilogale putorius ambarvalis	13	FL
Spilogale putorius interrupta	35	AR, IA, KS, NB, SD, TX
Spilogale putorius putorius	26	AL, GA, KY, NC, SC, VA
Spilogale gracilis	45	AZ, OR, TX, WA
Spilogale spp	52	WY
Total	**171**	

Camera trapping – In spring 2017, we generated 900 spatially balanced survey locations in suitable habitat throughout Wyoming (Figure 1). We relied on 84 previous observations (public records, pilot study by WGFD, and pilot study by UW) to determine the spatial extent of skunk distribution. We used GIS layers of rock outcrops, permanent water, and public lands delineate the suitable habitats. We merged rock outcrops and water layers and the buffered the resulting map by 500 m. To ensure we could access the sites we intersected the resulting map with a layer of roads. To increase the detection probability for plains spotted skunks we allocated more sites on the eastern part of the state. Between April and November 2017 we surveyed 203 of the 900 sites (609 camera traps). In from April to November 2018 we surveyed 293 sites (879 cameras). In all we sampled 496 locations across Wyoming.

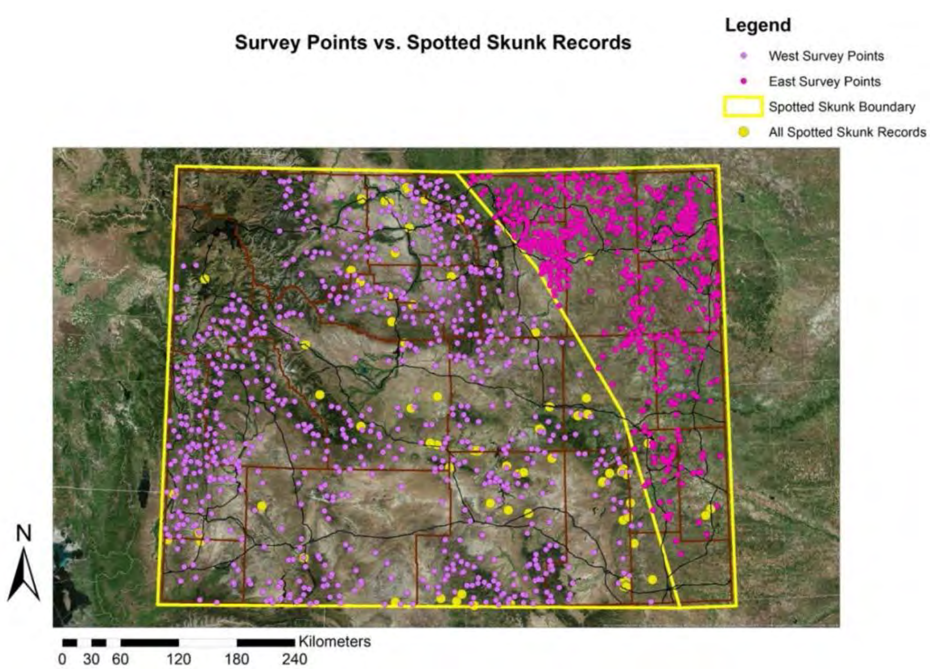


Figure 1. Sampling sites for eastern (pink) and western (purple) spotted skunks generated from merging rock outcrops and water layers and the buffering the resulting map by 500 m. Yellow dots represent previous observations from public records, pilot study by WGFD, and pilot study by UW.

At each site 3 baited cameras are placed at >500m apart. About 5 m in front of the camera 3-5 dead pheasant chicks were tied to a tent stake with biodegradable string. Pheasant chicks, all naturally dead at hatching, were obtained from the WGFD Downar Bird Farm near Wheatland. The site was laced with commercial skunk lure approximately 1-2 m above ground. Cameras were operated at each site for 14 days and checked and rebaited every 5-7 days.

We collected environmental data, including local habitat variables via field measurements at survey sites (e.g., over story and understory composition, local canopy cover) and landscape-level variables via remote sensing of the grid cells containing survey sites (e.g. elevation, slope, temperature, precipitation). Survey data will be analyzed with respect to these variables to estimate the influence of environmental factors on detection and occupancy of spotted skunks in Wyoming (MacKenzie 2006).

Live trapping - At sites where spotted skunks were photographically detected (Figure 2), 3-5 Tomahawk live traps (Model 201; Tomahawk Live Trap Co. Hazelhurst, WI) were set within 50 m of the camera. Live traps were baited with dead pheasant chicks and the surrounding area is laced with skunk lure. Traps were opened late each evening for 5-7 days and checked early every morning. To sedate the trapped skunks, we used a small rag liberally soaked in Isoflurane (Fluriso®; Vet One, Boise, ID) which was inserted into the chamber and the skunk's behavior was monitored closely until it showed signs of response to the anesthetic (Parker et al. 2008). Once sufficiently sedated, the skunk was removed from the trap, and manually injected with a dose of 9 mg/kg of Telazol®. From each skunk, we collected a 4 mm punch (Integra Miltex 4mm; York, PA) from the ear. The tissue was preserved in a 2 ml cryovial filled with 100-proof ethanol. If the site bled we used microcapillary tubes to collect a small blood sample into a clean empty cryovial. After processing, the skunk was allowed to recover in the trap. We used zip-ties to disable the spring on the trap door and prop it slightly open using a rod or stick. This allows the skunk to self-release after sufficiently recovering from the anesthesia (Figure 2).

