THREATENED, ENDANGERED, AND NONGAME BIRD AND MAMMAL INVESTIGATIONS

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

Annual Completion Report

Period Covered:
15 April 2012 to 14 April 2013

Edited by: Andrea C. Orabona

June 2013

The Wyoming Game and Fish Department receives Federal financial assistance from the US Fish and Wildlife Service. Under Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972, the US Department of the Interior and its bureaus prohibit discrimination on the basis of race, color, national origin, age, disability, or sex (in educational programs). If you believe that you have been discriminated against in any program, activity, or facility, or if you desire further information, please write to:

The US Fish and Wildlife Service
Office for Diversity and Civil Rights Programs – External Programs
4040 North Fairfax Drive, Suite 130
Arlington, VA 22203

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
United States Fish and Wildlife Service Cooperative Agreements
United States Fish and Wildlife Service Section 6 Funds
United States Fish and Wildlife Service State Wildlife Grants
Wyoming Game and Fish Department
Wyoming Governor's Big Game License Coalition
Wyoming Governor's Endangered Species Account Funds
Wyoming Landscape Conservation Initiative
Wyoming State Legislature General Fund Appropriations

TABLE OF CONTENTS

PREFACE

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

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

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

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

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

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

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

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

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

INTRODUCTION

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

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

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

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

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

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

THREATENED AND ENDANGERED SPECIES

DISTRIBUTION OF PREBLE'S MEADOW JUMPING MICE (*ZAPUS HUDSONIUS PREBLEI*) ALONG THE NORTH PLATTE RIVER

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Preble's meadow jumping mouse

FUNDING SOURCE: Wyoming Governor's Endangered Species Account Funds

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2012 – 14 April 2013

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

ABSTRACT

Accurately predicting species distributions is essential to prioritize survey and conservation efforts. This is especially important for species that have specialized habitat requirements, limited distributions, or are considered sensitive or rare. The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is dependent on riparian grasslands and is listed as federally Threatened. Surveys in Wyoming have thus far focused on increasing verified records, but little work has been done to refine distributional boundaries. From July through August 2012, we used live traps to document jumping mice at eight sites along the North Platte River, which roughly represents the northern distribution of the Preble's meadow jumping mouse in Wyoming. We did not capture jumping mice at any of these sites. However, all sites were near or below the lower elevation limit reported for the species. This low elevation, in combination with the lack of captures, suggests the North Platte likely does not represent substantial habitat in Wyoming. We set traps at an additional two sites along the western edge of the Laramie Range and captured jumping mice at one of these locations. Preble's meadow jumping mice and western jumping mice (*Z. princeps*) have both been documented at higher elevations in this drainage; genetic results from this capture are currently pending. The distribution of the Preble's meadow jumping mouse is not fully understood, emphasizing the need for targeted surveys. Further refining the distribution of the species will help direct conservation actions in the future to areas that are likely to have the greatest impact.

INTRODUCTION

Species distribution models provide a powerful tool with which to prioritize management and conservation activities. These models may be particularly useful for rare species with specific habitat requirements or limited distributions (Stockwell and Peterson 2002, Loiselle et al. 2003, Hernandez et al. 2006). Accurately delineating species distributions is especially important for species listed as Threatened or Endangered by the US Fish and Wildlife Service (USFWS), as these listings have important implications for land management activities. Underestimating species distributions may leave some populations vulnerable, whereas overestimating species distributions may lead to unnecessary restrictions in areas where the species does not occur. Although field sampling may be costly, an adequate sample size of survey data from the field can have important implications for model accuracy (Stockwell and Peterson 2002, Hernandez et al. 2006).

The Preble's meadow jumping mouse (Preble's; *Zapus hudsonius preblei*) is listed as federally Threatened throughout its range in Wyoming and Colorado. The Preble's is dependent on riparian habitat with relatively undisturbed grassland vegetation interspersed with shrubs (USFWS 2003*a*, Trainor et al. 2007). Riparian habitats often support a diverse assemblage of terrestrial species and, consequently, are important to biodiversity (Knopf et al. 1998, Grindal et al. 1999, Maisonneuve and Rioux 2001, Poff et al. 2011). However, these riparian habitats represent only a small part of the landscape overall and are exposed to a variety of threats that can diminish or degrade their availability and quality (Knopf et al. 1998, Poff et al. 2011). Consequently, the degradation and loss of habitat is recognized as the critical limiting factor for Preble's populations (USFWS 1998, 2008).

Despite considerable initial controversy over the taxonomy of the Preble's (Ramey et al. 2005, 2006; Vignieri et al. 2006; Cronin 2007), King et al. (2006) settled the debate in 2006 and concluded that the Preble's deserved subspecific status. As a result, the Wyoming Game and Fish Department (Department) contracted with Western Ecosystems Technology, Inc. (WEST) to conduct surveys for the Preble's throughout the predicted range and core distribution in southeastern Wyoming from 2009 through 2011 (Thompson and Grenier 2010; Thompson et al. 2011, 2012). These surveys increased confirmed records of Preble's in Wyoming, but were primarily conducted in the core distribution of the species, with only a few surveys near or outside the range boundary (Cudworth and Grenier 2011, 2012). Consequently, our knowledge of the borders of the Preble's range in Wyoming is lacking. Our objective in 2012 was to conduct surveys along the northern limit of the predicted range in order to increase records of Preble's in Wyoming and provide recommendations to modify boundaries where necessary.

METHODS

We conducted surveys from 9 July through 31 August 2012. To document the northern range of the Preble's, we chose sites along or immediately adjacent to the North Platte River from approximately Casper to Lingle. We also conducted surveys at two sites along the western edge of the Laramie Mountains (Fig. 1). Overall, sites contained a diversity of grass species, including reed canarygrass (*Phalaris arundinacea*), wheatgrass (Tribe Triticeae), brome (*Bromus* spp.), common reed (*Phragmites australis*), foxtail (*Alopecurus* spp.), and small amounts of sedges and forbs. Sites had varying degrees of canopy cover and overstory species, including eastern and narrowleaf cottonwoods (*Populus deltoides* and *P. angustifolia*), sandbar willow (*Salix exigua*), and Russian-olive (*Elaeagnus angustifolia*).

We followed protocol established by the USFWS to capture jumping mice (USFWS 2004). We used Sherman live traps (Models LFG and XLK folding and 339A non-folding traps; H.B. Sherman Traps, Inc., Tallahassee, Florida) baited with a mixture of peanut butter and oats to capture mice. We also supplied traps with poly-fil for bedding. We placed traps every 5 m along 2 parallel line transects spaced 10 m apart. We opened traps within 3 hrs of sunset and checked within 3 hrs of sunrise for 4 consecutive nights. We used a GPS to document locations and took photographs of all sites. We also recorded weather conditions each morning, including wind speed, temperature, and any moisture accumulated throughout the night, as well as a variety of habitat variables, including ground and overstory plant species, ground cover, and canopy cover at a random subset of trap locations. Although we attempted to fulfill the recommendation of 750 trap nights per site, weather and the amount of available habitat at a site occasionally resulted in <750 trap nights.

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

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

RESULTS

We surveyed 10 sites along the northern and western boundary of the predicted range of Preble's in Wyoming. We averaged 714.2 (±8.1) trap nights per site (range 574.5 to 796.5). We captured one jumping mouse two times along the North Laramie River (Fig. 1); genetic results are pending. This individual was an adult female that showed evidence of previous lactation, suggesting breeding was likely occurring in the area. We did not detect jumping mice at any of the other sites. Although we did not evaluate habitat characteristics among sites because of the low number of jumping mouse detections overall, the North Laramie River site was the only location that lacked any overstory.

We captured 477 nontarget individuals, which encompassed 10 different species. Nontarget captures, in order of number of captures, included: western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), long-tailed vole (*Microtus longicaudus*), house mouse (*Mus musculus*), dusky shrew (*Sorex monticolus*), Virginia opossum (*Didelphis virginiana*), prairie vole (*Microtus ochrogaster*), meadow vole (*M. pennsylvanicus*), least chipmunk (*Neotamias minimus*), and northern leopard frog (*Lithobates pipiens*). We also captured a number of voles (*Microtus* spp.) and shrews (*Sorex* spp.) for which we did not or were unable to identify species. These nontarget captures resulted in six updates to distribution and breeding locations in the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012; Table 1).

DISCUSSION

Despite conducting >5,500 trap nights at 8 sites along the North Platte River, we failed to detect any jumping mice. Although Preble's are known to occupy riparian habitat along large perennial rivers (USFWS 2003*b*), they do not appear to be common along the North Platte. In fact, only one jumping mouse has been captured along the North Platte despite numerous surveys since 1980, including those conducted for this project (USFWS 2008). This individual, a nonreproductive, adult female, was captured only once during a clearance survey for the City of Douglas in 1999 and was subsequently confirmed as a Preble's (King et al. 2006; I. Abernathy, pers. comm.). Preble's are typically found at elevations ranging from approximately 1,420 to 2,300 m; the lowest Preble's observation was recorded at 1,218 m in Colorado (USFWS 2003*b*, 2008). Our sites along the North Platte ranged from 1,190 to 1,466 m in elevation, which were near to or below the lower elevation limit reported for the Preble's. Given the low elevation combined with the lack of jumping mouse captures, it is likely the North Platte River does not represent substantial habitat for the Preble's in Wyoming.

We also surveyed two sites along the western edge of the Laramie Mountains: Sheep Creek and the North Laramie River. Both locations were within the elevational range of the Preble's (2,152 m and 2,000 m, respectively) and were within or adjacent to drainages with verified Preble's (WGFD unpublished report). We failed to document any jumping mice along Sheep Creek, which has not been surveyed previously. Although drainages along the eastern edge of the Laramie Mountains have documented Preble's, all drainages to the west and north that have been surveyed thus far have failed to document Preble's, suggesting this may represent the western and northern boundaries in Wyoming, although more surveys are likely necessary. We captured a single jumping mouse along the North Laramie River. Within this drainage, both Preble's and western jumping mice have been detected at higher elevations (WGFD unpublished report); this capture represents the lowest survey site thus far along the North Laramie. Genetic results for this capture were pending when this report went to press; results will be presented in subsequent reports.

The distribution of the Preble's in Wyoming is not fully understood. The range for the Preble's that was modeled for the Wyoming's State Wildlife Action Plan (WGFD 2010) was based upon the availability of suitable habitat and historical, unverified records of occurrence. Surveys to-date have focused on increasing verified records of the Preble's primarily throughout the core distribution. This project emphasizes the need for systematic surveys along distributional boundaries. Although single surveys within a drainage are likely not sufficient to conclude the absence of Preble's, repeated surveys along the North Platte River suggest this waterway likely does not represent substantial habitat. Further refining the range of the Preble's in Wyoming will not only increase our knowledge of boundaries, but will also help direct conservation actions in the future to areas that are likely to have the greatest impact on Preble's populations.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming Governor's Endangered Species Account funds, for which the Department is extremely grateful. We also extend a special thanks to the numerous land managers and landowners that provided access to their lands to assist this project, including: T. Townsend (Fort Laramie National Historic Site), P. Merlino (Camp Guernsey), R. Anderson and P. Sutton (Edness Kimball Wilkins State Park), and A. Dugan and A. Prettyman (Dave Johnston Power Plant). T. Stevenson (Guernsey State Park) generously provided housing during this project. I. Abernathy (Wyoming Natural Diversity Database) coordinated the transfer of genetic samples. Wyoming Game and Fish Department nongame biologists A. Trost, C. Atkinson, M. Karsch, and D. Romano; GIS technician B. Webber; and Fort Laramie National Historic Site technician S. Bryant provided invaluable assistance conducting field work; and J. Binfet, B. Cowling, S. Deselms, and M. Pollock provided technical and logistical support.

LITERATURE CITED

Cronin, M. A. 2007. The Preble's meadow jumping mouse: subjective subspecies, advocacy and management. Animal Conservation 10:159-161.

Cudworth, N., and M. Grenier. 2011. Genetic differentiation and distribution of Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and western jumping mouse (*Z. princeps*) in southeastern Wyoming. Pages 154-160 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Cudworth, N., and M. Grenier. 2012. Genetic differentiation and distribution of *Zapus* spp. captured in areas previously designated as Preble's meadow jumping mice (*Z. hudsonius preblei*) critical habitat in southeastern Wyoming. Pages 10-17 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Grindal, S. D., J. L. Morissette, and R. M. Brigham. 1999. Concentration of bat activity in riparian habitats over an elevational gradient. Canadian Journal of Zoology 77:972-977.

Hernandez, P. A., C. H. Graham, L. L. Master, and D. L. Albert. 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography 29:773-785.

King, T. L., J. F. Switzer, C. L. Morrison, M. S. Eackles, C. C. Young, B. A. Lubinski, and P. Cryan. 2006. Comprehensive genetic analyses reveal evolutionary distinction of a mouse (*Zapus hudsonius preblei*) proposed for delisting from the US Endangered Species Act. Molecular Ecology 15:4331-4359.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. 1998. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272-284.

Loiselle, B. A., C. A. Howell, C. H. Graham, J. M. Goerck, T. Brooks, K. G. Smith, and P. H. Williams. 2003. Avoiding pitfalls of using species-distribution models in conservation planning. Conservation Biology 17:1-10.

Maisonneuve, C., and S. Rioux. 2001. Importance of riparian habitats for small mammal and herpetofaunal communities in agricultural landscapes of southern Québec. Agriculture, Ecosystems and the Environment 83:165-175.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, amphibians, and reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Poff, B., K. A. Koestner, D. G. Neary, and V. Henderson. 2011. Threats to riparian ecosystems in western North America: an analysis of existing literature. Journal of the American Water Resources Association 47:1241-1254.

Ramey, R. R. II, H.-P. Liu, C. W. Epps, L. M. Carpenter, and J. D. Wehausen. 2005. Genetic relatedness of the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) to nearby subspecies of *Z. hudsonius* as inferred from variation in cranial morphology, mitochondrial DNA, and microsatellite DNA: implications for taxonomy and conservation. Animal Conservation 8:329-346.

Ramey, R. R. II, J. D. Wehausen, H.-P. Liu, C. W. Epps, and L. M. Carpenter. 2006. Response to Vignieri *et al*. (2006): should hypothesis testing or selective *post hoc* interpretation of results guide the allocation of conservation effort? Animal Conservation 9:244-247.

Stockwell, D. R. B., and A. T. Peterson. 2002. Effects of sample size on accuracy of species distribution models. Ecological Modeling 148:1-13.

Thompson, J., and M. Grenier. 2010. Live trapping of jumping mice in southeastern Wyoming completion report. Pages 197-200 *in* Threatened, endangered and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Thompson, J., N. Cudworth, and M. Grenier. 2011. Population inventories of jumping mice (*Zapus* spp.) in southeastern Wyoming. Pages 148-153 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Thompson, J., N. Cudworth, and M. Grenier. 2012. Population inventories of jumping mice (*Zapus* spp.) in areas previously designated as Preble's meadow jumping mice (*Z. hudsonius preblei*) critical habitat in southeastern Wyoming. Pages 3-9 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Trainor, A. M., T. M. Shenk, and K. R. Wilson. 2007. Microhabitat characteristics of Preble's meadow jumping mouse high-use areas. Journal of Wildlife Management 72:469-477.

United States Fish and Wildlife Service [USFWS]. 1998. Endangered and threatened wildlife and plants – final rule to list the Preble's meadow jumping mouse as a threatened species. Federal Register 63:26517-26530.

United States Fish and Wildlife Service [USFWS]. 2003*a*. Final environmental assessment designation of critical habitat for Preble's meadow jumping mouse (*Zapus hudsonius preblei*). Ecological Field Services Office, Cheyenne, Wyoming, USA.

United States Fish and Wildlife Service [USFWS]. 2003*b*. Preble's meadow jumping mouse recovery plan. Region 6, Lakewood, Colorado, USA.

United States Fish and Wildlife Service [USFWS]. 2004. Preble's meadow jumping mouse (*Zapus hudsonius preblei*) survey guidelines – revised April 2004. Ecological Services, Colorado Field Office, Lakewood, USA.

United States Fish and Wildlife Service [USFWS]. 2008. Endangered and threatened wildlife and plants – final rule to amend the listing for the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) to specify over what portion of its range the subspecies is threatened. Federal Register 73:39790-39838.

Vignieri, S. N., E. M. Hallerman, B. J. Bergstrom, D. J. Hafner, A. P. Martin, P. Devers, P. Grobler, and N. Hitt. 2006. Mistaken view of taxonomic validity undermines conservation of an evolutionarily distinct mouse: a response to Ramey *et al.* (2005). Animal Conservation 9:237-243.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Updates to distribution and breeding status of small mammals in the Wyoming Game and Fish Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming by latilong. We used live-traps to capture individuals in southeastern Wyoming from July-August 2012. B=nest, dependent young, juvenile animals, lactating or post-lactation females, or males in breeding condition were observed; b=animals were observed and, due to limited mobility, breeding is assumed; h=historical record of occurrence before 1965, but no recent data to suggest occurrence; ——=no verified records (Orabona et al. 2012).

Species	Latilong	Current status	Updated status
Didelphis virginiana	21	b	B
Sorex monticolus	20	b	B
Reithrodontomys megalotis	19	h	B
Microtus longicaudus	20	h	B
Microtus longicaudus	21	——	B
Mus musculus	20	——	b

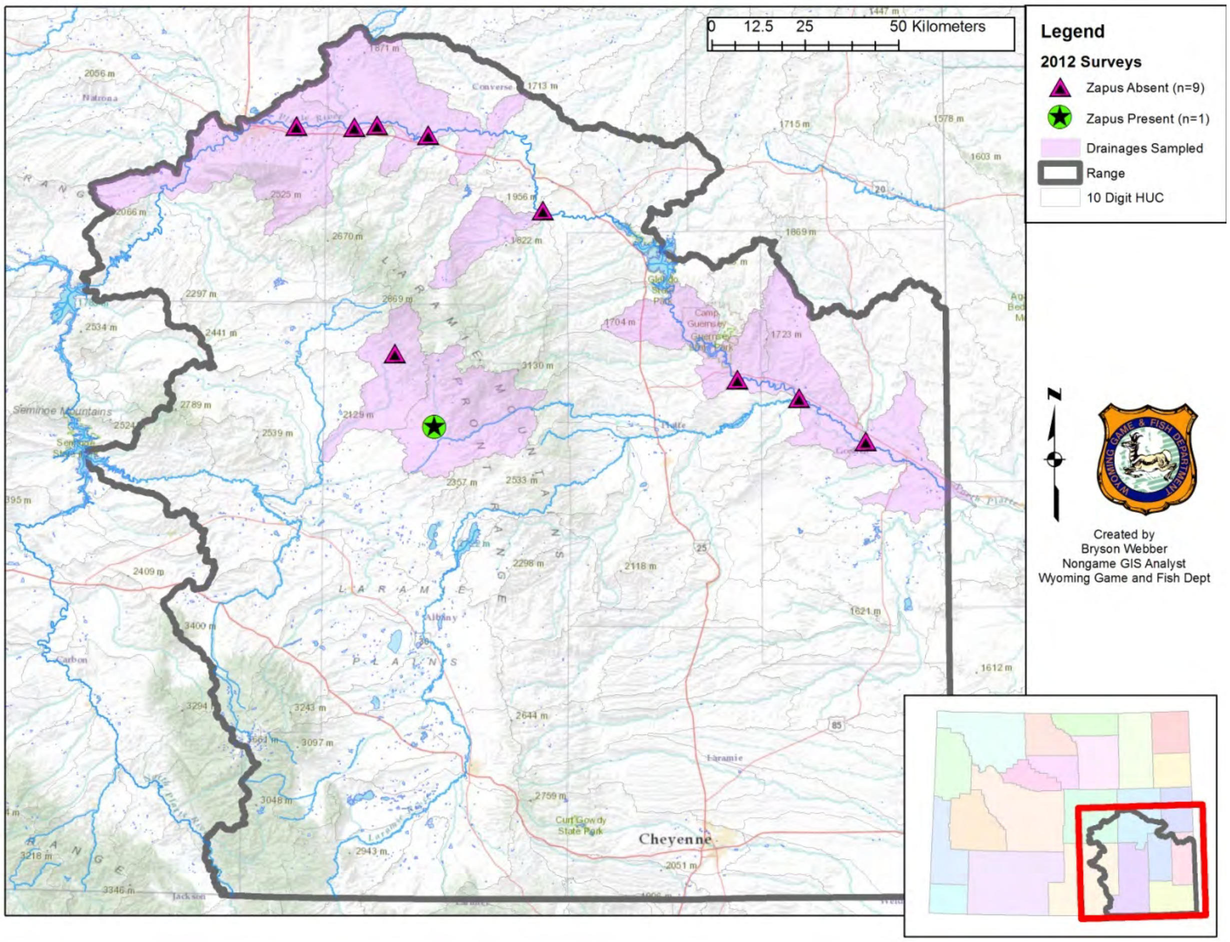

Figure 1. Trapping locations and 10-digit Hydrologic Unit Codes (HUC) for all sites surveyed for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming from July-August 2012. Sites where jumping mice were not detected are designated by pink triangles; sites where jumping mice were detected are designated by green stars. Genetic results were pending when this report went to press.

SPECIES OF GREATEST CONSERVATION NEED – *BIRDS*

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

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Trumpeter Swan

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

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Susan Patla, Nongame Biologist

ABSTRACT

Since the late 1980s, the Wyoming Game and Fish Department (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 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 United States Fish and Wildlife Service, Pacific Flyway Council, and the state agencies in Idaho and Montana. We completed four survey flights during 2012 and winter 2013 to collect census data on total number of adults and young in summer and winter and to document occupancy and productivity of all known nest sites. In the 2012 fall survey, we counted the same number of resident adult and cygnet Trumpeter Swans in Wyoming outside of Yellowstone National Park as we documented in 2010 (n = 143 adults, 48 cygnets), which is a record high for the State. We also documented the same number of occupied nest sites as in 2011 (n = 44), which is the largest number since we initiated surveys in the 1980s. In February 2013, we counted the second highest number of swans wintering in Wyoming (n = 1,075), with 62% of wintering swans located in the Snake River drainage. Growth of the resident population of Trumpeter Swans can be attributed to the Department's range expansion efforts beginning in the late 1980s in the Salt and Green River Basins. We remain concerned over the slow decline of swan numbers and productivity in the core Snake River area. To accommodate the growing number of nesting swans in the Green River Basin, we initiated a wetland habitat program in 2004 that focuses on cooperating with landowners to develop shallow-water wetland ponds that provide additional summer habitat for swans and other wildlife species. We have obtained funding for projects on four ranches to-date and have constructed 40 acres of new wetland

habitat. Plans to construct two additional wetland ponds on private land near Boulder are currently under development. The success of this wetland program focused on swan habitat has helped to stimulate other wetland-related projects in the Green River area. In July 2012, the Department submitted a standard million dollar North American Wetlands Conservation Act (NAWCA) grant proposal developed with The Conservation Fund and other partners to obtain conservation easements and develop wetland habitat in the Green River basin. Also in summer 2012, over 60 randomly selected wetland sites were sampled to complete field work for a wetland assessment project in the Green River basin in partnership with The Nature Conservancy of Wyoming and the University of Wyoming. This was the first basin-wide wetland assessment funded by the Environmental Protection Agency states program in Wyoming.

INTRODUCTION

The Trumpeter Swan (*Cygnus buccinator*; swan) is designated as a Species of Greatest Conservation Need (SGCN) in Wyoming with Native Species Status ranking 2 (WGFD 2010). Although swans were never listed under the Endangered Species Act of 1973, they have been a focal management species for federal and state agencies in the Greater Yellowstone Area (GYA) since the establishment of Red Rock Lakes National Wildlife Refuge in Montana in 1932. This refuge was created to conserve approximately 70 swans in the GYA, which were believed to be the last remaining Trumpeter Swans in the world. Due to conservation efforts, the number of swans in the GYA increased to >600 by the 1950s (USFWS 1998). However, the population has fluctuated since that time, and total number of adult birds in the GYA is currently <400 (Olson 2012*b*). 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 United States 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 (Lockman 2005).

The Department is a member of the Greater Yellowstone Trumpeter Swan Working Group, which consists of state and federal agencies, non-government organizations, and interested citizens. The working group meets annually in October to review and discuss productivity trends, as well as to coordinate management actions. Wyoming also participates on the Pacific Flyway RMP Trumpeter Swan Study Sub-Committee. This report summarizes management activities and monitoring data for swans in Wyoming for the 2012 nesting season and the 2012-2013 winter season.

METHODS

We conducted four fixed-wing airplane surveys to collect data on swans in western Wyoming. All surveys were flown using the same pilot and Scout airplane from Sky Aviation, Worland, Wyoming. Flying elevation averaged 30-70 m above ground level depending on terrain and surface winds; flight speed varied between 135-160 kph. During the survey, the observer counted white birds (i.e., adults and sub-adults) and gray cygnets. We surveyed all known nest sites on 31 May (Snake and Salt River drainages) and 14 June (Green River drainage) to determine occupancy and again on 5 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 12-13 September 2013 and the winter survey on 4-6 February 2013. Additional data were obtained through site-specific ground surveys, reports provided by federal agencies, and observations from the public. We presented survey results and participated in the Pacific Flyway Trumpeter Swan Sub-Committee meetings in July and December 2012 and March 2013, and also participated in the Greater Yellowstone Trumpeter Swan Working Group meeting, 9-10 October 2012, in Lakeview, Montana. The USFWS Mountain-Prairie Region Migratory Bird Office produced two reports summarizing results for the coordinated RMP surveys that included data collected in Wyoming (Olson 2012*b*, 2013).

RESULTS

During February 2013, we counted a total of 1,050 swans wintering in the Pacific Flyway portion of Wyoming outside of Yellowstone National Park (YNP), which represents a 10% increase over the previous year (Table 1). The largest increases in wintering swans occurred in the Snake River drainage, which wintered 14% more swans, and the Green River with 5% more birds (Table 1). An additional 32 swans were documented wintering in the Central Flyway portion of Wyoming including the Wind River (n=23), Alcova Reservoir (n=7), and one each at Glenrock and the Wheatland Power Plan. The number of swans wintering in the Pacific Flyway area in Wyoming has increased 7.0% per year between 1972 and 2011 ($P < 0.01$; Olson 2012*a*). Increase in wintering birds is the result of continued growth of the migrant interior Canada nesting population.

In fall 2012, we counted the second record high number of adults similar to the 2010 total in Wyoming outside of YNP (n=143; Table 2). This represents a 15% increase in adults from the previous survey year. The number of swans in Wyoming (1993-2011) has increased by 1.9% per year ($P < 0.01$) for white birds and 7.7% ($P < 0.001$) for cygnets (Olson 2012*b*). However, in the traditional Snake River core area (1999-2011), the number of swans appears to be declining over the past 13 years (-1.0%, P=0.18). Conversely, in the Green River expansion area the number of swans has increased by 10.7% ($P < 0.001$) over the past 13 years (Olson 2012*b*). Overall, the total TSAF fall count represented a 26.2% increase from the previous year and the highest count since 1990. The TSAF have shown a slight annual increase of 2.0% for white birds ($P < 0.01$) and a slight but not a significant increase in cygnets (2.5%, $P = 0.11$) between 1993 and 2011 (Olsen 2012*b*).

The number of nest sites occupied in 2012 in Wyoming outside of YNP (n=44) equaled the number documented in 2011, which represented a new record for Wyoming and greatly exceeded the 10-year mean (Table 3). The number of nesting pairs in 2012 also represents a record high. The number of young hatched and fledged in Wyoming outside YNP in 2012 exceeded the 10-year averages for 2002-2011 (Table 3). Of the 44 sites occupied in 2012, 65% of pairs initiated nesting, 41% hatched young, and 36% fledged at least one young. Overall, swans in the Green River Basin accounted for 54% of occupied sites and 81% of fledged young (Table 4). In the Snake River core, 50% of cygnets hatched did not fledge compared to only 11% that did not fledge in the Green River.

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

Summary of mortality data from 1991-2012 are presented in Table 6. We documented 27 mortalities in Wyoming, with the highest number of mortalities reported in early spring. Multiple mortalities (n=18) were found at one site on private land in Wilson where swans concentrated on ponds after ice melted in March. Carcasses have been submitted to the State Veterinary Laboratory and the national Wildlife Center in Madison, Wisconsin to determine cause of death.

DISCUSSION

Although the number and productivity of Trumpeter Swans in Wyoming outside of YNP has increased in recent years, this is solely the result of population growth in the Green River expansion area. We continue to document the slow decline in numbers of nesting pairs and low productivity of nest sites in the Snake River area. A total of 75% of the productivity in the Snake River core since 2002 has been from only seven territories, three of which are on the National Elk Refuge. During this period of decline, we have documented a dramatic increase in the number of migrant swans from interior Canada wintering in the core area. Migratory swans may be reducing available forage needed by resident swans in winter and early spring. Generally, most migrant swans depart by the end of March/early April. leaving resident swans to forage on remaining aquatic vegetation until additional wetlands thaw and open. Especially in cold, late springs such as 2011, when the thaw in some locations was delayed until late May or early June, available aquatic vegetation is in short supply. We hypothesize that the increase in the number of wintering swans negatively impacts resident pairs in the core area as a result of depleted foraging habitat that is in very limited supply during late winter and early spring. This idea is supported by results in 2007, which was one of the warmest springs on record in Wyoming, when swans produced a record number of young 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, increasing productivity and exponential growth of swans in the Green River expansion area in Wyoming indicates that late winter and early spring conditions provide adequate pre-nesting foraging habitat for the resident nesting population in this drainage. Swans that winter along the Green River below Fontenelle Dam start to move north as soon as the river begins to thaw above the dam in early to mid-March. This provides access to a much larger extent of new foraging habitat along the Green River corridor in the pre-nesting season compared to resident swans in the core area.

Swans in Wyoming now comprise between 35-40% of the total TSAF and, therefore, constitute an important portion of the current GYA resident population. Although, the success of the Green River range expansion program has resulted in increased numbers of swans in that area of the State, we remain concerned about declining numbers and productivity in the traditional core area including Yellowstone National Park. 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 2010). Given the increasing number and productivity of swans in the Green River Basin and possible long-term drought conditions, it is important that the Department continue to be a leader in habitat improvement projects for swans and other wildlife associated with shallow water wetland habitat. In 2012, swans used wetland sites developed by the Department as cooperative projects with landowners at four locations in the Pinedale area. Funding for these projects was obtained through the Wyoming Landscape Conservation Initiative, the Wyoming Wildlife and Natural Resource Trust, Natural Resources Conservation Service programs, and USFWS Partners Program. We are currently working on plans for two additional ponds on a ranch near Boulder, Wyoming. Also in 2012, we partnered with The Conservation Fund and 14 other partners to submit a standard NAWCA grant to obtain $1 million for conservation easements and wetland habitat projects in the upper Green River basin. This grant was ranked 9 of 11 non-coastal proposals and approved by the Migratory Bird Conservation Committee (MBCC) in December 2012 (Ali Duvall, Intermountain West Joint Venture, personal communication). 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. Completion of this 2-year study will provide a more complete understanding of the types and condition of wetlands in the basin and help to focus future conservation and restoration work.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature, the Wyoming Governor's Office, and US Fish and Wildlife Service cooperative agreements, for which the Department is extremely grateful. We would like to thank the following individuals for their valuable contributions to the Trumpeter Swan monitoring effort: B. Ahlers, K. Theule, and T. Koerner with Seedskadee National Wildlife Refuge; S. Dewey, W. Schere, A. May, and S. Wolff with Grand Teton National Park; E. Cole and N. Fath with the National Elk Refuge; K. Murphy and G. Hanvey with Bridger-Teton National Forest; P. Hnilicka with the USFWS; L. Baril, K. Duffy, and D. Smith with Yellowstone National Park; S. Dereusseau and T. Fletcher with the Caribou-Targhee National Forest, B. Long and D. Reed with Wyoming Wetlands Society; D. Stinson, pilot with Sky Aviation; B. Raynes and the Jackson Hole Bird Club; and volunteers D. Patla in Buffalo Valley and B. Jones of the Jackson Treatment Plant. Many other Department personnel and interested citizens contributed observations of swans throughout the State, and we appreciate their efforts. Nature Mapping Jackson Hole volunteers have helped map swan use throughout the year in the Jackson area. We also greatly appreciate the efforts of D. Olson with the USFWS for providing funding for the fall survey flight.

LITERATURE CITED

Groves, D. J. 2012. The 2010 North American trumpeter swan survey. Unpublished report. US Fish and Wildlife Service, Division of Migratory Bird Management, Juneau, Alaska.

Lockman, D. 2005. Wyoming Green River Basin Trumpeter Swan summer habitat project, February 14, 2005. Wyoming Game and Fish Department, Lander, USA.

Olson, D. 2012*a*. Trumpeter Swan survey of the Rocky Mountain population, winter 2012. US Fish and Wildlife Service, Migratory Birds and State Program, Mountain-Prairie Region, Lakewood, Colorado, USA.

Olson, D. 2012*b*. Trumpeter Swan survey of the Rocky Mountain population, US breeding segment, fall 2012. US Fish and Wildlife Service, Migratory Birds and State Program, Mountain-Prairie Region, Lakewood, Colorado, USA.

Olson, D. 2013. Trumpeter Swan survey of the Rocky Mountain population, winter 2013. US Fish and Wildlife Service, Migratory Birds and State Program, Mountain-Prairie Region, Lakewood, Colorado, USA.

Patla, S., and D. Lockman. 2004. Considerations and prescriptions for the design, construction, and management of shallow water wetlands for spring through fall use by Trumpeter Swans. Wyoming Game and Fish Department, Lander, USA.

Patla, S., and B. Oakleaf. 2004. Summary and update of Trumpeter Swan range expansion efforts in Wyoming, 1988-2003. Proceedings and Papers of the 19th Trumpeter Swan Society Conference, Richmond, British Columbia. North American Swans 32:116-118.

United States Fish and Wildlife Service [USFWS]. 1998. Pacific Flyway management plan for the Rocky Mountain population of Trumpeter Swans. Pacific Flyway Study Committee, Portland, Oregon, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Number of Trumpeter Swan (*Cygnus buccinators*) adults and cygnets counted in Wyoming for the coordinated Tri-State winter survey in February, 2003-2013. Results are shown for specific survey areas in Wyoming where wintering swans have been found. Occasional swans observed in the Platte River drainage are not included. Data for the entire Tri-State Area, which includes portions of southwestern Montana and southeastern Idaho, can be found in Olson 2012.

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

Table 1. Continued.

Year	Age group	Yellowstone National Park	Snake River	Green River	Salt River	Wind River	Wyoming total
	Adult	88	321	160	133	24	726
2009	Cygnet	2	63	27	8	12	112
	Total	90	384	187	141	36	838
	Adult	18	369	160	85	16	648
2010	Cygnet	5	56	30	12	8	111
	Total	23	425	190	97	24	759
	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

Table 2. Fall survey results for the Tri-State Area flocks of the Rocky Mountain Population of Trumpeter Swan (*Cygnus buccinator*) that are resident year-round in states of Idaho, Montana, and Wyoming, 2002-2012 (Olson 2012). YNP represents Yellowstone National Park. [a] Includes Grebe Lake nest data where four eggs were collected and four 1-day-old captive-hatched young released in 2012. Swans at that site used an artificial nest platform installed in winter 2012.

Year	Age group	Montana	Idaho	Wyoming YNP [a]	Wyoming outside YNP	Tri-State total
	Adult	89	112	16	74	291
2004	Cygnet	32	23	2	37	94
	Total	121	135	18	111	385
	Adult	112	136	18	89	355
2005	Cygnet	40	22	1	35	98
	Total	152	158	19	124	453
	Adult	117	132	14	114	377
2006	Cygnet	17	39	0	26	82
	Total	134	171	14	140	459
	Adult	157	113	10	103	383
2007	Cygnet	41	15	0	59	115
	Total	198	128	10	162	498
	Adult	140	112	6	121	379
2008	Cygnet	7	5	2	34	48
	Total	147	117	8	155	427
	Adult	138	122	4	97	361
2009	Cygnet	21	21	0	33	75
	Total	159	143	4	130	436
	Adult	129	101	2	143	375
2010	Cygnet	30	29	0	48	107
	Total	159	130	2	191	482
	Adult	123	98	9	124	354
2011	Cygnet	40	12	0	37	89
	Total	163	110	9	161	443
	Adult	129	97	12	143	381
2012	Cygnet	96	30	4	48	178
	Total	163	127	16	191	559

Table 3. Occupancy and productivity data for Trumpeter Swans (*Cygnus buccinator*) nesting in Wyoming outside of Yellowstone National Park, 1990-2012. 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 shown in bold are ones that have been changed to reflect corrections in historic data. [a] Production data includes a site in the Green River drainage where eggs were collected and five 1-day-old young from Wyoming Wetlands Society's captive flock were grafted to a pair successfully in 2000, of which four fledged, and again in 2001, of which five fledged. Mean and standard deviation is shown for the ten year period 2002-2011.

Year	Sites occupied (*n*)	Nesting pairs (*n*)	Pairs with hatchlings (*n*)	Pairs with fledglings (*n*)	Individuals hatched (*n*)	Individuals fledged (*n*)
1990	19	13	4	3	11	8
1991	22	8	2	2	3	2
1992	29	10	5	3	17	9
1993	24	11	7	5	15	8
1994	20	13	8	5	29	18
1995	22	12	7	5	25	15
1996	23	12	7	4	17	6
1997	26	14	6	4	19	17
1998	23	18	10	7	26	15
1999	21	15	6	6	19	12
2000 [a]	26	16	11	10	42	31
2001 [a]	28	17	11	10	34	27
2002	24	11	9	8	23	17
2003	26	18	13	11	42	35
2004	22	17	14	11	54	37
2005	24	16	11	10	38	35
2006	24	18	12	8	33	26
2007	35	26	20	18	74	59
2008	35	16	12	11	39	34
2009	32	24	15	11	50	33
2010	37	24	18	12	66	48
2011	44	25	18	15	51	38
2012	44	28	18	16	62	48
Mean (SD)	31.0 (7.0)	19.5 (4.9)	14.2 (3.5)	11.5 (3.0)	47.0 (15.3)	36.2 (11.3)

Table 4. Comparison of Trumpeter Swan (*Cygnus buccinator*) nest site occupancy and productivity data for core and expansion areas in Wyoming outside of Yellowstone National Park, 2007-2012. Expansion areas include drainages where Wyoming Game and Fish Department worked to expand both summer and winter distribution by translocation of wild swans or release of captive-raised swans from 1986-2003 (Patla and Oakleaf 2004). Core area is where swans nested in the Snake River drainage and its tributaries prior to range expansion efforts. Number of young fledged refers to the number of mature young counted on the September aerial survey conducted annually. Successful pair refers to those nesting pairs that hatched young.

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

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

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

Table 6. Summary of Trumpeter Swan (*Cygnus buccinator*) annual mortalities in Wyoming, showing age class and probable cause of death, 1991 through 15 April 15 2013. Mortality of cygnets includes only those lost following fledge counts in September, so does not include brood reduction during the nesting season. [a] Mortality total for years 1991-1995 is not broken out by individual years; the following years' data are recorded for 15 April through 14 April for each period, but also includes carcasses and remains found after snow melt in May. [b] Swans with all white plumage over 1 year of age; likely some yearlings are included in this group. [c] Age not determined for 11 reported mortalities this period; necropsy reports not completed on 14 specimens submitted to lab. [d] Summary statistics are calculated only for the years 1998-2011.