Figure 2. Top left: a spotted skunk is detected in a camera. Top right: a skunk entering the live-trap. Bottom left: a skunk ready for self-release after the trap locking-mechanism was disabled with a zip-tie. Bottom right: a fully recovered skunk after it left the trap detected in the camera again.

GPS telemetry - We deployed a 17 g LiteTrack RF20 GPS collar (Lotek Wireless Inc., Newmarket, Ontario, Canada) on skunks that weighed more than 320 g (Figure 3). We tracked each skunk from the ground approximately every two weeks and remotely download the data using a Lotek PinPoint Command Unit.

Figure 3. Sedated, female spotted skunk fitted with Lotek RF20 GPS collar

RESULTS

Tissue samples – The 47 samples analyzed to date yielded a total of 189,812,472 reads (Figure 4), with a mean read length of 274 base pairs (bp). The distribution of reads per sample was variable, ranging from a few thousands to nearly 10 million per sample (Figure 5). After filtering for sequence quality, 12 individuals with little data were eliminated. For the remaining samples, the number of reads ranged between 0.2 million to 3.5 million. These samples have exhibited 90% alignment to the spotted skunk reference genome. Identification of SNPs and assignment of individuals to clusters is on-going. Additional 124 individuals (Table 1) will be analyzed in spring 2019.

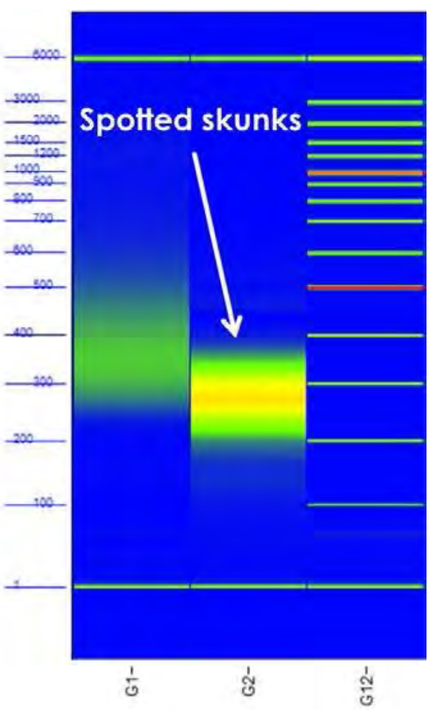


Figure 4. Visualization of spotted skunk DNA reads from an Illumina 4000 genomic analysis.

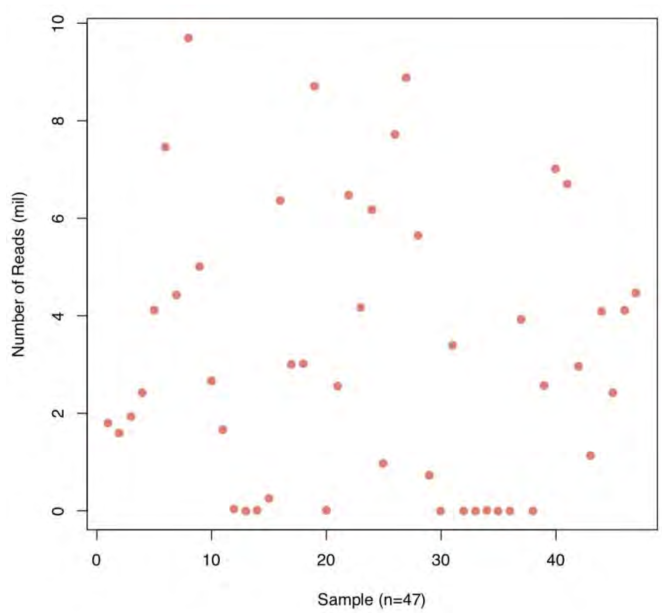


Figure 5. Distribution of number of reads per spotted skunk sample.

Camera and live trapping – To date, we surveyed 496 of the 900 sites across the state. Despite exhaustive effort in the eastern part of Wyoming (Figure 1 – pink symbols) no skunks have been detected in that part of the state. Skunks were detected in 71 sites (14%), representing over 100 individuals (see Figure 6 for example of multiple individuals at a single site). Exact number of individuals will be determined after all photographs are analyzed. Additional detections were reported from other WGFD efforts from western Wyoming and several additional carcasses were obtained from the public.

Figure 6. Three spotted skunks in the Shirley Mountains, Wyoming in August 7, 2018. Two adults (a male and a female) were captured at the site on August 8. The third skunk (apparently a juvenile) was never caught. This image was scored as a single detection in our count.

In spring and fall 2017 we captured 28 unique individuals (Figure 7). In fall 2018 we captured 24 skunks with the majority found in the Big Horn Basin (Figure 7). Adult male skunks captured in the Big Horn basin were larger (>700 g) than males captured elsewhere in Wyoming (400-600 g), suggesting that this population may have eastern ancestry. These individuals will be included in the next batch of DNA sequencing.

Telemetry - At the Granite Mountains, where most captures occurred (n = 22) in 2017, we fitted 10 adult spotted skunks with Lotek LiteTrack RF20 GPS collars. Preliminary results suggest that spotted skunks are capable of longer distance movements than previously reported (Figure 8; Lesmeister et al. 2009).

DISCUSSION

Our collaborators, Dr. Chhatre and Dr. Blouin from the Wyoming Bioinformatics Center, are conducting the analyses of genomic data in exchange for co-authorship on manuscripts. Additional 124 individuals (Table 1) will be analyzed in spring 2019 and added to the final analyses.

Our survey and trapping efforts have yielded more skunk detections and live captures than anticipated. We are currently analyzing the data collected using occupancy models.

In addition, using the high-quality photos we obtained during the project, we are pursuing the possibility of using machine learning to develop a protocol for identifying individuals.

We are currently working with engineering students at the University of Wyoming to build a telemetry tracking drone that we hope to use this spring to track skunks that will be trapped in the Laramie Range. Funding for this part of the project was obtained from the Wyoming Wildlife Foundation.

In addition to the efforts described above, we also presented the project at thee venues:

Riotto, R.J., Z. H. Bell, D. Keinath, and M. Ben-David. 2018. Study design and preliminary results from a spotted skunk survey in Wyoming. Midwest Furbearer Workshop, May 14-17, Medora ND.

Ben-David, M., R.J. Riotto, Z. H. Bell, and D. Keinath. 2018. Study design and preliminary results from a spotted skunk survey in Wyoming. Wildlife Society annual conference, October 7-11, Cleveland OH.

Riotto, R.J., Z. H. Bell, D. Keinath, and M. Ben-David. 2018. Study design and preliminary results from a spotted skunk survey in Wyoming. Wyoming Student Chapter of the Wildlife Society, November 19, Laramie, WY.

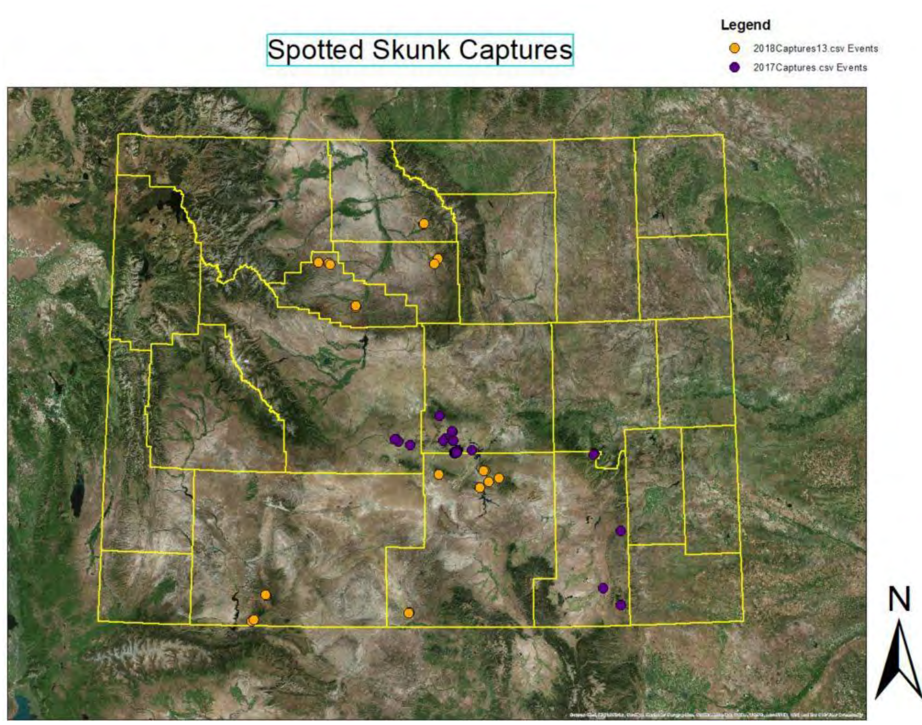


Figure 7. Distribution of spotted skunk captures in Wyoming in 2017 (purple) and 2018 (orange). In total 52 individuals were caught.