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 mortalities (*n*)	Unknown mortalities (*n*)
1991-1995[a]	38	21	0	17	12	4	10	1	11
1995-1996	11	9	0	2	5	0	2	0	4
1996-1997	8	3	0	5	4	0	0	0	4
1997-1998	5								
1998-1999	10	8	0	2	2	1	0	1	6
1999-2000	10	7	0	3	6	2	1	1	
2000-2001	34	18	4	12	6	5	0	0	23
2001-2002	14	8	3	3	3	2	0	0	9
2002-2003	12	6	2	4	1	1	2	0	8
2003-2004	38	21	7	10	3	5	0	5	25
2004-2005	9	3	2	4	0	6	0	0	3
2005-2006[c]	49	27		11	1	0	1	0	47
2006-2007	10	8	0	2	0	0	0	0	10
2007-2008	11	7	1	3	4	1	2	1	3
2008-2009	16	11	3	2	4	1	0	0	11
2009-2010	6	4	1	1	1	1	0	0	4
2010-2011	7	6	0	1	4	0	1	0	2
2011-2012	32	21	3	8	5	1	1	4	21
2012-2013	27	18	11	8	2		1		24
Total[d]	285	173	27	74	42	26	9	12	196
Percent (%)		63	10	27	15	9	3	4	69

Appendix Table 1. Annual summary of occupancy and production status for all known Trumpeter Swan (*Cygnus buccinator*) nests in Wyoming outside Yellowstone National Park, 2002-2012 by area. Sites include: CTNF – Caribou Targhee National Forest; GTNP – Grand Teton National Park; NER – National Elk Refuge; and Seedskadee NWR – National Wildlife Refuge. Key to the table codes includes: O – pair occupied site through nest period, did not attempt to nest, did not molt on site; OM – pair occupied territory through nest period, did not attempt to nest, molted on site; OL – pair occupied site late after nest initiation period; Nxy – pair nested, x = number of young hatched, y = number of mature young in September; OUID – pair reported on site but status not determined; NB – nonbreeding swans present, likely subadults; F – swans observed on fall (September) flight only; 1A – only one adult present; NS – not surveyed; --- – no swans observed all season.

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CTNF											
Ernest Lake	NB	NB	---	NB	---	---	---	---	---	---	---
Bergman Marsh	---	NB	---	---	---	---	---	---	---	---	---
Indian Lake	N33	N33	N55	N00	N10	N44	O	N40	N30	N30	N41
Widget Lake	---	F	---	---	---	---	---	---	---	---	---
Winegar Creek								N30	N20	N30	1A
Fall River Slough						N00	---	---	---	---	---
Loon Lake	---	F	---	---	---	---	---	---	OL	---	---
Rock Lake	---	---	OL	OM	N00	---	O	---	---	---	---
Rock Lake slough									N41	---	---
Junco Lake	---	---	---	---	N00	---	---	O	---	---	---
Fish Lake	---	---	---	---	---	---	---	---	---	---	---
Squirrel Meadows	NB	---	---	OL	---	---	---	---	---	---	---
Moose Lake	NB	---	---	---	---	---	---	---	---	---	---
GTNP											
Upper Glade			N00	OM	---	---	---	---	---	---	---
Steamboat Mountain	OM	---	N00	---	N43	O	O	OL	O	O	OL
Glade Cliff Slough				N00	N10	O	N00	O	O	O	N11
Glade South	N00	N10	N22	N00	O	O	---	---	---	---	---
Christian Pond	---	---	---	---	---	---	---	---	---	---	---
Arizona Lake	---	---	OM	N20	N40	N00	N00	N30	N20	N20	N00
Emma Matilda	NB	---	---	NB	NB	---	1A	OL	OL	OL	OL
Two Ocean Lake	N32	N30	N00	OM	OM	---	---	---	---	1A	---

Appendix Table 1. Continued.

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GTNP (cont.)											
Swan Lake	O	N00	N33	NB	OL	OM	N22	O	OM	N55	O
Hedrick Pond	O	O	---	NB	1A	O	---	---	---	---	---
Elk Ranch	OM	OM	OM	OM	OM	O	O	O	OL	OL	O
Cow Lake	---	---	---	---	---	---	---	---	---	---	---
Spread Creek Ponds	NB	---	---	---	---	---	---	---	---	---	---
Cygnet Lake	---	---	---	---	---	---	---	---	---	---	---
Polecat Slough	---	---	---	---	---	---	1A	1A	---	---	---
NER											
Highway Pond NER	N11	N10	---	N00	---	N55	---	---	N00	---	---
NE Marsh NER	N42	N33	N44	---	N32	NB	O	---	---	O	
Flat Creek Island NER								N00	N10	N00	N00
SE Marsh NER	N00	N11	N43	O	N11	N42	N00	N11	---	O	N11
Central Marsh NER	N00	---	N22	N44	N33	N57	N33	O	N55	N00	N11
Elk Jump Pond NER											N00
Pierre's Ponds	N11	N33	OM	O	OM	---	---	---	NB	O	---
Romney Ponds			OM	OL	NB	N44	N44	N43	NB	O	NB
Jackson area											
Skyline/Puzzleface	OM	OM	O	NB	---	---	---	---	NB	NB	NB
WGF South Park	---	---	---	1A	OL	OM	OM	N44	N66	N44	N55
Buffalo Valley											
Pinto/Halfmoon	N11	O	N31	N55	N33	N66	N44	N54	OM	N11	N00
Halfmoon BV										N44	----
Blackrock Slough											N60
Tracy Lake							OL	OL	OL	OL	NB
Lily Lake	N00	N20	---	---	---	---	---	---	---	---	---
Teton Wilderness											
Enos Lake	OM	N44	---	---	NB	NB	NB-3	---	NB	NB	NB
Atlantic Creek	---	---	---	---	---	---	---	nc	OUID	O	N00

Appendix Table 1. Continued.

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Salt River											
Kibby/Salt R Cove	N00	N00	N00	NB	---	---	---	---	---	---	---
Alpine Wetland North	1A	NB	NB	NB	NB	N00	---	NB	NB	NB	NB
Alpine Wetland South						NB	O	N00	N00	N21	N00
Jacknife Creek area											O
Gros Ventre River											
Lower Slide Lake	---		---		---	---	---	---	NB	NB	---
Upper Slide Lake	NB	OM	N11	N22	N00	OM	OM	OM	OM	O	O
Grizzly Lake Pothole	---	---	---	---	Dry	Dry		---	---	---	---
Burnt Fork	---	---	---	---	---	---	---	NB	---	---	---
Soda Lake	---	---	---	---	---	---	---	---	---	---	---
Green/New Fork Rivers											
Wagon Creek Lake	NB	O	O	---	---	---	NB	---	---	---	---
Rock Crib	---	O	---	---	---	---	NB	---	---	---	---
Wagon Cr Pothole						N00	---	---	N42	O	O
Mosquito Lake	OM	1A	OL	---	NB	N32	N00	N00	O	OL	O
Roaring Fork Pond	---	---	---	---	---	---	---	---	---	---	---
Mud Lake	N20	---	N50	N20	N20	N52	OE	---	OL	O	N00
Circle S slough									N00	---	NB
Jensen Pond, Green River											O
Carney Oxbow			N55	N22	N00	N44	N00	N00	N22	N00	O
Carney Pond								N30	---	---	---
Q Y Bar Reservoir						O	O	---	---	---	---
O Bar Y Pond, new 2012											N44
Marsh Creek Pothole						N22	---	---	---	---	---
Kendall Wetland	OM	N00	N00	NB	NB	OL	N11	N33	OM	O	N44
Blatt Res. Willow Creek											NB
Kitchen Main	N44	N54	N44	N22	N33	N54	N53	N11	N22	N32	N43
Kitchen Middle	NB	NB	NB	OM	OM	OM	O	N22	N55	N43	---
40 Rod CR area									F	NB	NB

Appendix Table 1. Continued.

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Webb Draw									F	N00	N10
McCroft Lane											N00
Fayette New Fork					NB	N33	N40	N00	---	N33	N55
Swift New Fork							N54	OL	N33	OL	NB
Barden Slough	---	N00	OM	OM	OM	---		---	---	---	---
Swift Reservoir	OM	NB	NB	---	OL	OL	NB	NB	OL	O	N21
East Fork Hunt Club										N11	N21
Jensen Slough N Fork							OL	O	N22	O	N21
Sommers Green River											O
Cottonwood Cr mouth											NB
Rimfire Rendezvous											NB
Rimfire Sophia											OL
Soaphole BLM pond											NB
Muddy Cr, n B. Piney											NB
Ferry Island						N22	N33	N00	N44	OL	N22
Shafer Slough	---	NB	---	---	NB	---	---	NB	NB	---	NB
Reardon Draw										N11	NB
Voorhees Pond	---	---	---	---	---	---	OL	---	N00	O	O
LaBarge Creek Pond										O	----
Big Sandy Reservoir	---	---	---	---	NS	---	nc	---	---	---	---
Eden Reservoir									1A	1A	NB2
Farson area									N22	O	O
<u>Seedskadee NWR</u>											
Hamp Unit			N33	N44	N53	O	N00	N00	N42	N42	N00
Hawley 1	NB	N44	N60	N65	N54	N22	N33	N43	NB	O	N55
Hawley 2		N44	N54	N00	N66	N33	N66	N44	N55	N44	N66
Hawley 2 S									N43	N33	---
Hawley 3		N43	---	N33	---	NB	NB	---	NB	O	---
Hawley 5								N33	NB	NB	---
Hawley 6	Dry	N44	N65	N77	N00	NB	NB	---	N44	N22	N55

Appendix Table 1. Continued.

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sage Pools						N31	N33	N75	N42	N22	N77
Other Wyoming											
Swamp Lake, Cody	1A	1A	---	---	---	---	NC	NC	NC	---	---
Trail Lake, Dubois				OM	OM	---	---	---	---	---	---
Dinwoody Lake									F	---	---
Lake Julia									O	1A	---
Martens Pond										O	---
Colony eastern WY	1A	NB	NB	NS	NS	---	---	NC	NC	OL	NB

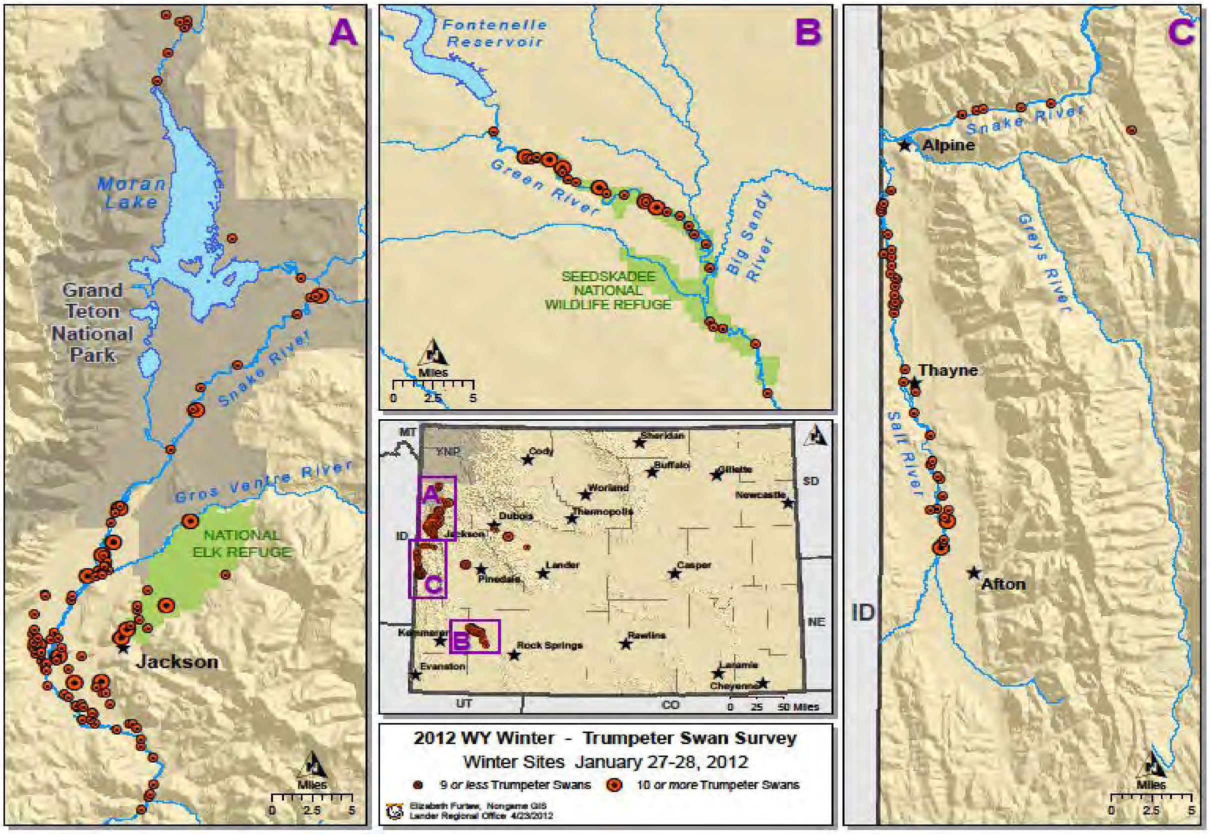

Figure 1. Locations of wintering Trumpeter Swans (*Cygnus buccinator*) in Wyoming documented during the annual winter aerial survey flown 27-28 January 2012. Swans were observed in similar locations in February 2013 on the winter survey. The State map in the lower center shows all wintering locations with the three main wintering areas labeled to correspond to the expanded sub-area maps including: A – Snake River core area, B – Green River range expansion area, and C – Salt River range expansion area. Prior to management efforts beginning in the late 1980s to increase the distribution of swans in the Tri-State area, all swans wintered in the Jackson core area.

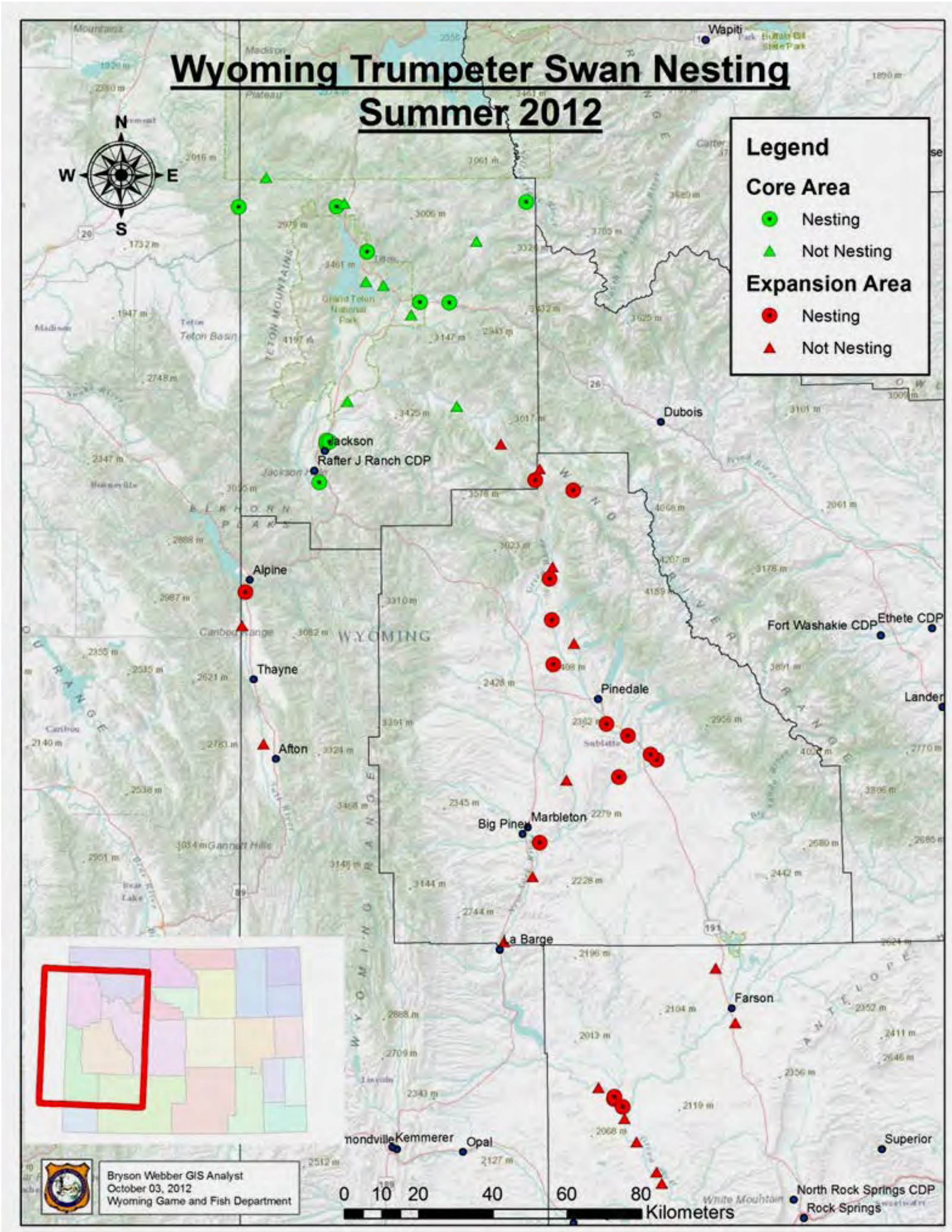

Figure 2. Locations of nest sites occupied by pairs of Trumpeter Swans (*Cygnus buccinator*) in Wyoming in the 2012 nesting season. Shown are nests in the core Snake River area (green dots) and nests in the range expansion areas (red dots). In a few cases, a single dot represents >1 occupied site for sites located in close proximity to each other. Pairs did not lay eggs at all occupied sites.

FACTORS AFFECTING DETECTABILITY OF HARLEQUIN DUCKS (*HISTRIONICUS HISTRIONICUS*) IN THE PRE-SEASON NESTING SEASON

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Harlequin Duck

FUNDING SOURCE: Donations from Bob Berry of Sheridan, Wyoming and Wyoming Game and Fish Department

PROJECT DURATION: May – June 2004

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Susan Patla, Nongame Biologist
Bob Oakleaf, Nongame Coordinator

ABSTRACT

This report makes available a previous unpublished report of a 2004 study that has been useful in understanding results of monitoring programs for Harlequin Ducks (*Histrionicus histrionicus*). Previous surveys for the species left unanswered questions; this study was designed to provide some answers: What is the best time of day or month to conduct surveys? What variables might affect detection rates? A stream in northern Grand Teton National Park offered nesting pairs of harlequins that were visible from vantage points that would not disturb the birds. The objective of the study was to obtain data on behavior and activity patterns of harlequins in the pre-nesting period in western Wyoming, after they first return from wintering grounds but prior to egg-laying, to determine what factors might affect detection rates of ducks in the early morning hours. Our study protocol called for two observers to conduct a minimum of three surveys 2-4 days in length: 1) early to mid-May after ducks arrive, 2) near the end of May, and 3) in early June. Each day we observed harlequins for a 4-hr period in the morning, 0600-1000 hrs, with an additional 2-hr period randomly selected from 1000-1600 hrs. We recorded locations, behavior, and factors that may influence the potential for ducks to be observed from a survey helicopter. The proportion of time spent foraging was highest in the early morning period 0530-0800 hrs (81%) and in the late afternoon 1600-1800 hrs (92%) but remained above 50% for all periods. We noted that typical foraging habitat included riffles with constantly changing light reflections and that harlequins were especially difficult to see while foraging. Ducks were less active during the 1000-1200-hr time period, with 43% of total time spent resting. Harlequins tended to rest for longer intervals in the middle part of the day. Typical resting habitat included eddies or bare islands and gravel bars where harlequins appear easier to detect as opposed to feeding habitats.

INTRODUCTION

This report makes available a previous unpublished report that has been useful in understanding results of monitoring programs for Harlequin Ducks (*Histrionicus histrionicus*). Helicopter surveys were conducted by Wyoming Game and Fish Department (Department) Nongame Program personnel in May/June 2002 for Harlequin Ducks (*Histrionicus histrionicus*) during the pre-nesting season along 35 rivers and streams in Teton and Sublette Counties, Wyoming. Our results suggested that detection rates of harlequins might be biased low in the early morning hours prior to 0800 (Oakleaf et al. 2003). During the surveys, we documented a total of 63 harlequins, including 21 pairs in previously unsurveyed habitat on the Bridger-Teton National Forest. Aerial surveys were run between 0700 and 1600 hrs when lighting conditions were thought to be most optimal and to avoid heavy shading along drainages early and late in the day. Almost all detections, however, occurred between the hours of 0800 and 1600 hrs. We observed only one pair prior to 0800 hrs, although we surveyed 63 km of stream/river courses during this time period in areas where historic records existed. Particularly noticeable were results from Owl and Berry Creek drainages in the northern portion of Grand Teton National Park (GTNP) where, based on previous records, we anticipated finding up to seven pairs, but observed only one (Oakleaf et al. 2003, Wallen 1987). The objective of the current study was to obtain data on behavior and activity patterns on harlequins in the pre-nesting period in western Wyoming, after they first return from wintering grounds but prior to egg-laying, to determine what factors might affect detection rates of ducks in the early morning hours. Information on factors influencing harlequin detection should help plan more effective and efficient aerial monitoring surveys in the future. This would be especially valuable given the high cost of helicopter surveys, and the difficulty of scheduling survey flights in spring due to variable weather and run-off conditions.

The Harlequin Duck is a summer resident in western Wyoming and one of the State's rarest nesting waterfowl species. Nesting pairs have been documented along remote mountain streams in the northwestern part of the state (Department Wildlife Observation System records). Harlequin Ducks arrive in late April/early May in Wyoming and depart by the end of September for wintering areas on the Pacific Coast (Wallen 1987). Wyoming constitutes the southeastern perimeter of the Pacific Coast population's range. Potential threats to the species in the State include range contraction due to population fluctuations, stress from long distance migrations, habitat loss or degradation, and reduced productivity in areas of heavy human recreational use (Wallen 1993). The overall range of the harlequin has been reduced in some peripheral areas, and ducks no longer breed in Colorado and California (Robertson and Goudie 1999). The objectives of the Department's Nongame Plan for this species include adequately documenting distribution in the state, and coordinating with other agencies to monitor known nesting populations (WGFD 1996).

METHODS

We selected the Moose Creek drainage in GTNP as the primary study area, as it provided reasonable access to a concentration of harlequins early in the season. A park cabin located close to survey sites was also available for observers to use. During a helicopter survey on 25

May 25 2002, we had observed a total of five pairs of harlequins along the lower stretch of this drainage. In 2003, we conducted scouting trips in June and October to identify potential ground observation sites. The sites offering the best visibility included the steep forested ridge located north of the creek, an open bluff bordering the creek to the south, and creek-side sites at strategic points with dense willow cover. All surveys were conducted from the mouth of the creek to a point approximately 2 km upstream where the north and middle branches of Moose Creek divide. Above this point, the stream gradient increased and forest cover became dense, making it difficult to observe ducks from any location.

We conducted ground surveys during the optimal time we had identified for spring helicopter survey work; that is, as soon as ducks arrived from wintering grounds in May until early June when spring run-off occurred or females began to initiate nesting. Study protocol called for two observers to conduct a minimum of three surveys 2-4 days in length: 1) early to mid-May after ducks arrive, 2) near the end of May, and 3) in early June. Each day observers were to survey a 4-hr period in the morning, 0600-1000 hrs, with an additional 2-hr period randomly selected from 1000-1600 hrs. Observers, using binoculars and spotting scopes (45x) and in radio contact with one another, collected focal point time budget data on individual pairs or ducks, and recorded activities (forage, rest, preen, swim, or out of sight) to the minute. Observers also noted any behaviors or physical features that could result in decreased visibility of ducks. Duck locations were documented by GPS waypoints or use of a grid overlay on aerial photographs of the drainage. Surveys were cancelled or shortened if visibility was impaired due to fog or precipitation. In addition to ground surveys, two aerial fixed-wing surveys were flown. The first (17 May) was to determine the location of ducks in the drainage prior to the start of the first survey period. We scheduled a second aerial survey to coordinate with a ground survey (27 May 27) to compare the number of pairs observed from the air to those being seen by ground observers and to document, if possible, the response of harlequins to an aerial disturbance.

For time budget data analysis, observation data for pairs or individual ducks were summarized over consecutive 2-hr time periods between 0600 and 1800 hrs. The proportion of time spent per activity was averaged over each 2-hr period and compared between periods to determine variability in behavior during the course of the day. Behavior of males and females in pairs observed in May was remarkably synchronous, so behavior was coded for each pair rather than for individual pair members. For the few times when one pair member behaved differently than its mate, behavior was coded for the more active individual. For instance, if the female foraged while the male rested, pair behavior was coded as foraging. Observers collected data prior to 0600 hrs on a few days, and the summary time period 0600-0800 hrs includes observations recorded between 0530-0600 hrs, as behaviors observed during this time were similar to the subsequent 2 hr period. These pre-0600-hr observations accounted for 18% of the total data collected in the 0600-0800 hrs period. We did not run statistical analyses on the time-budget data, as total observation time was not equal between all periods of the day, and we could not determine how many different individuals or pairs contributed to the data set overall.

During May and early June 2004, we coordinated with various agency personnel to look for harlequins in other locations in western Wyoming, including Yellowstone National Park (YNP), Granite Creek and Cascade Creek (GTNP), and Teton Creek on the Caribou-Targhee

National Forest. Pairs were observed in YNP, but harlequins were not observed in the other drainages surveyed.

RESULTS

Conditions for conducting Harlequin Duck surveys in spring 2004 proved to be challenging. As a result of ongoing drought, river and stream flows were well below average but, ironically, higher than average precipitation fell during the actual field season in May. As of 1 May 2004, Jackson Lake reservoir capacity was 55% of average (259,600 acre-feet compared to 471,000 acre-feet; Natural Resources Conservation Survey, Wyoming Basin Outlook Report, June 2004). The lakebed was exposed in the northern portion of the basin where the study was conducted, and the Snake River and associated streams flowed through empty mud flats that normally are covered by reservoir water at this time of year. Access to the study site required hiking across mudflats from the GTNP Lizard Point campground on the east side of the reservoir, while pulling a canoe or kayak for crossing the exposed Snake River channel. Due to a greatly reduced snow pack (46% of average as of 1 June), stream flows were also greatly reduced, running only 55% of normal in the upper Snake River Basin. Lower stream flows and lack of reservoir water likely affected duck foraging and movement patterns, and fewer pairs were observed on a daily basis compared to the total of five pairs documented on a single day (25 May) in 2002 when lake and stream levels were more normal. Field conditions on most days in May 2004 proved to be wet and cold, and precipitation for the month totaled 37% above average (Natural Resources Conservation Survey, Wyoming Basin Outlook Report, June 2004). Precipitation occurred on almost every survey day in May 2004, resulting in reduced survey hours and decreased visibility on some days. Water temperature in the creek ranged from -1 to 10^{o} C. Air temperatures in early mornings hovered near freezing, and on most survey days did not range above 7 to 13^{o} C.

We completed over 75 hours of surveys on 12 different days at Moose Creek between 13 May and 13 June 2004 (Table 1). We did not use the ridge observation site on the north side of the creek after 19 May, as it proved to be of limited value compared to the bluff observation point on the south side and observation sites located directly along the stream channel. Observers found that if we stayed low and moved slowly, we could observe and follow harlequins along the stream bank without disturbing or displacing the ducks. The highest number of pairs seen during any observation period was a total of three on 22 May. We did not locate additional pairs from the aerial observation flights on 17 May and 27 May compared to numbers we found on the ground on the same days.

We summarized time budget data for observations from 17 May-28 May (Table 2). Total time budget data we collected equaled 30.8 hrs, with 54% of the data collected between 0530-1000 hrs (Table 2). We did not include summary data in this analysis from the last survey period on 13-14 June, as harlequin behavior collected for one pair and one male during this last session was quite different compared to earlier survey periods. From 17-28 May, harlequins spent a majority of time between 0530-1800 hrs foraging (Table 2). The proportion of time spent foraging was highest in the early morning period 0530-0800 hrs (81%) and in the late afternoon 1600-1800 hrs (92%), but remained above 50% for all periods (Table 2). Ducks were less active during the 1000-1200-hr time period, with 43% of total time spent resting. Harlequins tended to rest for longer intervals in the middle part of the day compared to early and late in the day. In the 13-14 June survey period, resting time for the ducks exceeded foraging time throughout the day, a reverse of the pattern we documented in May (Table 2).

In May, we observed harlequins moving upstream and downstream throughout the study area to forage, but they often used the same locations along the creek to haul out and rest or sleep. The sites used most frequently were open, gravel-covered areas on island bars or along the creek edge, often by an eddy/riffle complex. They occasionally hauled out on large snags or rocks. The ducks would usually jump out of the water completely, but a few times we observed them standing in the water next to shore, resting or preening. When pairs were hauled out on gravel bars or edges, they were visible even from a distance due to the bright pattern of the male harlequins.

Although we often observed pairs and individual harlequins at the same locations during different observation periods, we could not always find them at the start of an observation period or keep them in view constantly. We did not have ducks in view 15% of the total survey time. During some observation periods, no ducks were detected, even though some had been observed earlier or later that same day. On 19 May, for example, we observed two pairs during the early morning observation period but found none in the afternoon in the study area. During some survey periods, we did not see pairs immediately, but then found them later along the same stretch. We never observed harlequins flying in or out of the Moose Creek area. We also did not see harlequins moving out of the stream into vegetation along the bank, but this may have been difficult to observe. On a few occasions, we saw harlequins early or late in the day near or below the confluence of Moose and Berry Creeks. This suggests that there were some movements by ducks out of the Moose Creek drainage into the main channel of the Snake River.

Harlequins foraged while moving up and downstream, but tended to concentrate foraging activity in the most swiftly moving segments of water. During May 2004, Moose Creek did not have large extensive patches of riffles, but when ducks used such patches they were more difficult to see. The ducks foraged most frequently with only their heads under water, compared to complete submersion. On occasion, harlequins dove to forage in deep pools or channels, completely disappearing under water for up to 18 sec. Pair members usually foraged close together in similar water depth and behaved in a similar fashion. When two pairs forged in the same location, we observed agonistic interactions occasionally, with males rushing toward the other male or pair. Often, pairs would move apart after such interactions.

There appeared to be some differences in pair behavior observed on the first two survey days compared to later sessions in May. On 17 and 18 May, both males and females in pairs fed and rested together consistently. The following week, males did not forage as consistently as the females and often appeared to be more alert and looking about, a behavior we characterized as “guarding”. Males, during some sessions, would haul out and rest more frequently compared to females.

We observed harlequins responding to disturbances on a number of occasions. Disturbances that resulted in changes of behavior included elk or deer crossing the creek, other species of ducks foraging duck close by [Barrow's Goldeneye (*Bucephala islandica*) and American Wigeon (*Anas americana*))], human activity on the bank, and low flying aircraft. Harlequin responses varied in intensity along a behavioral gradient ranging from: 1) a short cessation of foraging to look about; 2) drifting slowly downstream away from the disturbance; 3) swimming across the stream to an open eddy area and remaining alert for a short while before resuming feeding; 4) swimming quickly for cover either around a bend, near a bank, or behind vegetation or a gravel bar; 5) skittering swiftly across the creek to the opposite bank, often accompanied by a vocalization; and 6) bursting into flight low over the creek and flying away either up- or downstream. Responses seemed to depend upon the location of the ducks and their current state of activity and alertness. If actively feeding, they appeared to be more likely to respond then if hauled out and resting. For instance, when a low flying survey plane passed overhead a few times on 27 May, one pair of harlequins was hauled out sleeping on a gravel bar. These two ducks looked up and moved a little at the first fly-over, but did not respond to additional passes and remained resting on the bar. Another pair that was foraging downstream dove when the plane first passed over, resurfaced in the same location after a few seconds and continued to forage.

DISCUSSION

Results from this study indicate that harlequins in Wyoming forage most intensely early and late in the day during the pre-nesting period when they first return to breeding streams. Other studies have suggested a similar pattern of behavior during the breeding season for both sexes of harlequins (Robertson and Goudie 1999). This pattern of behavior likely reduces the probability of detecting ducks during aerial surveys in the early morning hours prior to 0800 hrs, although other factors will also influence survey results in the pre-nesting season. Following is a summary of important points to consider for planning future aerial surveys, based on both our quantitative and qualitative observations:

1) The intensity and angle of early morning sunlight results in subtle changes in color and reflection, both in the surface water and the harlequins' back feathers. Before 0800 hrs in May, when ducks were foraging with heads down and only upper backs exposed, they could easily be mistaken at certain moments for rocks in the stream, even from a short distance. At times, due to this type of optical illusion, they would appear to vanish before an observer's eyes without actually leaving the area. Sparkling glare reflecting off of riffle areas, where ducks often foraged, increased the difficulty of seeing them. Given their pattern of coloration, harlequins would be camouflaged any time of day in riffle patches, but this effect seemed greatest when sunlight was of low intensity and angle early and late in the day. Considering that most of the year harlequins are found in the northern oceans where light is often subdued, it makes sense that their feather patterning would provide most effective camouflaging under low light conditions.

2) The intensity of duck foraging behavior and length of individual foraging bouts was greatest in the early morning hours compared to later in the day when ducks rested more

frequently. A higher rate and intensity of foraging behavior in the early morning would decrease the probability of detection compared to later in the day, in addition to the light effects described above. Given the striking pattern of the male ducks, if they are hauled out of the water or floating upright, the chances of observing them especially from the air is greatly increased. If ducks are foraging with heads submerged or diving, an aerial observer in a helicopter passing overhead rapidly could easily miss them. Also, it appears that actively foraging harlequins are more responsive to disturbances and, thus, more likely to dive or hide compared to resting ducks.

3) Movements of ducks in the early part of the breeding season appear to be quite dynamic. Varying conditions of spring runoff and invertebrate abundance likely affect such movements. Although Wallen (1987) concluded that most pairs should be at nesting areas in GTNP by 15 May, this might vary considerably between years. Pairs that nest at higher elevation areas in western Wyoming might not settle into nesting areas until stream discharge increases in their nesting streams, especially in years with low flows in May. Also, newly arriving ducks might stay at staging areas for varying amounts of time prior to moving on to actual nesting areas. We observed fewer total pairs in 2004 along Moose Creek compared to 2002, suggesting that ducks may be responding to hydrological conditions that vary between years. The variation in number of ducks seen on a daily basis during this current study on Moose Creek also suggests that ducks were not settled into their nesting territories or consistent in their use of stream segments. Movements outside of the study site may have been occurring or harlequins may have been hauling out to inspect nest sites in vegetation along the bank. The overall result was that we could not predict how many ducks we were going to see during any particular observation session.

4) We did not observe pairs of harlequins in Owl or Berry Creeks during our early morning survey on 25 May 25 2002, suggesting low detection rates in early morning. Although Wallen (1987) estimated that 6-12 pairs should be found along Berry and Moose Creeks, he, in fact, found only 6 broods total along these creeks per year in the intensive years of his study in 1985 and 1986. Number of adult females reported for these years was six or seven per creek, but it is not clear if these included unpaired females or perhaps repeat sightings of the same adults over time. Ground surveys are needed along these drainages during the nesting season to determine how many nesting pairs currently occupy Owl and Berry Creeks compared to Moose Creek. The five pairs we observed in May 2002 may have included some pairs that moved over to Owl and Berry Creeks to nest later in the season.

Results of the current study suggest that, given early morning conditions and duck behavior, lack of observations along stream segments prior to 0800 hrs during our May 2002 aerial survey need to be considered with caution. Segments of streams where no harlequins were seen should be resurveyed in future years to determine status of harlequin occupancy. Our assumption, that aerial surveys would be best if flown in May as soon as ducks returned and prior to run off, should also be tested. Even though we found many pairs along some streams in May 2002, we may have flown other stream segments too early in the season, before pairs settled into nesting areas. We recommend that a future aerial survey study be conducted along selected streams in the Wind River and Gros Ventre Ranges where no ducks were detected in 2002, as well as a few control streams where numerous pairs were documented. For this study, surveys should be scheduled first in mid-May and then repeated 2-3 weeks later to determine if detection rates increase due to water flow or behavioral changes. The optimal time to fly surveys may be later than we first surmised.

In addition to further testing aerial survey methods, we recommend that a long-term monitoring program be set up in coordination between Yellowstone and Grand Teton National Parks, the Bridger-Teton National Forest, and the Department to make sure that numbers of this rare waterfowl species continue to persist in the state of Wyoming. Monitoring of recreation and management activities along nesting streams is also needed in some historic nesting areas. During the current study, we were surprised to discover a number of backcountry recreationists in the Moose Creek area, especially given the poor access and weather conditions in May. The popularity of new guidebooks that specifically direct hikers to relatively unvisited areas of our public lands may be increasing visitation, especially early in the season in remote areas of harlequin habitat that have been relatively undisturbed in the past. The fact that no pairs were found along the more highly visited streams, such as Granite and Cascade Creeks in GTNP, also needs further investigation. A recommended long-term survey protocol can be found in Oakleaf et al. (2003).

ACKNOWLEDGEMENTS

This project was funded through a generous donation to the Department's Nongame Program from Bob Berry of Sheridan, Wyoming. D. Lingle and M. Merigliano, veterans of the Teton Range backcountry and numerous other field projects, collected most of the data on duck behavior. G. Lust, owner of Mountain Air Research out of Driggs, Idaho, flew the aerial surveys and provided timely information on duck locations. S. Wolff, GTNP biologist, provided logistical support and guidance for obtaining a park research permit. We thank the GTNP North Ranger District personnel for use of the Lower Berry Creek Cabin. M. Hare provided help with graphics.

LITERATURE CITED

Oakleaf, B., S. Patla, and K. Taylor. 2003. Harlequin duck inventories and technique development. Unpublished report. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Robertson, G. J., and R. I. Goudie. 1999. Harlequin Duck (*Histronicus historionicus*). *In* The Birds of North America, Number 466 (A. Poole and F. Gill, Editors). The Birds of North America, Ind. Philadelphia, Pennsylvania, USA.

Wallen, R. 1987. Habitat utilization by harlequin ducks in Grand Teton National Park. Thesis. Montana State University, Bozeman, USA.

Wallen, R. L. 1993. Status and distribution of harlequin ducks in Wyoming. Unpublished report. Grand Teton National Park. Moose, Wyoming, USA.

Wyoming Game and Fish department [WGFD]. 1996. Nongame Bird and Mammal Plan. Unpublished report. (Prepared by B. Oakleaf, A. O. Cerovski, and B. Luce). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Table 1. Summary of Harlequin Duck (*Histrionicus histrionicus*) survey effort per observer in the Moose Creek drainage, Grand Teton National Park, spring 2004, Wyoming Game and Fish Department.

Date	Start time (hrs)	End time (hrs)	Total minutes	# pairs	# single males	Notes/observer location
5/13/04	1300	1700	240	0		Scout trip, no ducks seen
5/17/04	1554	1871	177	2		First time budget survey
5/18/04	0615	1100	285	1		Creek side observation site
5/18/04	0608	1000	232	1	1	Ridge observation site
5/18/04	1400	1600	120	2		Creek side observation site
5/18/04	1400	1600	120	1		Ridge observation site
5/19/04	0555	0903	188	1		Bluff observation site
5/19/04	0605	1000	235	1	1	Ridge observation site
5/19/04	0915	1011	56	1		Upstream survey
5/19/04	1141	1400	139	1	1	Ridge observation site
5/19/04	1204	1400	116	0	1	Creek side observation site
5/21/04	1500	1700	120	0		Survey lower end of creek
5/22/04	0845	1230	225	3		Heavy rain early morning
5/23/04	0535	0906	221	1		Mouth of creek
5/23/04	0540	1000	262	1		Upstream and bluff
5/26/04	1516	1700	104	1		Bluff and creek side
5/27/04	0530	1000	270	1		Creek side observation site
5/27/04	0533	0940	247	1		Creek side observation site
5/27/04	1400	1600	120	1		Hairpin bend
5/27/04	1400	1600	120	1		Beaver pond outlet
5/28/04	0530	1006	276	1		Creek side observation site
5/28/04	0530	1000	270	0	1	Upstream survey
6/12/04	1332	1655	203	0	1	Creek side observation site
6/13/04	0715	1000	165	1	1	Creek side observation site
Total			4511			75.2 Hours Total

Table 2. Summary of Harlequin Duck (*Histrionicus histrionicus*) daily time budget data showing average (and standard deviation) for time periods, 17-28 May 2004. Proportion of activity shown was calculated based on total time that ducks were in view during that particular time period (*n*=number of individual observation sessions of either pairs or single males per period).