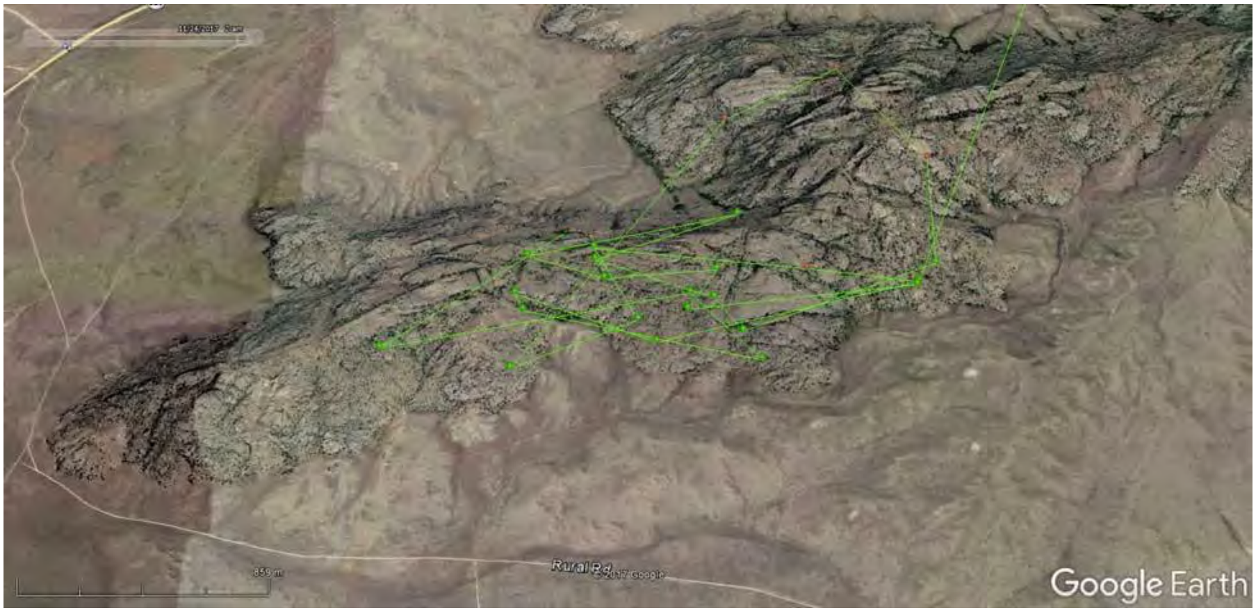


Figure 8. An example of female skunk movements in the Granite Mountains, Wyoming in October – December 2017.

ACKNOWLEDGEMENTS

Funding for the project was provided by the Wyoming Game and Fish Department (WGFD). We thank N. Bjornlie, J. Boulerice, L. Knox, B. Zinke, and Z. Walker from the WGFD for sharing data, help with obtaining samples, and logistical support. D. Keinath, a co-PI on this project was instrumental in developing the proposal, hiring the graduate students, and designing the sampling scheme.

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APPENDIX II
OTHER PRESENTATIONS AND PUBLICATIONS

Boulerice, J., Bjornlie, N., and Z. Walker. (In Press). Returning a native species home: a black-footed ferret conservation story. The Wildlife Professional.

Boulerice, J., and B. Zinke. (Under Review). Habitat association of spotted skunks (*Spilogale* spp.) in south-central Wyoming. American Midland Naturalist.

Rocke, T. E., D. W. Tripp, R. E. Russel, R. C. Abbott, K. Richgels, M. Matchett, D. Biggins, R. Griebel, G. Schroeder, S. Grassel, R. Gillibrand, J. Cordova, A. Kavalunas, B. Maxfield, J. Boulerice, and M. Miller. (Under Review). Bait-delivered sylvatic plague vaccine protects prairie dogs (*Cynomys* spp.) from plague in field efficacy trials in western U.S. Ecohealth.

Bron, G. M., K. Richgels, M. D. Samuel, J. E. Poje, F. Lorenzsonn, J. P. Matteson, J. E. Osorio, and T. E. Rocke. (Under Review). The impact of the prairie dogs (*Cynomys* spp.) oral sylvatic plague vaccine on non-target small rodents in grassland ecosystems. Ecohealth.

APPENDIX III
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**				
169.0	Snow Goose *	*Anser caerulescens*		M
170.0	Ross's Goose *	*Anser rossii*	(FL)	M
171.0	Greater White-fronted Goose *	*Anser albifrons*	(FL)	M
174.0	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, NSS2/II, No season
180.0	Tundra Swan *	*Cygnus columbianus*		W, No season
179.0	Whooper Swan	*Cygnus cygnus*	(AS)	A
144.0	Wood Duck *	*Aix sponsa*		S
139.2	Garganey	*Spatula querquedula*	(AS)	A
140.0	Blue-winged Teal *	*Spatula discors*		S
141.0	Cinnamon Teal *	*Spatula cyanoptera*		S
142.0	Northern Shoveler *	*Spatula clypeata*		S
135.0	Gadwall *	*Mareca strepera*		R
136.0	Eurasian Wigeon	*Mareca penelope*	(AS)	A
137.0	American Wigeon *	*Mareca americana*		R
132.0	Mallard *	*Anas platyrhynchos*		R
133.0	American Black Duck	*Anas rubripes*	(AS)	A
134.0	Mottled Duck	*Anas fulvigula*	(AS)	A
143.0	Northern Pintail *	*Anas acuta*		R
139.0	Green-winged Teal *	*Anas crecca*		R
147.0	Canvasback *	*Aythya valisineria*		S
146.0	Redhead *	*Aythya americana*		S
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
155.0	Harlequin Duck *	*Histrionicus histrionicus*		S, NSS3/II
166.0	Surf Scoter *	*Melanitta perspicillata*	(FL)	M
165.0	White-winged Scoter *	*Melanitta deglandi*	(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
131.0	Hooded Merganser *	*Lophodytes cucullatus*		R
129.0	Common Merganser *	*Mergus merganser*		R
130.0	Red-breasted Merganser *	*Mergus serrator*		S
167.0	Ruddy Duck *	*Oxyura jamaicensis*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Gallinaceous Birds **Order: Galliformes** **Family: Odontophoridae**				
289.0	Northern Bobwhite *	*Colinus virginianus*	(AS)	R
Family: Phasianidae				
288.2	Chukar *	*Alectoris chukar*		R
288.1	Gray Partridge *	*Perdix perdix*		R
309.1	Ring-necked Pheasant *	*Phasianus colchicus*		R
300.0	Ruffed Grouse *	*Bonasa umbellus*		R
309.0	Greater Sage-Grouse *	*Centrocercus urophasianus*		R, NSS4/II
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
Grebes **Order: Podicipediformes** **Family: Podicipedidae**				
006.0	Pied-billed Grebe	*Podilymbus podiceps*		S
003.0	Horned Grebe	*Podiceps auritus*		S
002.0	Red-necked Grebe	*Podiceps grisegena*	(AS)	S
004.0	Eared Grebe	*Podiceps nigricollis*		S
001.0	Western Grebe	*Aechmophorus occidentalis*		S, NSSU/II
001.1	Clark's Grebe	*Aechmophorus clarkii*		S, NSSU/II
Doves and Pigeons **Order: Columbiformes** **Family: Columbidae**				
313.1	Rock Pigeon	*Columba livia*		R, Invasive non-native
312.0	Band-tailed Pigeon	*Patagioenas fasciata*	(AS)	M
315.9	Eurasian Collared-Dove	*Streptopelia decaocto*		R, Invasive non-native
315.0	Passenger Pigeon	*Ectopistes migratorius*		Extinct
319.0	White-winged Dove	*Zenaida asiatica*	(FL)	A
316.0	Mourning Dove *	*Zenaida macroura*		S
Cuckoos **Order: Cuculiformes** **Family: Cuculidae**				
387.0	Yellow-billed Cuckoo	*Coccyzus americanus*	(FL)	S, Threatened, NSSU/II
388.0	Black-billed Cuckoo	*Coccyzus erythropthalmus*	(FL)	S, NSS4/II
Nightjars **Order: Caprimulgiformes** **Family: Caprimulgidae**				
421.0	Lesser Nighthawk	*Chordeiles acutipennis*	(AS)	A
420.0	Common Nighthawk	*Chordeiles minor*		S, NSS4/III
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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
424.0	Vaux's Swift	*Chaetura vauxi*	(AS)	A
425.0	White-throated Swift	*Aeronautes saxatalis*		S
<u>Hummingbirds</u> **Order: Apodiformes** **Family: Trochilidae**				
426.0	Rivoli's Hummingbird	*Eugenes fulgens*	(AS)	A
428.0	Ruby-throated Hummingbird	*Archilochus colubris*	(AS)	A
429.0	Black-chinned Hummingbird	*Archilochus alexandri*	(FL)	S, NSSU/II
431.0	Anna's Hummingbird	*Calypte anna*	(AS)	A
432.0	Broad-tailed Hummingbird	*Selasphorus platycercus*		S
433.0	Rufous Hummingbird	*Selasphorus rufus*		S, NSS4/II
436.0	Calliope Hummingbird	*Selasphorus calliope*		S, NSS4/II
<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, NSSU/III
214.0	Sora *	*Porzana carolina*		S
218.0	Purple Gallinule	*Porphyrio martinicus*	(AS)	A
219.0	Common Gallinule	*Gallinula galeata*	(AS)	A
221.0	American Coot *	*Fulica americana*		S
Family: Gruidae				
206.0	Sandhill Crane *	*Antigone canadensis*		S, 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
273.0	Killdeer	*Charadrius vociferus*		S
274.0	Semipalmated Plover	*Charadrius semipalmatus*		M
277.0	Piping Plover	*Charadrius melodus*	(AS)	M, Threatened
281.0	Mountain Plover	*Charadrius montanus*		S, NSSU/I
278.0	Snowy Plover	*Charadrius nivosus*	(AS)	S, NSSU/III
Family: Scolopacidae				
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, Threatened
233.0	Stilt Sandpiper	*Calidris himantopus*		M
248.0	Sanderling	*Calidris alba*		M

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information a, b
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
228.0	American Woodcock	*Scolopax minor*	(AS)	A
230.0	Wilson's Snipe	*Gallinago delicata*		S
263.0	Spotted Sandpiper	*Actitis macularius*		S
256.0	Solitary Sandpiper	*Tringa solitaria*		M
255.0	Lesser Yellowlegs	*Tringa flavipes*		M
258.0	Willet	*Tringa semipalmata*		S
254.0	Greater Yellowlegs	*Tringa melanoleuca*		M
224.0	Wilson's Phalarope	*Phalaropus tricolor*		S
223.0	Red-necked Phalarope	*Phalaropus lobatus*		M
222.0	Red Phalarope	*Phalaropus fulicarius*	(AS)	A
Seabirds, Gulls, and Terns **Order: Charadriiformes** **Family: Stercorariidae**				
036.0	Pomarine Jaeger	*Stercorarius pomarinus*	(AS)	A
037.0	Parasitic Jaeger	*Stercorarius parasiticus*	(AS)	A
038.0	Long-tailed Jaeger	*Stercorarius longicaudus*	(AS)	A
Family: Alcidae				
023.0	Long-billed Murrelet	*Brachyramphus perdix*	(AS)	A
021.0	Ancient Murrelet	*Synthliboramphus antiquus*	(AS)	A
Family: Laridae				
040.0	Black-legged Kittiwake	*Rissa tridactyla*	(AS)	A
062.0	Sabine's Gull	*Xema sabini*	(FL)	M
060.0	Bonaparte's Gull	*Chroicocephalus philadelphia*		M
055.1	Black-headed Gull	*Chroicocephalus ridibundus*	(AS)	A
060.1	Little Gull	*Hydrocoloeus minutus*	(AS)	A
061.0	Ross's Gull	*Rhodostethia rosea*	(AS)	A
058.0	Laughing Gull	*Leucophaeus atricilla*	(AS)	A
059.0	Franklin's Gull	*Leucophaeus pipixcan*		S, NSSU/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
043.0	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, (AS) except L19 and L27
074.0	Least Tern	*Sternula antillarum*	(AS)	A, Endangered