Time period in hrs (number of sessions)	% Foraging (SD)	% resting / preening	% swimming or display	Total viewing time (min)
0600-0800 (*n*=6)	81 (7)	8 / 6	1	525
0800-1000 (*n*=6)	76 (19)	22 / 20	2	479
1000-1200 (*n*=3)	55 (19)	43 / 16	3	174
1200-1400 (*n*=2)	73 (16)	25 / 13	2	163
1400-1600 (*n*=4)	62 (32)	37 / 32	1	361
1600-1800 (*n*=2)	93 (9)	3 / 0	4	145

HARLEQUIN DUCK (*HISTRIONICUS HISTRIONICUS*) INVENTORIES IN NORTHWEST WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Harlequin Duck

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations, Wyoming Game and Fish Department, and Unites States Forest Service Bridger-Teton National Forest.

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Bob Oakleaf, Nongame Coordinator
Susan Patla, Nongame Biologist

ABSTRACT

The State monitoring plan for the Harlequin Duck (*Histrionicus histrionicus*) includes helicopter surveys of designated monitoring streams every 5 years. Baseline surveys were completed in 2002 and follow up surveys in 2007, 2008, and 2012. We surveyed 158.6 km of monitoring streams in 2012 and located 22 pairs and 2 single males for a total of 46 harlequins. Results in 2012 were similar to 2002 baseline numbers of 27 pairs and 2 single harlequins on selected monitoring streams. We also located four pairs of harlequins in 2012 with surveys of 81.9 km of additional stream segments to improve our knowledge of distribution. We discussed possible variables affecting results.

INTRODUCTION

Harlequin Ducks (*Histrionicus histrionicus*; harlequins) occur in disjunct populations associated with Pacific and Atlantic coastlines in North America and Asia. Harlequins winter and molt in coastal habitats and migrate inland to nest along swift flowing mountain streams. In western North America, the breeding range extends from Alaska, British Columbia, Washington, and Oregon to eastern slopes of the continental divide in Alberta and Montana, and south to southeastern Idaho and northwestern Wyoming (AOU 1983). The abundance, distribution, and status of harlequins in Wyoming are detailed in Oakleaf et al (2003). We estimated at least 70 breeding pairs of Harlequin Ducks in Wyoming based on results from 2002 and previous surveys. As detection rates can be as low as 50% for harlequin surveys, given the difficulty of observing this species, this should be considered a minimum estimate (Oakleaf et al. 2003).

Wyoming Game and Fish Department (Department) objectives for monitoring Harlequin Ducks include helicopter surveys of designated drainages every 5 years for a count of breeding pairs. Additional surveys are conducted as cooperative funding becomes available to improve our knowledge on distributional information. Monitoring efforts are coordinated with Grand Teton National Park (GTNP), Yellowstone National Park (YNP), the Shoshone National Forest (SNF), Bridger-Teton National Forest (BTNF), and Caribou-Targhee National Forest (CTNF).

We developed monitoring plans based on extensive ground and aerial surveys previously conducted (Oakleaf et al. 2003). Portions of an exhaustive survey conducted in 2002 provided a baseline for comparison. In 2007, we conducted the 5-year follow-up monitoring effort. Results from the 2007 survey indicated a much lower number of nesting pairs, especially in the Teton Wilderness area of the BTNF (Patla and Oakleaf 2009). However, we conducted 2007 surveys during extreme drought conditions and early spring runoff that preceded our surveys. In 2008, we received funding from the SNF and BTNF to conduct follow-up aerial monitoring surveys to assess whether the low numbers of nesting pairs observed in 2007 reflected an annual fluctuation (a result of low water flows in May) or perhaps a more systemic decline in nesting pairs compared to 2002 results. Surveys in 2008 indicated harlequin numbers at or near 2002 abundance levels, indicating that harlequins probably dispersed in 2007 without nesting after finding low water levels. Ground surveys for broods during the summers of 2002, 2007, and 2008 strongly substantiated the relevance of aerial breeding pair survey (Patla and Oakleaf 2009).

METHODS

Aerial surveys for breeding pairs of Harlequin Ducks were conducted in 2012 with a Bell 47 Soloy helicopter on 29-30 May. We attempt to schedule surveys after known arrival dates of harlequins, but prior to the onset of incubation and high water of spring runoff. The helicopter was flown along drainages at approximately 55 kph and 20-50 m above ground level. A pilot and two Department biologists experienced in Harlequin Duck aerial surveys were aboard. Data collected included GPS locations, and number and gender of harlequins observed, as well as other wildlife species of interest. We surveyed all drainages twice (up and back) to account for different lighting conditions and wind speed. We verified that harlequins located on the second pass were different than those detected on the first pass by checking on the nearest pair to assure the observation was not a duplicate and could be added to the results.

RESULTS

We surveyed 158.6 km of designated monitoring streams for harlequins by helicopter in GTNP and BTNF on 29-30 May 2012. In addition, we surveyed 81.9 km that are not part of the designated monitoring streams to improve our information on distribution and abundance of harlequins (Table 1). All distances were for the length of the drainage surveyed and not the flight path of the helicopter.

We recorded 22 pairs and 2 single males for total of 46 harlequins on the monitoring streams. We also located four pairs during the 14 June surveys of Fremont and Pole Creaks in the Wind River Range near Pinedale, Wyoming (Table 2). We compared results from only designated monitoring streams to past years (Table 3). Thirteen harlequins (6 pairs) were documented on GTNP monitoring streams in 2012 and 2002, while 2007 surveys recorded 10 harlequins (5 pairs). We located 33 harlequins (16 pairs) on streams in the Teton Wilderness (BTNF) in 2012, while 43 harlequins (21 pairs) were recorded in 2002.

In 2002, we recorded only three Bald Eagles (*Haliaeetus leucocephalis*; eagles) during surveys of streams in the Teton Wilderness. Along these same streams, we recorded 17, 6, and 26 Bald Eagles during 2007, 2008, and 2012 surveys, respectively. The distribution of harlequins and eagles is presented (Fig 1).

DISCUSSION

Our surveys of designated monitoring streams for Harlequin Ducks documented numbers in 2012 similar to 2002, the first year we conducted helicopter spring surveys. Although the distribution of harlequins in GTNP streams varied, total numbers remained similar in 2002 and 2012 and also similar to numbers that Wallen reported previously (1987). These data indicate that the low numbers we observed in 2007 reflected variable annual conditions rather than a serious decline in number of nesting pairs occupying streams in western Wyoming. The number of harlequin detections can be the result of a number of different factors, including timing of surveys, survey conditions, insufficient monitoring methods, annual variability in number of nesting pairs, or actual population changes. We suspect that in 2007, harlequins may have returned to nesting streams but departed quickly in response to extremely low water conditions that year. Low water conditions would increase vulnerability of harlequins to predation from Bald Eagles and Peregrine Falcons (*Falco peregrinus*; peregrines) and might also decrease the availability of secure nest sites. Snow pack and water levels were at or exceeded long-term averages in most mountain ranges in northwestern Wyoming in 2008 and 2012, so conditions were much improved over 2007.

Heath et al. (2006) found that the density and stability of harlequin populations were negatively correlated with nesting densities of raptors along 11 rivers in northern Labrador. The influx of migratory Bald Eagles to feed on spawning cutthroat trout (*Onchorynchus clarki*) in the Teton Wilderness area appears to be a relatively new development, as we recorded only three eagles in 2002. Numerous aerial surveys by the Department for nesting Bald Eagles and Trumpeter Swans (*Cygnus buccinator*) in 1978-2002 also failed to locate more than two to four eagles in a portion of the area where we recorded 26 in 2012. The impact on the nesting population of harlequins in the BTNF is not known, but many locations where we observed harlequins in 2012 were different compared to 2002. Results clearly show the separation of harlequin observations and eagle observations in the 2012 survey, suggesting that harlequins are responding to the presence of eagles. The one exception is where we located a pair of harlequins near two immature Bald Eagles on the way up Thorofare Creek. On the return trip, eagles were gone and we located the original pair of harlequins and three additional pairs, suggesting that the additional pairs were hiding in response to eagles. We also observed four pairs of harlequins at the upper reaches of Thorofare Creek in a narrow slot canyon that appeared to provide excellent cover from foraging raptors.

Overall, we recorded 10 (5 pairs) fewer harlequins in 2012 on the BTNF monitoring streams than in 2002. This difference was the result of a lower count on the North Fork of the Buffalo Fork, where we located only one pair compared to six in 2002. We observed an adult peregrine actively pursuing waterfowl in 2012 within 5 km of where we recorded most of the harlequin observations in 2002, 2007, and 2008 but over 10 km from the 2012 observation of harlequins. Perhaps the lower count in 2012 was the result of harlequins hiding in response to a foraging peregrine that occurred at the same time as our survey. It is also unknown if increased pressure from avian predators raises the likelihood of an increased response to the survey helicopter.

On 23 May 2002, we conducted aerial surveys of 158 km of streams in the Wind River Range of the BTNF and failed to locate harlequins. Three of the drainages had previous reports of harlequins, and we continue to get sporadic reports from this area. We took advantage of reduced ferry time with the helicopter and pilot conducting other surveys in the vicinity to resurvey theses streams on 14 June 2012. We surveyed 75.6 km of these streams and located four harlequin pairs. All of the pairs were above 3,000 m in elevation located in small (<50 m) stretches of open water (Fig. 2), while harlequins observed on 29-30 May 2012 surveys were 2,200-3,000 m in elevation. Adjacent lakes and streams were frozen and snow covered in habitats occupied by harlequins on the June survey. We only flew 45 km of these streams in 2002 and typically broke off surveys when we started encountering frozen and snow covered streams. We may have surveyed these streams too early or not extensively enough in 2002 to locate harlequins.

In 2012, we limited our harlequin monitoring efforts to 158.6 km of designated monitoring streams based on past survey results which indicated that approximately 50% of the breeding population in Wyoming could be monitored with this approach (Oakleaf et al. 2003). If we expand our monitoring surveys to include streams occupied by low densities of breeding pairs in the SNF and the southern half of the BTNF, we could monitor an estimated additional 10% of known breeding pairs. However, including these stream segments would increase the cost of monitoring by four to five times over the 2012 total. In addition, Heath et al. (2006) found that numbers of harlequins on low density rivers were erratic from year to year, indicating that it would be difficult to determine trend from surveys of these streams. We continue to be concerned with the challenges of adequately monitoring harlequins due to low duck densities, low but unknown detection rates, and other variables affecting counts (Oakleaf et al. 2003, Patla and Oakleaf 2013). Results indicate that we have been able to establish a baseline that should be valuable for future comparisons.

We recommend that we continue monitoring designated stream segments every 5 years, and also initiate discussions with Montana and Idaho to develop a coordinated regional monitoring strategy that would track this population of harlequins that represents the most eastern breeding component of the Pacific coast population.

ACKNOWLEDGMENTS

Funding for this project was provided by the Wyoming State Legislature and the US Forest Service Bridger-Teton National Forest, for which the Department is extremely grateful. Dave and Nora Savage provided excellent helicopter service. GTNP and BTNF staff offered valuable logistical support for survey work in the Park. In particular, we thank Susan Wolff of GTNP. We are grateful overall for the outstanding interest shown by Wyoming citizens and visitors in the Harlequin Duck and other nongame species that enrich the Wyoming landscape.

LITERATURE CITED

American Ornithologists' Union [AOU]. 1983. Check-list of North American Birds, 6th Edition. Allen Press, Inc., Lawrence, Kansas, USA.

Heath, J. P., G. J. Roberson, and W. A. Montevecchi. 2006. Population structure of breeding Harlequin Ducks and the influence of predation risk. Canada Journal of Zoology 84:855-864.

Oakleaf, B., S. Patla, and K. Taylor. 2003. Harlequin Duck inventories and technique development completion report. Pages 80-95 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. O. Cerovski, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Patla, S., and B. Oakleaf. 2009. Harlequin Duck inventories and technique development completion report. Pages 49-57 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Patla, S., and B. Oakleaf. 2013. Factors affecting detectability of Harlequin Ducks (*Histrionicus histrionicus*) in the pre-season nesting season. Pages 35-45 *in* Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Wallen, R. 1987. Habitat utilization by Harlequin Ducks in Grand Teton National Park. M.S. Thesis, Montana State University, Bozeman, Montana, USA.

Table 1. Drainages included and distances surveyed in the Wyoming Game and Fish Department's helicopter surveys for Harlequin Ducks (*Histrionicus histrionicus*), May 2012. June 2012 information was not part of the monitoring effort, but is included for reference.

Survey route	Date (2012)	Monitoring stream	Distance (km)
Berry Creek	29 May	yes	13.2
Owl Creek	29 May	yes	3.8
Moose Creek	29 May	yes	11.2
North Fork Buffalo	29 May	yes	26.8
Soda Fork	29 May	yes	6.6
South Fork Buffalo	29 May	yes	36.8
Thorofare Creek	30 May	yes	32.4
Yellowstone River	30 May	yes	27.8
Atlantic Creek	30 May	no	6.3
Pine Creek	14 June	no	12.2
Fremont Creek	14 June	no	31.3
Pole Creek	14 June	no	32.1

Table 2. Number of Harlequin Ducks (*Histrionicus histrionicus*) observed during helicopter surveys in Wyoming, May and June 2012. Streams selected for monitoring are denoted by an asterisk.

Survey stream	Km	No. of pairs	Single male	Single female	Totals
Berry Creek *	13.2	2	0	0	4
Owl Creek *	3.8	4	0	0	8
Moose Creek *	11.2	0	1	0	1
North Fork Buffalo *	26.8	1	0	0	2
Soda Fork *	6.6	0	0	0	0
South Fork Buffalo *	36.8	2	1	0	5
Thorofare/Open Creeks *	32.4	7	0	0	14
Yellowstone River *	27.8	6	0	0	12
Atlantic Creek	6.3	0	0	0	0
Pine Creek	12.2	0	0	0	0
Fremont Creek	31.3	2	0	0	4
Pole Creek	32.1	2	0	0	4
Monitor Streams Total		22	2	0	46
Total All Streams		26	2	0	53

Table 3. Number of Harlequin Ducks (*Histrionicus histrionicus*) detected during helicopter surveys in Wyoming, May 2002-May 2012. GTNP=Grand Teton National Park, BTNF= Bridger-Teton National Forest, ns=not surveyed.

Survey stream	Agency	2002 total	2007 total	2008 total	2012 total
Berry Creek	GTNP	2	2	ns	4
Owl Creek	GTNP	1	0	ns	8
Moose Creek	GTNP	10	8	ns	1
North Fork Buffalo	BTNF	12	2	8	2
Soda Fork	BTNF	0	0	0	0
South Fork Buffalo	BTNF	5	0	8	5
Thorofare/Open Creeks	BTNF	12	2	15	14
Yellowstone River	BTNF	14	4	10	12
GTNP subtotal		13	10	ns	13
BTNF subtotal		43	6	41	33
Totals		56	18	41	46

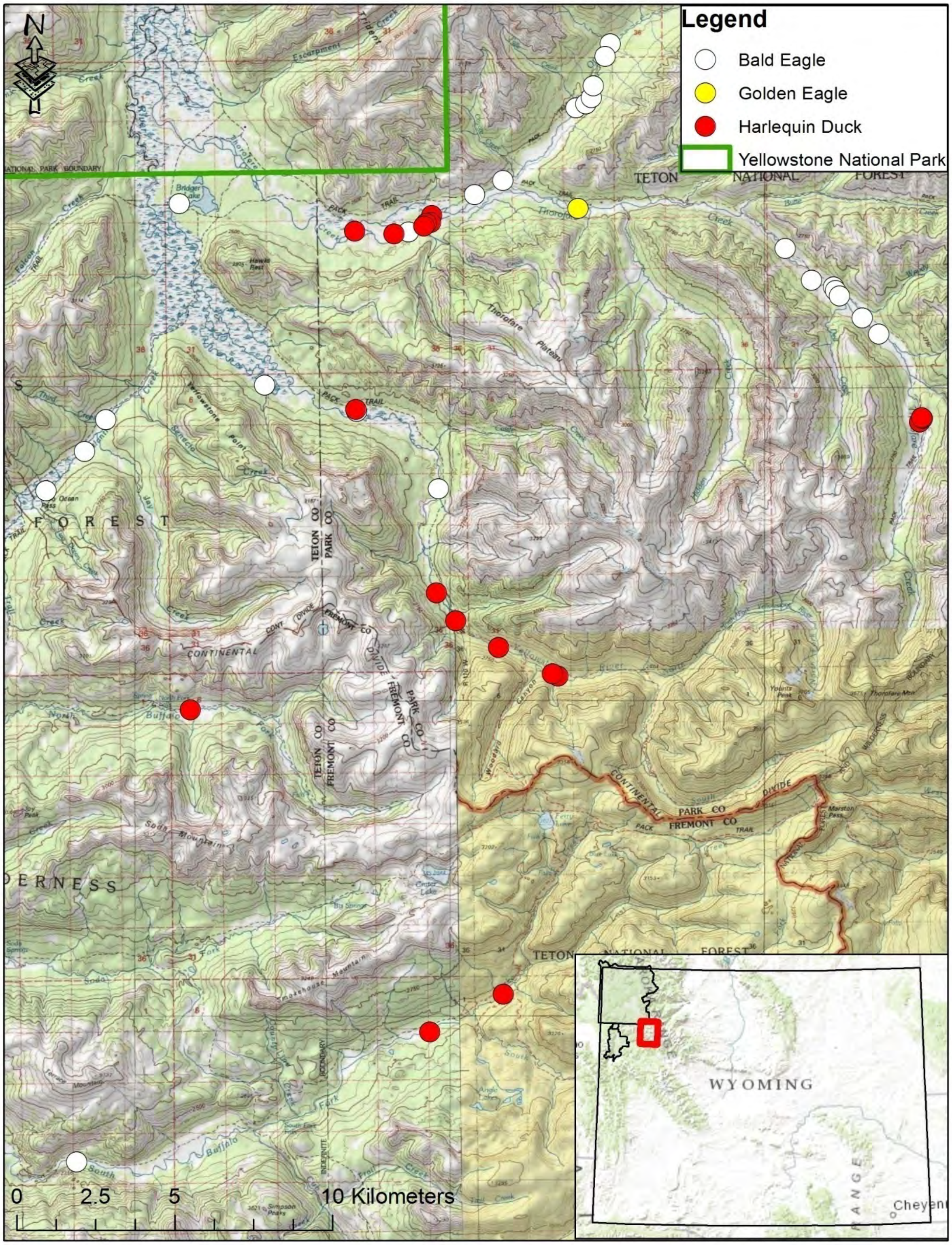

Figure 1. Distribution of Harlequin Ducks (*Histrionicus histrionicus*) and Bald Eagles (*Haliaeetus leucocephalis*) in the Teton Wilderness, Wyoming, 29-30 May 2012.