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
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
Loons **Order: Gaviiformes** **Family: Gaviidae**				
011.0	Red-throated Loon	*Gavia stellata*	(AS)	M
010.0	Pacific Loon	*Gavia pacifica*	(FL)	M
007.0	Common Loon	*Gavia immer*		S, NSS1/I
008.0	Yellow-billed Loon	*Gavia adamsii*	(AS)	A
Shearwaters **Order: Procellariiformes** **Family: Procellariidae**				
088.1	Streaked Shearwater	*Calonectris leucomelas*	(AS)	A
Storks **Order: Ciconiiformes** **Family: Ciconiidae**				
188.0	Wood Stork	*Mycteria americana*	(AS)	A, Threatened
Cormorants and Frigatebirds **Order: Suliformes** **Family: Fregatidae**				
128.2	Lesser Frigatebird	*Fregata ariel*	(AS)	A
Family: Phalacrocoracidae				
120.0	Double-crested Cormorant	*Phalacrocorax auritus*		S
Pelicans and Wading Birds **Order: Pelecaniformes** **Family: Pelecanidae**				
125.0	American White Pelican	*Pelecanus erythrorhynchos*		S, NSS4/II
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, NSS4, II
196.0	Great Egret	*Ardea alba*	(FL)	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, NSS3/II
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
New World Vultures **Order: Cathartiformes** **Family: Cathartidae**				

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
326.0	Black Vulture	*Coragyps atratus*	(AS)	A
325.0	Turkey Vulture	*Cathartes aura*		S
324.0	California Condor	*Gymnogyps californianus*	(AS)	A
<u>Ospreys, Hawks, Kites, and Eagles</u> **Order: Accipitriformes** **Family: Pandionidae**				
364.0	Osprey	*Pandion haliaetus*		S
Family: Accipitridae				
328.0	White-tailed Kite	*Elanus leucurus*	(AS)	A
349.0	Golden Eagle	*Aquila chrysaetos*		R, NSS4/II
331.0	Northern Harrier	*Circus hudsonius*		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
352.0	Bald Eagle	*Haliaeetus leucocephalus*		R, NSS3/II
329.0	Mississippi Kite	*Ictinia mississippiensis*	(AS)	A
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)
347.0	Rough-legged Hawk	*Buteo lagopus*		W
348.0	Ferruginous Hawk	*Buteo regalis*		R, NSS4/II
<u>Owls</u> **Order: Strigiformes** **Family: Tytonidae**				
365.0	Barn Owl	*Tyto alba*	(AS)	S,
Family: Strigidae				
374.0	Flammulated Owl	*Psiloscops flammeolus*	(AS)	S, NSSU/III
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/II
366.0	Long-eared Owl	*Asio otus*		R
367.0	Short-eared Owl	*Asio flammeus*		R, NSS4/II
371.0	Boreal Owl	*Aegolius funereus*	(FL)	R, NSS3/II
372.0	Northern Saw-whet Owl	*Aegolius acadicus*	(FL)	R
<u>Kingfishers</u> **Order: Coraciiformes** **Family: Alcedinidae**				
390.0	Belted Kingfisher	*Megaceryle alcyon*		R
<u>Woodpeckers</u> **Order: Piciformes** **Family: Picidae**				

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
408.0	Lewis's Woodpecker	*Melanerpes lewis*		S, NSSU/II
406.0	Red-headed Woodpecker	*Melanerpes erythrocephalus*	(FL)	S, NSS4/II
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, NSS3/II
402.0	Yellow-bellied Sapsucker	*Sphyrapicus varius*	(AS)	A
402.1	Red-naped Sapsucker	*Sphyrapicus nuchalis*		S
401.0	American Three-toed Woodpecker	*Picoides dorsalis*		R
400.0	Black-backed Woodpecker	*Picoides arcticus*	(FL)	R, NSSU/II
394.0	Downy Woodpecker	*Dryobates pubescens*		R
393.0	Hairy Woodpecker	*Dryobates villosus*		R
399.0	White-headed Woodpecker	*Dryobates albolarvatus*	(AS)	A
412.2	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, NSS4/III
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**				
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
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, NSS3/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
458.0	Black Phoebe	*Sayornis nigricans*	(AS)	A
456.0	Eastern Phoebe	*Sayornis phoebe*	(AS)	S
457.0	Say's Phoebe	*Sayornis saya*		S
471.0	Vermilion Flycatcher	*Pyrocephalus rubinus*	(AS)	A
Family: Laniidae				
622.0	Loggerhead Shrike	*Lanius ludovicianus*		S, NSS4/II
621.0	Northern Shrike	*Lanius borealis*		W
Family: Vireonidae				

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information a, b
631.0	White-eyed Vireo	*Vireo griseus*	(AS)	A
634.0	Gray Vireo	*Vireo vicinior*	(AS)	S, NSSU/II
628.0	Yellow-throated Vireo	*Vireo flavifrons*	(AS)	A
629.2	Cassin's Vireo	*Vireo cassinii*	(AS)	M
629.3	Blue-headed Vireo	*Vireo solitarius*	(AS)	M
629.1	Plumbeous Vireo	*Vireo plumbeus*		S
626.0	Philadelphia Vireo	*Vireo philadelphicus*	(AS)	M
627.0	Warbling Vireo	*Vireo gilvus*		S
624.0	Red-eyed Vireo	*Vireo olivaceus*		S, NSS4/II
Family: Corvidae				
484.0	Canada 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	Woodhouse's Scrub-Jay	*Aphelocoma woodhouseii*	(FL)	R, NSS3/II
491.0	Clark's Nutcracker	*Nucifraga columbiana*		R, NSS4/II
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				
616.0	Bank Swallow	*Riparia riparia*		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
611.0	Purple Martin	*Progne subis*	(AS)	S, NSSU/III
613.0	Barn Swallow	*Hirundo rustica*		S
612.0	Cliff Swallow	*Petrochelidon pyrrhonota*		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, NSS3/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, NSS4/III
721.0	House Wren	*Troglodytes aedon*		S
722.1	Pacific Wren	*Troglodytes pacificus*	(AS)	M
722.0	Winter Wren	*Troglodytes hiemalis*	(AS)	M
724.0	Sedge Wren	*Cistothorus platensis*	(AS)	A
725.0	Marsh Wren	*Cistothorus palustris*		S

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
718.0	Carolina Wren	*Thryothorus ludovicianus*	(AS)	A
719.0	Bewick's Wren	*Thryomanes bewickii*	(FL)	S, NSS4/III
Family: Polioptilidae				
751.0	Blue-gray Gnatcatcher	*Polioptila caerulea*		S, NSS4/III
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
707.0	Curve-billed Thrasher	*Toxostoma curvirostre*	(AS)	A
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, Invasive non-native
Family: Bombycillidae				
618.0	Bohemian Waxwing	*Bombycilla garrulus*		W
619.0	Cedar Waxwing	*Bombycilla cedrorum*		R
Family: Passeridae				
688.2	House Sparrow	*Passer domesticus*		R, Invasive non-native
Family: Motacillidae				
697.0	American Pipit	*Anthus rubescens*		S, NSS4/III
700.0	Sprague's Pipit	*Anthus spragueii*	(AS)	M
Family: Fringillidae				
514.1	Brambling	*Fringilla montifringilla*	(AS)	A
514.0	Evening Grosbeak	*Coccothraustes vespertinus*		R
515.0	Pine Grosbeak	*Pinicola enucleator*		R
524.0	Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*		R
525.0	Black Rosy-Finch	*Leucosticte atrata*		R, NSSU/II
526.0	Brown-capped Rosy-Finch	*Leucosticte australis*	(FL)	R, NSSU/II
519.0	House Finch	*Haemorhous mexicanus*		R
517.0	Purple Finch	*Haemorhous purpureus*	(AS)	W
518.0	Cassin's Finch	*Haemorhous cassinii*		R
528.0	Common Redpoll	*Acanthis flammea*		W
527.0	Hoary Redpoll	*Acanthis hornemanni*	(AS)	W

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
521.0	Red Crossbill	*Loxia curvirostra*		R, NSS4/II
522.0	White-winged Crossbill	*Loxia leucoptera*	(FL)	R
526.1	European Goldfinch	*Carduelis carduelis*		A, Controlled
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
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: Passerellidae				
578.0	Cassin's Sparrow	*Peucaea cassinii*	(AS)	A, (AS) except confirmed breeding in Torrington area
546.0	Grasshopper Sparrow	*Ammodramus savannarum*		S, NSS4/II
573.0	Black-throated Sparrow	*Amphispiza bilineata*	(AS)	S
552.0	Lark Sparrow	*Chondestes grammacus*		S
605.0	Lark Bunting	*Calamospiza melanocorys*		S
560.0	Chipping Sparrow	*Spizella passerina*		S
561.0	Clay-colored Sparrow	*Spizella pallida*		S
563.0	Field Sparrow	*Spizella pusilla*	(AS)	S
562.0	Brewer's Sparrow	*Spizella breweri*		S, NSS4/II
585.0	Fox Sparrow	*Passerella iliaca*		R
559.0	American Tree Sparrow	*Spizelloides arborea*		W
567.7	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)
554.0	White-crowned Sparrow	*Zonotrichia leucophrys*		S
557.0	Golden-crowned Sparrow	*Zonotrichia atricapilla*	(AS)	A
553.0	Harris's Sparrow	*Zonotrichia querula*		W
558.0	White-throated Sparrow	*Zonotrichia albicollis*		M
574.3	Sagebrush Sparrow	*Artemisiospiza nevadensis*		S, NSS4/II
540.0	Vesper Sparrow	*Pooecetes gramineus*		S
548.0	LeConte's Sparrow	*Ammospiza leconteii*	(AS)	M
549.1	Nelson's Sparrow	*Ammospiza nelsoni*	(AS)	A
545.0	Baird's Sparrow	*Centronyx bairdii*	(AS)	S, NSS4/II
542.0	Savannah Sparrow	*Passerculus sandwichensis*		S
581.0	Song Sparrow	*Melospiza melodia*		R
583.0	Lincoln's Sparrow	*Melospiza lincolnii*		S
584.0	Swamp Sparrow	*Melospiza georgiana*	(FL)	M
591.0	Canyon Towhee	*Melozone fusca*	(AS)	A
590.0	Green-tailed Towhee	*Pipilo chlorurus*		S
588.0	Spotted Towhee	*Pipilo maculatus*		S
587.0	Eastern Towhee	*Piplio erythrophthalmus*	(AS)	A