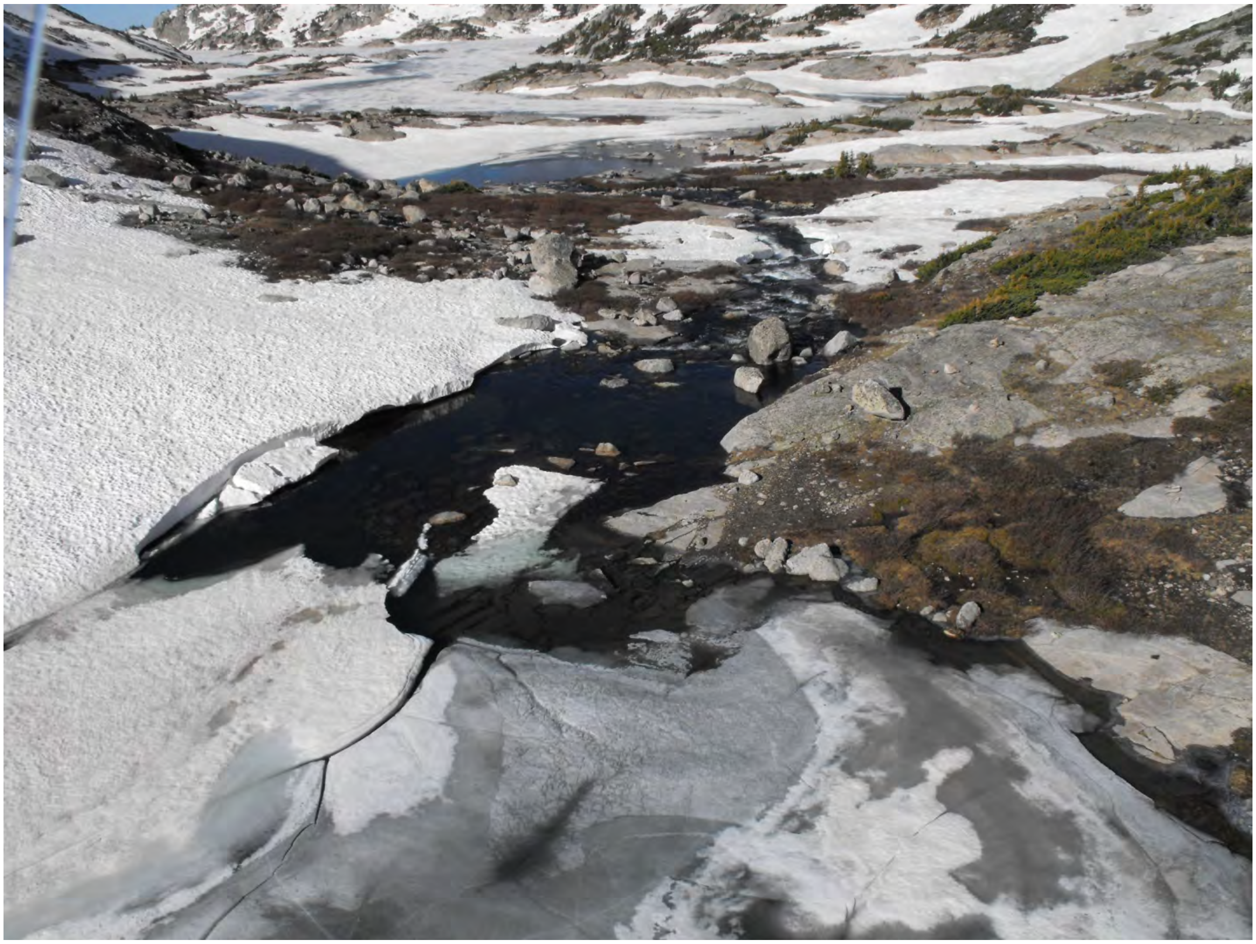

Figure 2. Habitat occupied by a Harlequin Duck (*Histrionicus histrionicus*) pair on Pole Creek, Bridger-Teton National Forest, Wyoming, 14 June 20012.

SURVEYS OF COMMON LOON (*GAVIA IMMER*) NEST SITES IN WESTERN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Common Loon

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

PROJECT DURATION: 15 May 1987 – 30 August 2012

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Susan Patla, Nongame Biologist
Andrea Orabona, Nongame Bird Biologist

ABSTRACT

The Common Loon (*Gavia immer*) has the smallest nesting population and most restricted breeding distribution of any bird species in Wyoming. It is the only bird species ranked as Native Species Status 1 in the State Wildlife Action Plan (WGFD 2010). The Common Loon is one of five loon species that occur worldwide. Common Loons that nest in Wyoming comprise the most southern breeding population and are disjunct from other populations that nest in North America. The loon has a life history characterized by high longevity, low fecundity, and delayed sexual maturation. There is a great deal of public interest in Common Loons resulting from their size, beauty, and haunting vocalizations. They remain in the forefront of many aquatic-based conservation efforts as a symbol of northern wilderness. The need to conserve isolated and peripheral populations of Common Loons has been recognized by the United States Fish and Wildlife Service in their current status and conservation plan and in the State Wildlife Action Plan for Wyoming (Evers 2004, WGFD 2010). Wyoming Game and Fish Department (Department) biologists have monitored Common Loons since 1987 to collect data on number of breeding pairs and their productivity. Pairs of Common Loons occupy fewer than 30 lakes in the Greater Yellowstone area, with approximately one-third located outside of Yellowstone National Park (YNP), where Department biologists have focused surveillance monitoring efforts. YNP received funding in 2012 to conduct aerial surveys of historic nesting locations in the Park. This report presents data from the 2012 nesting season for all nesting loons in Wyoming. This past winter, we developed a proposal to conduct a more intensive monitoring effort in cooperation with Biodiversity Research Institute and YNP in the 2013-2014 nesting seasons depending on available funding. Results from this study would be used to develop site-specific management and monitoring plans focused on the long-term viability of the Common Loon nesting population in Wyoming.

INTRODUCTION

The Wyoming Game and Fish Department (Department) classifies the Common Loon (*Gavia immer*; loon) as a Species of Greatest Conservation Need with a Native Species Status 1 because of its limited abundance and restricted distribution in Wyoming, its vulnerability to human disturbance during the nesting season, and its sensitivity to environmental degradation and climate change (WGFD 2010). Although loons can be observed statewide during spring and fall migration, and nonbreeding loons can be found throughout the State during the summer, traditional breeding habitat is restricted to fewer than 30 lakes in the northwestern corner of Wyoming. Loons in Wyoming are the southern-most nesting population in North America and are disjunct from other nesting populations by 200 miles (Evers 2004).

In 2012, we surveyed known nesting areas of loons to document occupancy at each lake, productivity of nesting pairs, and survival of young using both aerial and ground surveys. Biologists from Yellowstone National Park (YNP) and Grand Teton National Park (GTNP) contributed data for sites located within their jurisdictions. In addition, we asked Department personnel, biologists from other agencies, non-governmental organizations, and the public to report all sightings of loons to assist us in determining status of loons on these historical nesting lakes, as well as for other locations in Wyoming.

METHODS

Since 1987, we have focused monitoring efforts for loons at seven lakes located in northwest Wyoming outside of YNP. These include six lakes on the Caribou-Targhee National Forest (CTNF), and one lake on the border between GTNP and the Bridger Teton National Forest (BTNF). Two additional lakes in GTNP were added to the monitoring schedule in recent years. These include Emma Matilda Lake and Leigh Lake. In August 2007, a photographer documented an adult loon with one young in the southwestern bay of Emma Matilda Lake. In August of 2009, we observed a pair of loons on Leigh Lake, and learned from Park volunteers that a pair had occupied the lake in previous years. Also in September 2009, a GTNP biologist reported an observation of an adult loon with one small young on Leigh Lake.

In most years, we conducted surveys of potential nesting lakes three times during the year: late-May to mid-June to document presence of adults; mid-to late July to document number of young hatched; and mid- to late August to count number of mature young. Surveys included a combination of ground and aerial surveys, and not all sites were surveyed three times each year due to road access issues. We also searched for additional occurrences of loons opportunistically at other lakes in the area in conjunction with other field surveys.

Although loons forage most intensively during early morning and early evening hours, they continue to forage between resting bouts throughout the day, so surveys can be conducted any time during daylight hours. For ground surveys, we sat quietly at vantage points that provided the most optimal view and used binoculars and spotting scopes to search the lake and shoreline for activity or nest sites. Each survey lasted at least45 min or until adults or young were detected. At some lakes, more than one vantage point was needed to observe the entire lake area. We recorded the number of adult and young loons detected, loon activity and behavior (i.e., diving, foraging, feeding self or young, calling, flying, loafing, agitation), and other bird and mammal species observed or heard. We also recorded additional information on human activity, potential disturbances, impacts or degradation to habitat, development of new two-track roads or trails, and condition of shoreline habitat.

We conducted aerial surveys of lakes where loons were known to nest in conjunction with surveys for Trumpeter Swans in late May/early June and early July. We used a fixed-wing aircraft which flew at an average elevation of 50-100 m above ground level, depending on terrain and surface winds, and at air speeds between 135-160 kph. We circled each lake one to three times and recorded number of adults and young seen.

RESULTS

In 2012, we surveyed all nine lakes that were known to been have been used by loons during the breeding season in Wyoming outside of YNP (Table 1). We surveyed two other sites where loons have been recorded occasionally in the summer season: Enos Lake (BTNF) and Rock Lake (CTNF). We also provided additional monitoring data for YNP on Winegar Lake and Tanager Lake near the southern border of YNP. We documented pairs at four lakes on the CTNF and at two lakes in GTNP (Table 1). We also recorded a pair on Tanager Lake (YNP) on May 31 and a single loon on Winegar Lake (YNP) on August 14. Loons produced five young at three sites: Indian Lake, Loon Lake, and Arizona Lake. Brood reduction occurred at Indian Lake where two newly hatched loonlets were observed on June 21 but only one young was seen in August.

In YNP, biologists surveyed 26 lakes plus potential nest areas on Yellowstone Lake via fixed-winged aircraft in July and August, with additional ground visits to some sites (Baril et al. 2012). Pairs in YNP occupied a minimum of 11 sites, and eight young were produced at five sites. Three pairs produced two young each. For all sites in Wyoming combined in 2012, loons produced 13 young at eight lakes, for an average of 1.62 young per successful pair (Table 2).

In addition to normal monitoring observations, we noted a few interactions of interest in 2012. From data collected in previous years at Indian Lake/Bergman Reservoir (CTNF), we believed that these sites acted as a complex for one nesting pair rather than being two separate breeding sites. Adults that nested on Indian Lake appeared to forage at Bergman and to move young over to the reservoir at times in late summer if water persisted. Water is drained from Bergman every year for irrigation so, as the lake drops, fish are concentrated in the remaining pool. On June 21, an adult was seen on Indian Lake with two newly hatched chicks. On that same date, we observed a pair of adults interacting on Bergman Reservoir but no nest site or young were observed. We speculated that the adult male from Indian may have been interacting with another female on Bergman that day. At Loon Lake (CTNF) on August 14, one adult with a large young interacted with two different individual loons that flew in at different times. There was a great deal of calling, bill dipping, and duet diving between the territorial adult and one of the individuals that flew in.

DISCUSSION

Loons occupy traditional nesting lakes every year in Wyoming, but at low numbers and in a very restricted range. From 1987-2011, we observed a total number of 9-18 pairs of loons per year during the breeding season in western Wyoming, excluding the 6 years for which data were unavailable (Table 2). The maximum number of pairs reported in any one year during this period was 14 in YNP, and 6 pairs for lakes outside of YNP. The maximum number of young produced in a single year was 12 in YNP (reported in 1994) and 10 outside of YNP (reported in 1988). Over the most recent 10-year period from 2002 through 2011, we observed a mean of 8.8 pairs per year in YNP and 3.4 young per year. For Wyoming outside of YNP, we observed a mean of 4.4 pairs and 2.8 young per year. Combining data from all sites in the State over this same 10-year period, we observed a mean of 12.9 pairs and 4.5 young per year. It was encouraging to see that extra monitoring effort in YNP in 2012 resulted in documenting an increased number of pairs with young than in the previous 10 year period. However, the total number of sites that produced young in Wyoming overall (n = 8) is still much lower than the total of 12-14 reported in some years prior to 2002. Also**,** given the small size of many of the nesting lakes in Wyoming, loons likely used complexes of lakes rather than occupy only one site, and interactions between pairs and non-breeding adults likely occur over the course of a season. Number of pairs vying for the best nest sites may be larger than indicated from monitoring results that are based only on a few, brief visits to known nesting lakes.

Although data indicate that a decline in number of pairs and productivity has occurred in Wyoming, monitoring effort has been inconsistent between years and survey methods have not been standardized between YNP and the Department. It is difficult, based on current monitoring results, to determine the number of birds in this population, the extent of a possible declining population trend, or to identify reasons that may be affecting nest success. The 2010 State Wildlife Action Plan recommends that survey methods be standardized and that a species specific management plan be developed (WGFD 2010). Given the small size of this population, it is important to collect additional information before any further declines might take place.

YNP obtained funds in 2012 from the Yellowstone Park Foundation to initiate a monitoring project in partnership with Biodiversity Research Institute (BRI). BRI's Center for Loon Conservation focuses on loon species across the country as key bioindicators of aquatic integrity for lake ecosystems, and BRI is recognized as a leader in loon research and conservation. The objective of the YNP project is to evaluate habitat, disturbance factors, and nest success of loons to provide data for development of a site-specific management plan for loons in YNP. The Department is seeking additional funding for a complementary project in partnership with BRI focused on loons that occur outside of YNP in 2013-2014. We worked with BRI and YNP in 2012 to produce a short status report for common loon in Wyoming that concisely summarizes current trends, threats, and management opportunities (Evers and Taylor 2012). If adequate funding is obtained for expanded monitoring at all known nest sites in Wyoming, the results will provide a basis for coordinated management and monitoring between Federal and State agencies to ensure the long-term conservation of loons that nest in Wyoming.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would like to acknowledge the following Department personnel for their contributions in 2012: J. Longobardi and D. Brimeyer. We would also like to thank the staff from GTNP, including S. Wolff, W. Scherer, A. May, and J. and P. Reagan (volunteers at Leigh Lake). D. Smith and L. Baril provided data for birds in YNP. We appreciate the help provided by CTNF biologists T. Fletcher and S. Derusseau for removing debris from the Moose Lake site, which we observed during loon surveys.

LITERATURE CITED

Baril, L. M, L. Henry, and D. W. Smith. 2012. Yellowstone Bird Program 2010 Annual Report. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-2011-04.

Evers, D. C. 2004. Status assessment and conservation plan for the Common Loon (*Gavia immer*) in North America. Final draft April 12 2004. USFWS Division of Migratory Birds, Hadley, Massachusetts, USA.

Evers. D. C., and K. Taylor. 2012. Status report for the Common Loon: Wyoming. Science Communications Series BRI 2012-42. Biodiversity Research Institute, Gorham, Maine, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State Wildlife Action Plan 2010. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Annual summary of observations of Common Loons (*Gavia immer*) at lakes we surveyed 1998-2012 where nesting is known to occur in Wyoming outside Yellowstone National Park. These data represent the greatest number of adults and young observed at each location based on all surveys during the nesting season. Key to the table codes includes: CTNF – Caribou Targhee National Forest; GTNP – Grand Teton National Park; 0 – no loons of any age class were observed during the season. The remaining codes are comprised of two parts; a number (*n*) followed by a letter. The number of adults is denoted by *n*A, and the number of young observed for nesting pairs is denoted by *n*N. When no survey was conducted, it is represented by *ns*. Bergman Marsh and Indian Lake are a multi-lake nesting area; adults nest on Indian but move between these two sites to forage, so loons documented on Bergman Marsh most likely represent birds from Indian Lake in most cases. YNP reported seeing young at Fish Lake on a 9 July 2012 aerial survey, which we were not able to confirm. Data from 1987-1997 can be found in previous Annual Completion Reports.

Site	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CTNF															
Bergman Marsh	0	0	1A	0	1A	1A	2A	1A	2A	1A	0	2A	0	*ns*	2A
Indian Lake	2N	2N	2N	1N	1N	1N	4A	2N	2N	1N	1N	1N	2N	2A	2N
Moose Lake	1N	2A	2A	1N	1A	2N	2A	2A	2A	2A	3A	2A	1A	0	0
Loon Lake	1A	2A	1N	1N	1N	2A	2N	2A	2N	2A	3A	2A	2A	2A	1N
Junco Lake	0	0	1N	1N	2A	1A	1A	0	0	2A	0	0	0	*ns*	0
Fish Lake	0	2A	2A	2A	1A	1A	3A	2A	3A	1A	0	2A	2A	*ns*	2A
GTNP															
Arizona Lake	0	2N	1N	0	1A	1N	2A	2A	2A	2N	1A	2N	2N	1N	2N
Emma Matilda Lake	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	N1	2A	2A	1A	1A	2A
Leigh Lake	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	1N	2A	0	0

Table 2. Data for Common Loons (*Gavia immer*) representing nesting, productivity, and production for sites surveyed in Wyoming, 1987-2012. Data for some years are incomplete and total surveillance effort has not been consistent for all years reported. Key to table codes: "*na*" – not available, "*in*" – incomplete, "*ns*" – not surveyed. The number of young reported does not represent the number of young that survived to fledging in all cases, but only the highest number of young that were observed during a nesting season in a particular year.

Year	Outside Yellowstone Nat'l Park			Yellowstone National Park			Total		
	No. of pairs	No. of young	No. of lakes with young	No. of pairs	No. of young	No. of lakes with young	No. of pairs	No. of young	No. of lakes with young
1987	6	9	6	*na*	*na*	*na*	*in*	*in*	*in*
1988	6	10	6	*na*	*na*	*na*	*in*	*in*	*in*
1989	6	4	3	*na*	*na*	*na*	*in*	*in*	*in*
1990	6	6	4	11	9	9	17	15	13
1991	*ns*	*ns*	*ns*	9	*na*	*na*	*in*	*in*	*in*
1992	6	*ns*	*ns*	11	6	4	17	*in*	*in*
1993	5	*ns*	*ns*	12	6	4	17	*in*	*in*
1994	5	3	3	12	12	8	17	15	11
1995	3	3	2	13	8	12	16	11	14
1996	5	3	2	5	4	4	10	7	6
1997	4	6	4	5	6	5	9	12	9
1998	2	3	2	12	8	6	14	11	8
1999	4	4	2	14	2	2	18	6	4
2000	5	5	4	9	8	9	14	13	13

Table 2. Continued.

Year	Outside Yellowstone Nat'l Park			Yellowstone National Park			Total		
	No. of pairs	No. of young	No. of lakes with young	No. of pairs	No. of young	No. of lakes with young	No. of pairs	No. of young	No. of lakes with young
2001	4	3	3	9	7	9	13	10	12
2002	3	2	2	9	5	4	12	7	6
2003	4	4	4	8	1	1	12	4	5
2004	5	2	1	9	3	2	14	5	3
2005	5	2	1	8	4	3	13	6	4
2006	4	4	2	9	6	4	13	10	6
2007	6	4	3	*na*	*na*	*na*	*in*	*in*	*in*
2008	5	1	1	*na*	*na*	*na*	*in*	*in*	*in*
2009	4	3	2	7	4	3	11	8	5
2010	5	4	2	8	3	3	13	7	5
2011	3	2	1	12	1	1	15	3	2
2012	5	5	3	11	8	5	16	13	8

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

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – American Bittern

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

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

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

ABSTRACT

The American Bittern (*Botaurus lentiginosus*) is classified as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department because of severely limited wetland habitat necessary for reproduction and survival. Because of their secretive behavior, American Bitterns require a species-specific call-playback technique to document presence. In 2012, we used this survey technique to continue annual monitoring along four transects and initiate monitoring on one new transect in the Cokeville Meadows National Wildlife Refuge in western Wyoming in an attempt to develop population trends. Although two transects demonstrated declining populations, one other demonstrated an increase in American Bitterns we detected. We had insufficient data to develop a population trend for the fourth transect, but data suggest American Bitterns are likely increasing on this transect as well. When sufficient data are accumulated for the fifth transect, we will conduct a population trend analysis on these data, as well. Although results should be interpreted cautiously until additional data can be accumulated and analyzed, current trends suggest habitat improvements are likely leading to increases in the number of nesting American Bitterns on the Cokeville Meadows National Wildlife Refuge.

INTRODUCTION

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

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

METHODS

We surveyed five transects for bitterns in the Cokeville Meadows National Wildlife Refuge (Refuge) in western Wyoming: Bartlett transect (2.0 km), Diamond transect (2.8 km), Peterson transect (3.2 km), Pixley transect (3.6 km; new in 2012), and Thornock transect (1.6 km). Transect location and length was based upon the amount of suitable bittern habitat present and known locations of bitterns from previous passive-listening surveys. We designed our survey methods following recommendations by the USFWS and USGS (1999) and Conway (2005). Detections of secretive marsh birds, including bitterns, have been shown to increase when surveys include a mixture of passive listening and call-playback techniques (Conway and Nadeau 2006). Consequently, we conducted annual surveys of bitterns during the breeding season between 13 May and 30 June when they were most vocal and responsive to this survey technique. We surveyed each transect twice, with a minimum of 2 weeks between replicates. All surveys were conducted between 1800 and 2200 hrs to coincide with the peak of bittern vocalization activity; however, if individuals were heard calling before or after this timeframe, we adjusted surveys accordingly. We spaced our survey locations every 400 m along each transect. At each location, we initiated the survey by passively listening for bittern vocalizations for 5 min. We then played a recorded bittern call for 1 min and finished the survey by listening for a response for 1 min. We recorded all bitterns heard or seen during all phases of the survey, and marked the approximate location of each individual bittern on a transect map. To index number of breeding pairs we divided the number of individuals detected by two. We also noted other species observed or heard at each location.