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
Family: Icteridae				
683.0	Yellow-breasted Chat	*Icteria virens*		S
497.0	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*		S
494.0	Bobolink	*Dolichonyx oryzivorus*	(FL)	S, NSSU/II
501.0	Eastern Meadowlark	*Sturnella magna*	(AS)	A
501.1	Western Meadowlark	*Sturnella neglecta*		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, NSSU/II
498.0	Red-winged Blackbird	*Agelaius phoeniceus*		S
495.0	Brown-headed Cowbird	*Molothrus ater*		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
Family: Parulidae				
674.0	Ovenbird	*Seiurus aurocapilla*		S
639.0	Worm-eating Warbler	*Helmitheros vermivorum*	(AS)	A
675.0	Northern Waterthrush	*Parkesia 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	*Leiothlypis peregrina*	(FL)	M
646.0	Orange-crowned Warbler	*Leiothlypis celata*		S
645.0	Nashville Warbler	*Leiothlypis ruficapilla*	(FL)	M
644.0	Virginia's Warbler	*Leiothlypis virginiae*	(FL)	S, NSSU/II
678.0	Connecticut Warbler	*Oporornis agilis*	(AS)	A
680.0	MacGillivray's Warbler	*Geothlypis tolmiei*		S, NSS4/II
679.0	Mourning Warbler	*Geothlypis philadelphia*	(AS)	A
677.0	Kentucky Warbler	*Geothlypis formosa*	(AS)	A
681.0	Common Yellowthroat	*Geothlypis trichas*		S, NSS4/III
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	*Setophaga 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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
665.0	Black-throated Gray Warbler	*Setophaga nigrescens*	(FL)	S, NSS4/II
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
Family: Cardinalidae				
609.0	Hepatic Tanager	*Piranga flava*	(AS)	A
610.0	Summer Tanager	*Piranga rubra*	(FL)	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, NSS4/III
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
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
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
806.0	American 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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
804.1	Preble's Shrew	*Sorex preblei*		R, NSS3/III
802.0	Vagrant Shrew	*Sorex vagrans*		R
Family: Talpidae				
810.0	Eastern Mole	*Scalopus aquaticus*		R
<u>Bats</u> **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, Threatened, 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
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
<u>Lagomorphs</u> **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
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
<u>Rodents</u> **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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
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 lutescens*		R, NSS4/II
Family: Heteromyidae				
865.0	Olive-backed Pocket Mouse	*Perognathus fasciatus*		R, NSS4/II
893.0	Plains Pocket Mouse	*Perognathus flavescens*		R, NSS4/II
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 Kangaroo 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
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
895.1	Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*		R, NSS4/II, Threatened
896.0	Western Jumping Mouse	*Zapus princeps*		R
Family: Erethizontidae				
900.0	North American Porcupine *	*Erethizon dorsatum*		R, Predatory animal

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
<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
909.0	Fisher	*Pekania pennanti*		R
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	Wapiti (Elk) *	*Cervus canadensis*		R
932.0	Mule Deer (Black-tailed Deer) *	*Odocoileus hemionus*		R
933.0	White-tailed Deer *	*Odocoileus virginianus*		R
931.0	Moose *	*Alces 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, NSS4/II
		AMPHIBIANS [f]		
<u>Salamanders</u> **Order: Caudata** **Family: Ambystomatidae**				

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
950.0	Tiger Salamander	*Ambystoma mavortium*		R; includes Blotched, Western (NSS4/III), and Arizona subspecies
Toads and Frogs **Order: Anura** **Family: Pelobatidae**				
951.0	Plains Spadefoot	*Spea bombifrons*		R, NSSU/III
951.1	Great Basin Spadefoot	*Spea intermontana*		R, NSSU/I
Family: Bufonidae				
951.2	Western Toad	*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
		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, NSSU/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

Spp. code	Common name	Scientific name	Doc. type	Seasonal status and additional information [a, b]
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 2017) .

[c] Common and scientific names and species order are from the American Ornithologists' Union/American Ornithological Society (1983, 2019). 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 and species order are from Bradley et al. (2014).

[f] Common and scientific names and species order are from Baxter and Stone (1992) and Crother (2012).

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