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

RESULTS

We attempted to survey all transects three times; however, we were only able to conduct the first two survey periods because of scheduling conflicts during the final replicate. As in 2010 and 2011, we detected bitterns on all four survey routes (Table 1). Detections of bitterns varied from a low of 0.5 individuals detected per km on the Bartlett transect to a high of 6.3 individuals detected per km on the Thornock transect. Route locations and the number of bitterns we detected at each stop are depicted in Figure 1.

Prior to the 2012 survey, the number of detections of bitterns has increased slightly on the Thornock transect since the initiation of species-specific surveys in 2007. The number of bitterns detected in 2012 was the same as 2011, but trend since 2007 has shown a very slight decrease of 0.13 individuals per km per year (R^2=0.013; Fig. 2). Detections of bitterns on the Peterson transect increased by an average of 0.65 individuals per km per year (R^2=0.153; Fig. 3). On the Bartlett transect, detections of bitterns have continued to decrease by 0.44 individuals per km per year (R^2=0.816; Fig. 4). The Diamond and Pixley transects have only been surveyed for 3 years and 1 year, respectively, and were not included in these analyses.

DISCUSSION

Although the same number of bitterns were detected in 2012 on the Thornock transect as in 2011 and 2008, we detected fewer bitterns during these years than in three previous count years. We also detected fewer bitterns on the Bartlett transect compared to previous years, with the exception of 2011. However, we were only able to conduct surveys during the first two replicate periods due to scheduling conflicts. Although two surveys were also conducted in 2011, these were done during the second and last replicates, which are typically more consistent and detect more bitterns that the first survey period. The seasonal and annual fluctuation in number of bitterns we detected on these transects may simply be a response to local conditions, as results can fluctuate due to inconsistent spring weather. Bitterns nest only 6 cm above the water surface and are negatively impacted by rapid or even moderate flooding (Desgranges et. al 2006). This decrease in bittern detections has had a disproportional impact on the trend for the Thornock transect, where we reported an increase of 1.51 individuals per km per year (R^2=0.73) in 2010 (Orabona and Cudworth 2011), to an increase of only 0.26 individuals per km per year (R^2=0.03) in 2011 (Cudworth and Orabona 2012), and a slight decrease of 0.13 bitterns per km

(R^2=0.013) in 2012. The trendline on the Bartlett transect continues to demonstrate a sharp decline compared results from previous years (Cudworth and Orabona 2012). Our results in 2012 may have been different if we had been able to conduct all replicates along these transects.

For the Peterson transects, we reported a decrease in the number of bitterns we detected in 2012, but the overall trendline continues to show an increase over time due to higher detections during two survey years. A limited number of surveys preclude analysis of the Diamond transect. Our ability to survey these transects in previous years was impacted by unfavorable weather conditions, time constraints, available personnel, and access issues. However, on occasions when we surveyed the Diamond and Peterson transects prior to 2010, we detected few bitterns, which we hypothesized was due to a limited availability of nesting habitat. Since 2006, personnel at the Cokeville Meadows National Wildlife Refuge have actively improved habitat for bitterns by controlling flooding, which has expanded the amount of suitable habitat available to bitterns for nesting.

It is difficult to monitor trends of bitterns with only 5-6 years of data, so results should be interpreted with caution. Small sample sizes make these trends especially susceptible to stochastic fluctuations, as observed for the Thornock transect, which can obscure overall trends. However, bittern detections appear to be increasing, likely reflecting the current habitat improvement and expansion projects in place on the Refuge. Our efforts to continue annual surveys for bitterns will increase the precision of trend analyses, allow for better trend estimation, and will help elucidate how habitat projects are influencing distribution and abundance of bitterns on the Cokeville Meadows National Wildlife Refuge.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would also like to express our appreciation to US Fish and Wildlife personnel at the Cokeville Meadows National Wildlife Refuge and Seedskadee National Wildlife Refuge for supporting our monitoring program and their continued efforts to improve wetland habitat at Cokeville Meadows to benefit this Species of Greatest Conservation Need.

LITERATURE CITED

Bolenbaugh, J. R., D. G. Krementz, and S. E. Lehnen. 2011. Secretive marsh bird species co-occurrences and habitat associations across the Midwest, USA. Journal of Fish and Wildlife Management 2:49-60.

Brown, M., and J. J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. The Journal of Wildlife Management 50:392-397.

Conway, C. J. 2005. Standardized North American marsh bird monitoring protocols. Wildlife Research Report Number 2005-04. USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, USA.

Conway, C. J., and C. P. Nadeau. 2006. Development and field-testing of survey methods for a continental marsh bird monitoring program in North America. Wildlife Research Report Number 2005-11. USGS Arizona Cooperative Fish and Wildlife Research Unit, Tucson, USA.

Cudworth, N., and A. Orabona. 2012. Surveys for American Bittern in western Wyoming. Pages 59-68 *in* Threatened, endangered, and nongame bird and mammal investigations (M.B. Grenier, B. Able, and N. Cudworth, Editors). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, A. L. Zimmerman, and B. R. Euliss. 1999 (revised 2002). Effects of management practices on grassland birds: American Bittern. USGS Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Desgranges, J., J. Ingram, B. Drolet, J. Morin, C. Savage, and D. Borcard. 2006. Modeling wetland bird response to water level changes in the Lake Ontario-St. Lawrence River hydrosystem. Environmental Monitoring and Assessment 113:329-365.

Gibbs, J. P., S. Melvin, and F. A. Reid. 1992. American Bittern (*Botaurus lentiginosus*). *In* The Birds of North America, Number 18 (A. Poole, P. Stettenheim, and F. Gill, Editors). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

McMenamin, S. K., E. A. Hadly, and C. K. Wright. 2008. Climatic change and wetland desiccation cause amphibian decline in Yellowstone National Park. Proceedings of the National Academy of Sciences 105:16988-16993.

Orabona, A. 2010. Coordinated colonial waterbird inventory and monitoring completion report. Pages 133-1336 *in* Threatened, endangered, and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Orabona, A., and N. Cudworth. 2011. Surveys for American Bittern in western Wyoming. Pages 56-62 *in* Threatened, endangered, and nongame bird and mammal investigations (M.B. Grenier, Editor). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, reptiles, and amphibians in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Steen, D. A., J. P. Gibbs, and S. T. A. Timmermans. 2006. Assessing the sensitivity of wetland bird communities to hydrologic change in the eastern Great Lakes region. Wetlands 26:605-611.

United States Fish and Wildlife Service and United States Geological Survey [USFWS and USGS]. 1999. Proceedings of the marsh bird monitoring workshop. USFWS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Total and number per km of American Bitterns (*Botaurus lentiginosus*) detected during surveys conducted May-June 2012 on the Cokeville Meadows National Wildlife Refuge, western Wyoming. Transect length for each route is reported in parentheses.

Bartlett Transect (2.0 km)		Diamond Transect (2.8 km)		Peterson Transect (3.2 km)		Pixley Transect (3.6 km)		Thornock Transect (1.6 km)	
Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km	Total no. detected	No. per km
1	0.5	1	0.4	3	0.9	2	0.6	10	6.3

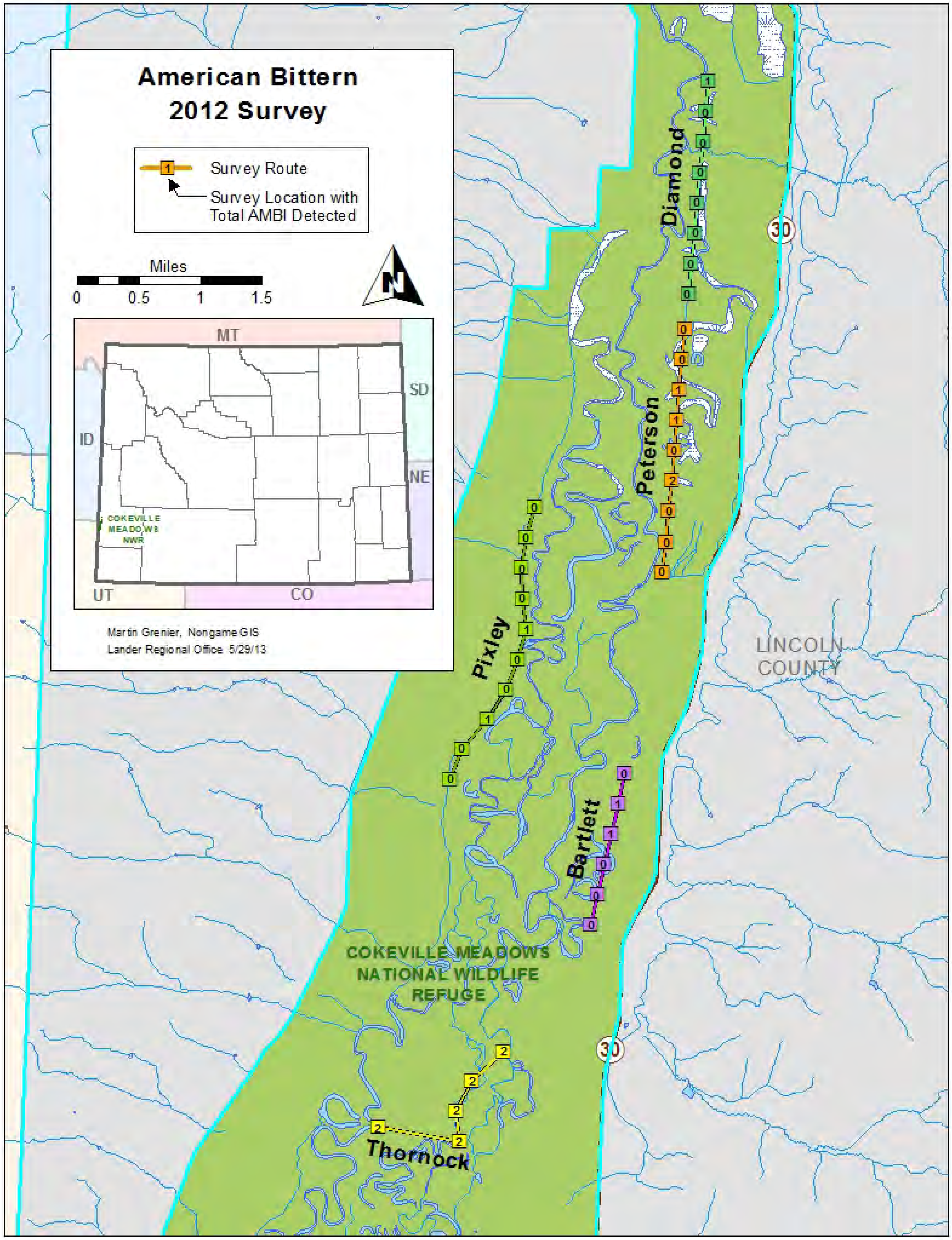

Figure 1. American Bittern (*Botaurus lentiginosus*) transect locations and numbers detected during the 2012 surveys on the Cokeville Meadows National Wildlife Refuge. Numbers on the Bartlett and Peterson transects indicate bitterns detected at more than one stop (not included in analysis).

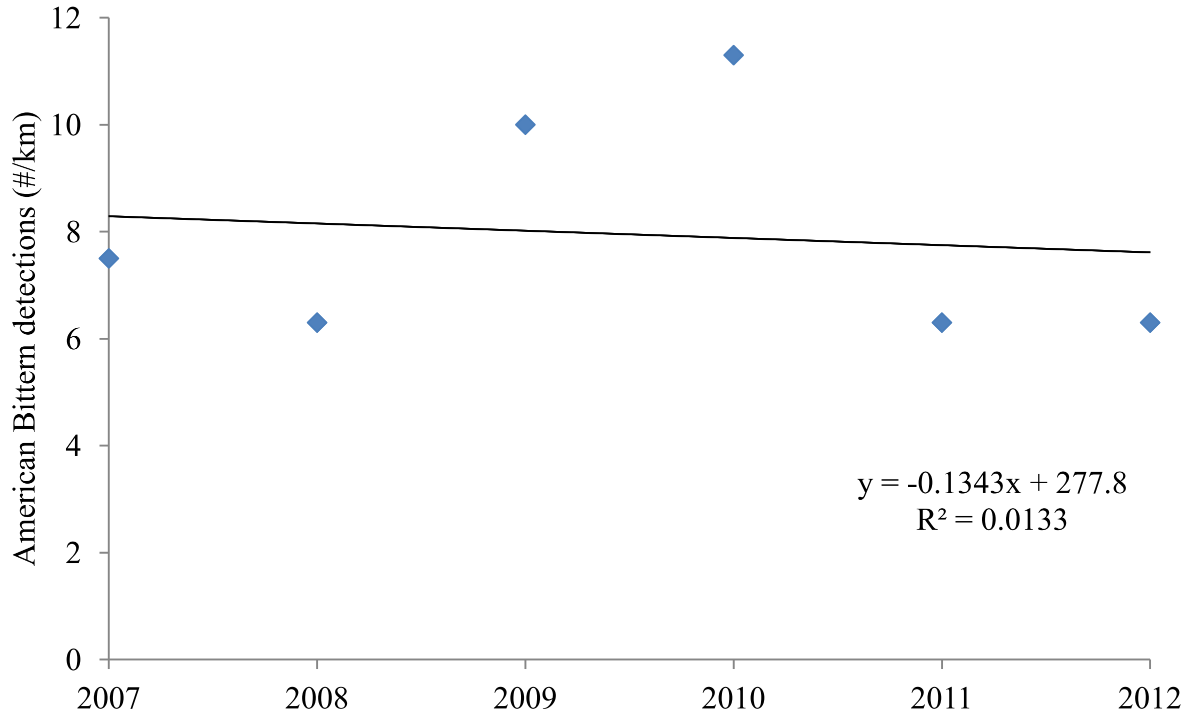

Figure 2. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Thornock transect (1.6 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2007-2012. The trendline is shown for reference.

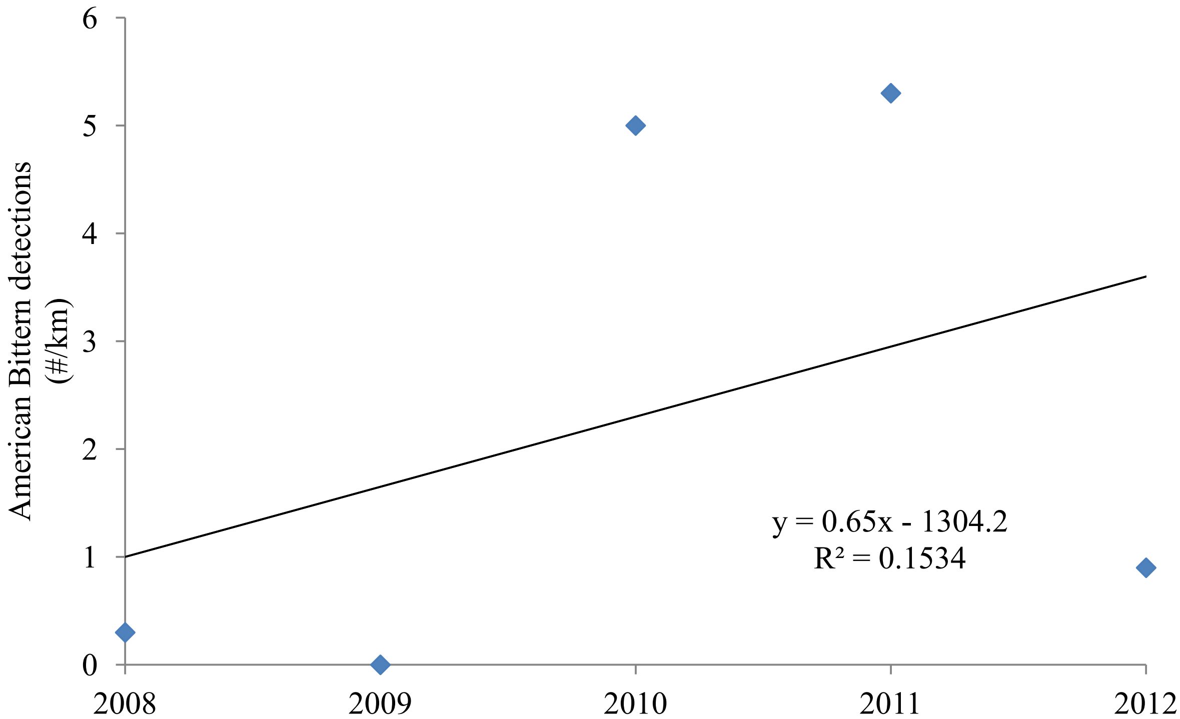

Figure 3. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Peterson transect (3.2 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2009-2012. The trendline is shown for reference.

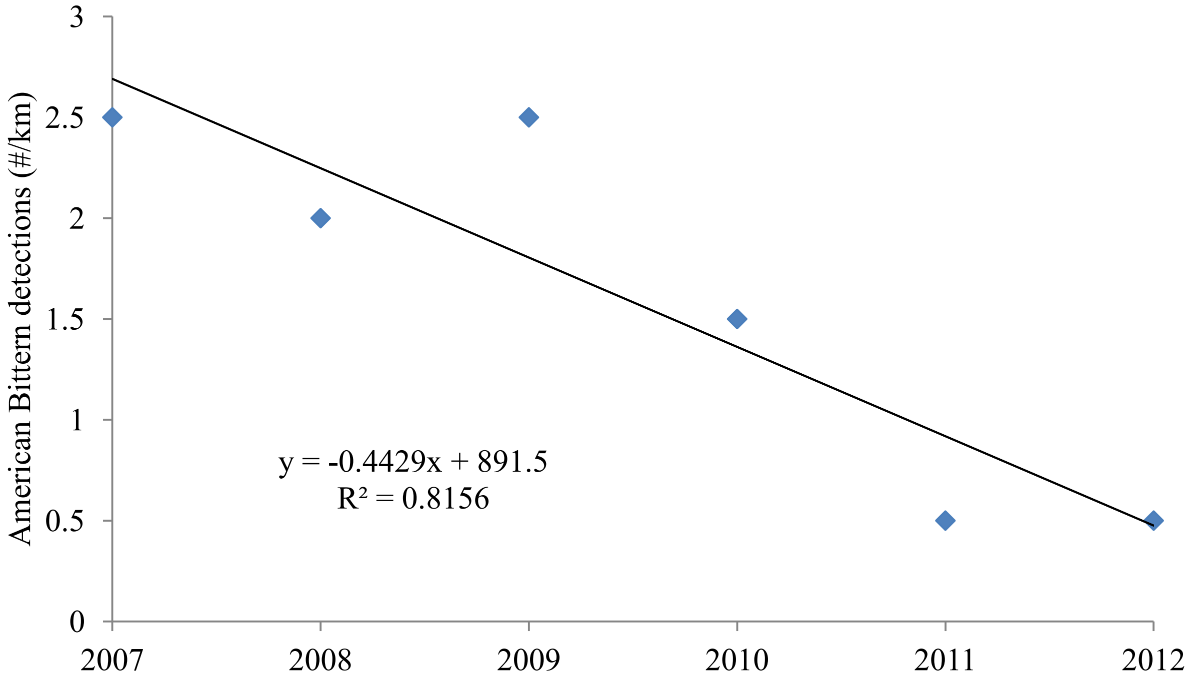

Figure 4. Number of American Bittern (*Botaurus lentiginosus*) detections per km on the Bartlett transect (2.0 km) in the Cokeville Meadows National Wildlife Refuge, western Wyoming, 2007-2012. The trendline is shown for reference.

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) MONITORING IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Bald Eagle

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

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Susan Patla, Nongame Biologist
Bob Oakleaf, Nongame Coordinator

ABSTRACT

The Bald Eagle (*Haliaeetus leucocephalus*) occurs throughout most of North America from Alaska to central Mexico, wintering 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 Eagles statewide in 1978. The Bald Eagle, although no longer designated as a Threatened species under the Endangered Species Act, remains protected under the Bald and Golden Eagle Protection Act and is classified as a Species of Greatest Conservation Need with Native Species Status of 2 in Wyoming. We currently monitor the population of Bald Eagles that nest in the western portion of the state (i.e., Snake and Green River drainages) annually and obtain data when available from other areas of the State. We have detected a minimum of 139 nest sites to-date. However, we believe there is potential habitat for ≥200 territories to occur statewide. In 2012, we obtained occupancy data for 91 territories and productivity data for 77 nest sites. We did not obtain data for this report from sites in the eastern portion of the State. As in previous years, Bald Eagles occupied a high proportion (i.e., ≥85%) of nesting territories we monitored. We documented a total of 70 mature young during our surveys in western Wyoming. Bald Eagles that nest in Wyoming continue to experience some site-specific risks due to increasing energy development, rural development, recreational activities, and environmental contaminants. We continue to receive and process numerous requests for information and management recommendations for Bald Eagle nest and roost sites.

INTRODUCTION

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

The USFWS removed the Bald Eagle from protection under the Endangered Species Act in the western US in July 2007. However, the species continues to be protected under the Bald and Golden Eagle Protection Act. The Wyoming Game and Fish Department (Department) initiated monitoring for Bald Eagles statewide in 1978. Currently, our program objectives include monitoring occupancy and productivity at nesting territories in the Snake River and Green River Basin, south to Seedskadee National Wildlife Refuge. 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) requests data every year on nest site status located adjacent to the Snake River dike system in the Jackson, Wyoming area to schedule maintenance projects. The ACE has provided funding support the last few years for aerial survey work. Management guidelines have been developed for nest sites for the GYA based on a long-term ecological study, and provide valuable information for avoiding disturbance to nesting eagles (Greater Yellowstone Bald Eagle Working Group 1996). We are actively involved in reviewing new federal regulations through participation in the Pacific and Central Flyways' Nongame Technical Committees.

METHODS

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

In 2012, we conducted a nest occupancy survey on 27 March and productivity surveys on 31 May and 14 June, using a single observer and a Scout fixed-wing airplane that flew approximately 100-200 m above ground level and at speeds of 120-160 kph. We combined the productivity flights for eagles with monitoring surveys for Trumpeter Swans (*Cygnus buccinator*) to reduce overall survey costs. We surveyed all known nest sites along the main stem and tributaries of the Snake River, Gros Ventre River, Salt River, New Fork River, and the Green River from Green River Lakes south to Fontenelle Dam.

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

Craighead Beringia South (CBS), a nonprofit wildlife research organization, trapped and marked Bald Eagles in the Jackson area as part of their investigation into lead ingestion by scavenging eagles (Bedrosian and Craighead 2009). The Department and CBS also obtained funding through the Pinedale Anticline Project Office to initiate a study using satellite-radio transmitters on resident adult Bald Eagles in the Pinedale area. The objective of this project is to collect movement and habitat use data in relation to energy development sites in this area.

RESULTS

We present the results for Bald Eagle surveys completed by the Nongame Program statewide in Table 1. In 2012, we evaluated occupancy status of 91 nest sites. Data collected from nest sites in Yellowstone National Park and by private consultant groups in other parts of Wyoming are not summarized here; consequently, this report represents a minimum count of nesting Bald Eagles that occur statewide. Monitoring effort was greatest in western Wyoming where the majority of nests are known to occur.

Bald Eagles occupied 85% of sites surveyed. Table 1 presents productivity data for nest sites in western Wyoming that were monitored consistently through repeated aerial or ground surveys. Although total number of occupied nests was higher in the Snake River area compared to the Green River drainage, percent of occupied sites and number of mature young produced per occupied territory were higher in the Green River Basin (Table 1). Bald Eagles in the Green River drainage are now producing overall a similar number of young as in the Snake River drainage. Overall, 66% of the territories checked for productivity in western Wyoming produced mature young. A total of 0.91 young was produced per occupied territory. The number of mature young produced per active nest was 1.40.

Biologists from Craighead Beringia South placed a total of six satellite transmitters on five adult males and one juvenile female bald eagle in the Anticline Project study area near Pinedale, Wyoming in 2012. Two of the adult males trapped in winter 2012 returned in spring 2012 to northern Canada, migrated back to Wyoming in fall 2012, and have again returned to Canada in spring 2013. Three other adult males were local breeders: two nested close to the Green River and one nested at a previously unidentified site southwest of Big Piney 8 km off the main river channel. One of these males was 20 years old and had been banded as a nestling in eastern Idaho. This bird died in May 2013 and the carcass has been collected for necropsy. The marked juvenile female stayed in Wyoming during her first winter, but wandered widely (Fig. 1) until 21 February 2013; this was the last transmission from this bird, which is assumed to be dead. These are the first tracking data obtained on Bald Eagles resident in the Green River Basin. To obtain more information on this project see: http://www.beringiasouth.org/.

DISCUSSION

The number of nesting pairs of Bald Eagles appears to have stabilized in the Snake River drainage in Wyoming, but the nesting population is still increasing in the Green River Basin and likely at other locations in the State. Comparing productivity data for the Greater Yellowstone population collected from 1982-1995 to the present year indicates that current productivity or the number of young produced per occupied site for 2012 is within the historic range (Greater Yellowstone Bald Eagle Working Group 1996). We provide 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, Bald Eagles could experience higher mortality rates, lower productivity, or loss of nest sites if adequate mitigation measures are not applied.

Hopefully information on how the species responds to natural gas development during different seasons of the year from the recently initiated study in the Pinedale area in partnership with CBS will be useful for planning and mitigating future energy projects in Bald Eagle nesting habitat areas. A separate summary report on the Pinedale tracking study will be completed that will analyze movements and survivorship.

ACKNOWLEDGEMENTS

Funding for this project was provided by the US Army Corps of Engineers and Wyoming State Legislature, for which the Department is extremely grateful. We greatly appreciate the efforts of the following individuals for providing data on nesting Bald Eagles in 2012: D. Patla (volunteer), B. Bedrosian (Craighead Beringia South), E. Cole (National Elk Refuge), B. Ahlers (Seedskadee NWR), W. Scherer and A. May (Grand Teton National Park), and B. Jones (Teton County). In addition, we wish to thank Dave Stinson of Sky Aviation who piloted the Bald

Eagle nest surveys. We appreciate funding provided by the Army Corp of Engineers (Walla Walla office) to help cover the cost for aerial surveys.

LITERATURE CITED

Bedrosian, B., and D. Craighead. 2009. Blood levels of Bald and Golden Eagles sampled during and after hunting seasons in the Greater Yellowstone Ecosystem. Pages 219-220 *in* Ingestion of lead from spent ammunition: implications for wildlife and humans (R. T. Watson, M. Fuller, M. Pokras, and W.G. Hunt, Editors). The Peregrine Fund, Boise, Idaho, USA.

Greater Yellowstone Bald Eagle Working Group. 1996. Greater Yellowstone Bald Eagle management plan: 1995 update. Greater Yellowstone Bald Eagle Working Group, Wyoming Game and Fish Department, Lander, USA.

Harmata, A., and B. Oakleaf. 1992. Bald Eagles in the Greater Yellowstone Ecosystem: an ecological study with emphasis on the Snake River, Wyoming. Wyoming Game and Fish Department, Cheyenne, USA.

Swenson, J. E., K. A. Alt, and R. L. Eng. 1986. Ecology of Bald Eagles in the Greater Yellowstone Ecosystem. Wildlife Monographs 95:1-46.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

United States Fish and Wildlife Service [USFWS]. 2012. Land-based wind energy guidelines. OMB Control Number 1018-0148. US Fish and Wildlife Service, Washington, D.C., USA.

Table 1. Summary of Bald Eagle (*Haliaeetus leucocephalus*) nesting data collected by the Wyoming Game and Fish Department Nongame Program in Wyoming 2012. We present data by major drainages and geographic boundaries in Wyoming. [a] Greater Yellowstone Area (GYA) does not include data for three pairs in Lincoln County (Salt River) or data from Yellowstone National Park. [b] Aerial surveys from Green River Lakes to Fontenelle Dam; ground surveys on the Seedskadee National Wildlife Refuge. [c] Few reports were received in 2012 so data for the rest of Wyoming are not provided. [d] Percentage of occupied territories checked for productivity that produced mature young. [e] Mature young is the number of fully feathered nestlings counted prior to fledging in June and July. Key to status codes: nc=not checked; na=not available (check Wildlife Observation System for additional data).

Nesting data	Wyoming portion of GYA [a]	Green River [b]	Bear River	Salt River	Other Wyoming [c]	Statewide total
Territories checked for occupancy (*n*)	50	39	nc	2	na	91
Territories occupied (*n*)	39	36		2		77
Percent of territories occupied	78.0%	92.3%		100%		84.6%
Territories surveyed for productivity (*n*)	38	36		2		76
Territories that produced young (*n*)	27	21		2		50
Percent of successful nests [d]	71.0%	58.3%		100%		65.8%
Mature young produced [e] (*n*)	34	33		3		70
Mature young per occupied territory ($\bar{x}$)	0..87	0.92		1.5		0.91

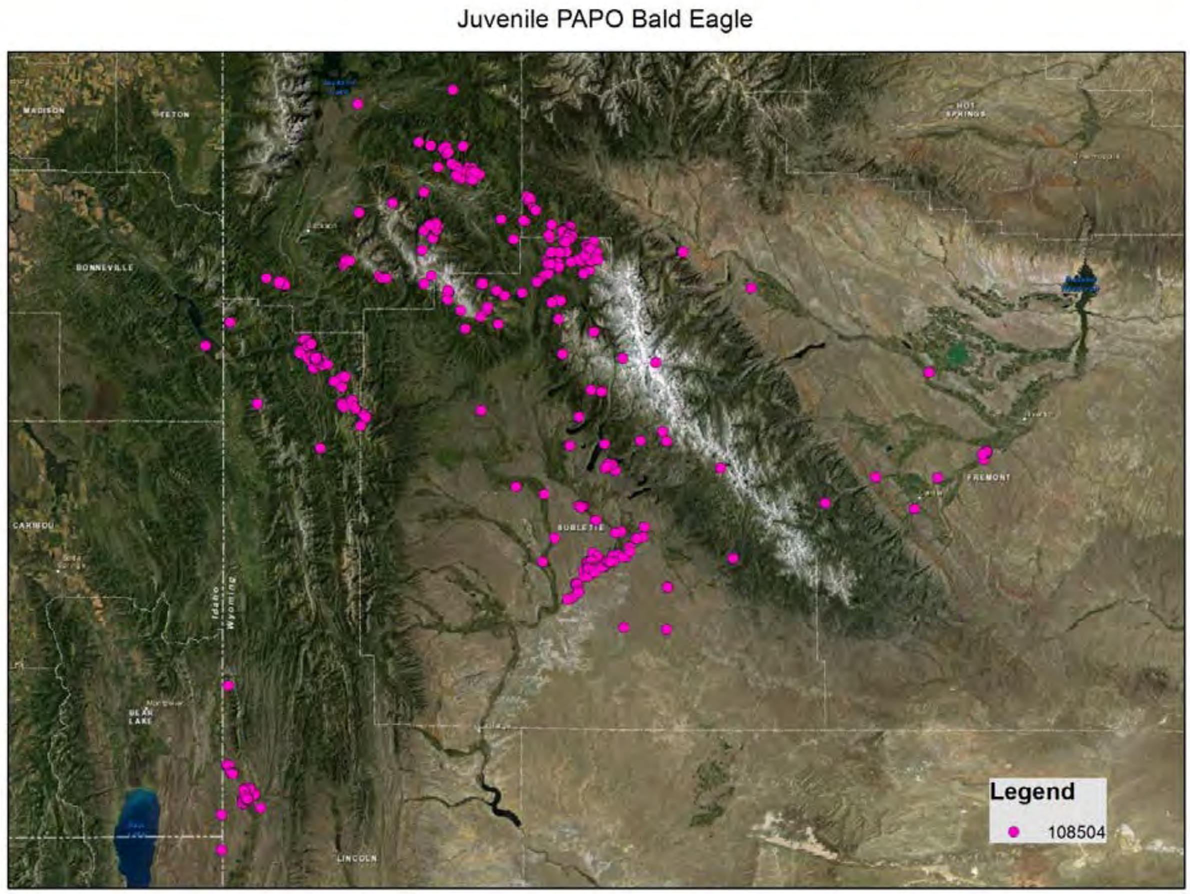

Figure 1. Map of PTT locations of a female juvenile Bald Eagle (*Haliaeetus leucocephalus*) from July 2012-21 February 2013. Map provided by Bryan Bedrosian, Craighead Beringia South.

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

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Northern Goshawk

FUNDING SOURCE: United States Fish and Wildlife Service Cooperative Agreement and Wyoming Game and Fish Department

PROJECT DURATION: 24 February 2012 – 31 December 2013

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Jenny Berven, Rocky Mountain Bird Observatory

ABSTRACT

The Wyoming Game and Fish Department (Department) contracted Rocky Mountain Bird Observatory (RMBO) to design and conduct surveys for nesting Northern Goshawks (*Accipiter gentilis*) during the 2012 and 2013 nestling and fledgling seasons in the Wyoming Range in southwestern Wyoming. Data are needed on this State Species of Greatest Conservation Need associated with mature and older aged conifer forests, as a number of landscape-scale habitat projects have been proposed for this area of the Bridger-Teton National Forest. This work, funded through the Federal State Wildlife Grants program, continues survey efforts initiated in 2009 by the Department to locate nest sites and collect habitat data to identify and map suitable nesting habitat in the range. The Department also funded occupancy surveys by RMBO in 2009 in the Wyoming Range and the adjacent Salt River Range as part of a US Forest Service region-wide Northern Goshawk survey effort. In addition to locating new active nests, RMBO was responsible for collecting nest site habitat data at all new nests found and for checking the status of seven historic nest sites. RMBO designed an unbiased survey based on Northern Goshawk Monitoring and Technician Guide protocols (Woodbridge and Hargis 2006). We split the approximately 73,000 ha study area into 160 Primary Sampling Units (PSUs) by laying 600.25 ha grids across the study area. PSUs along the study area boundary varied in size, as they were clipped to the study area boundary. We ranked PSUs using a spatially balanced design with generalized random tessellation stratification (GRTS) and then re-ranked the grids according to the amount of primary habitat within each PSU. Technicians conducted broadcast acoustical surveys at all accessible call stations within the PSU located in safe, suitable habitat. Technicians did not survey at locations with a slope greater than 36% or within 1.6 km of previously identified nest sites. We defined suitable habitat as any location within 150 m of any tree cover.

During the 2012 field season, technicians surveyed 2,196 call stations in 38 PSUs between 10 June and 21 August. Technicians surveyed a PSU in an average of 4.7 survey days.

Technicians detected goshawks in six PSUs and found four new active nests. The naïve detection rate for PSUs was 15.8% and 0.73 detections per 100 call stations. Of the seven historic nest sites, two nests were active. Technicians recorded nest tree elevation, slope aspect, and slope percent. Technicians also recorded canopy cover, number of seedlings, downfall, live and dead trees per hectare, average ground cover height, dominant ground cover species, and average diameter of all live and dead species of trees within a 0.217 ha radius plot. Overall, new nests were found in lodgepole pine (*Pinus contorta; n*=2), Douglas-fir (*Pseudotsuga menziesii*; *n*=1) and limber pine (*Pinus flexilis; n*=1) trees within mixed coniferous stands.

INTRODUCTION

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

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

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

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

METHODS

RMBO used the same Primary Sampling Units (PSU) grid developed for the 2009 regional monitoring effort for 2012 survey work (Berven and Pavlacky 2010). Using ArcGIS (ESRI 2006), a study area-wide grid was created using 600.25 ha PSUs overlaid onto the Department's study area border layer based on in the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006). If any part of the PSU fell within the study area boundary, that PSU was included in the sampling frame and the PSU boundary was clipped to the study boundary.

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

Habitat selection or stratification is a common method to increase the effectiveness of surveying over a study area. Goshawks are known to nest in Douglas-fir and lodgepole pine trees in the Wyoming Range and in nearby areas of eastern Idaho and western Wyoming (Patla 2005). RMBO used a post-hoc weighting system to prioritize between preferred habitat (Douglas-fir and lodgepole pine stands) and secondary habitat (aspen, spruce, limber pine) forest types. According to the LANDFIRE (2006*a*) data set, the eastern half of the Wyoming Range is strongly dominated by spruce-fir forests with only pockets of either Douglas-fir or lodgepole pine stands. After the PSUs were ranked by the GRTS function, PSUs were re-ranked using area of preferred habitat against its GRTS function rank. Therefore, PSUs with a greater area of Douglas-fir and lodgepole pine were weighted more and ranked higher than PSUs with little or no preferred habitat.

Using ArcGIS, we added a call station grid to the study area after we completed the ranking. For unclipped PSUs, 120 call stations on 10 transect lines (each containing 12 stations spaced 200 m apart) were overlaid on the PSU. Each transect line was placed 250 m apart, offset by 100 m and located at least 150 m from the PSU border. The call station grid was expanded so all irregularly-shaped border PSUs had equally and consistently spaced call stations within the PSU. Call stations in unsuitable locations (slope >36% or >150 m away from forest cover) were identified using ArcGIS. A 30 x 30 m LANDFIRE slope layer (2006*b*) was used to identify call stations located in areas that were too steep to survey. The LANDFIRE vegetation cover layer (2006*a*) was used to identify call stations >150 m from tree cover. Goshawks maintain consistent territory sizes; therefore, we excluded call stations located within historic nest site territories as defined by the RFP (Reynolds and Joy 1998, Reich et al. 2004, Woodbridge and Hargis 2006). Call stations within 1.6 km and 2.4 km of a historic nest were identified using the buffer tool in ArcGIS. When technicians found a new nest, all remaining call stations within the PSU or within 1.6 km of the new nest were removed from the survey effort. Technicians surveyed at call stations in preferred habitat between the 1.6 km and 2.4 km nest buffer. PSUs were further scrutinized to the call station level to eliminate PSUs from the survey effort that had no call stations with suitable habitat within the study area (e.g., WY-BT-NOGO6).

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

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

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

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

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

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

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

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

RESULTS

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

PSUs were selected and ranked from 1 to 160 (Fig. 2) using GRTS. The habitat weighting system effectively moved the survey effort priority to lower elevations with large stands of preferred habitat (Fig. 3). This process also helped decrease the potential of having a highly GRTS-ranked border PSU require surveying if the PSU had little or no suitable habitat.

Technicians conducted broadcast acoustical surveys from 10 June-21 August 2012. A total of 2,196 call stations were surveyed in 38 PSUs with a majority of stations visited during the nestling season (Table 1; *n*=1,395). Technicians used the adult goshawk alarm call until 25 July and then juvenile food begging or wail call for the duration of the season.

The two crews surveyed a total of 91 days. The survey window allows 110 possible workdays for two crews; 6 of those days were required office/coordination days where technicians submitted timesheets, copied data, and prepared themselves for the following pay period (purchased food, determined work, etc.). Four days within the survey window were spent conducting targeted nest searches or collecting habitat data. The remaining workdays were not spent surveying because of the following reasons: Fontenelle Fire (5 days), technician injury (2 days), and vehicle repair needs (2 days). Field crews completed PSUs, on average, in 4.7 survey days (range: 0.7-11.4 survey days). Survey days is the time each crew member spent surveying. Generally, 2 survey days equals 1 work day because each crew usually had 2 members.

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

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

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

In addition to call stations misidentified by GIS in steep locations or far from tree cover, technicians found call stations in recently or currently logged or burned locations (*n*=493). Additionally, there were 437 call stations deemed inaccessible, unsafe, or in unsuitable habitat by technicians in the field. At the beginning of the field season, we expected dynamic environmental factors to be access issues due to high water, snow, or hazardous wildlife. Technicians never reported issues related to those factors; instead, the large Fontenelle Fire, which started on 24 June 2012, eliminated a large survey area (see Appendix A). A total of 1,003 call stations previously expected to be surveyed were located within the burn perimeter.

Technicians conducted surveys at any location with suitable habitat that could be safely accessed and used the GIS designations of too steep or lack of tree cover only as a guide. Technicians surveyed 30 call stations designated as too steep by GIS and one call station designated as greater than 150 m from tree cover. Twenty-seven of the surveyed GIS-designated too steep call stations were at 36% slope as defined by GIS.

Considering call stations within new nest buffers and the area within the Fontenelle Fire burn perimeter, 8,250 call stations are currently not expected to be surveyed at any time during the project (Fig. 4). Eliminating the 2,196 call stations surveyed in 2012, 4,192 call stations in suitable habitat remain to be evaluated.

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

Technicians found one nest during the nestling season and three nests during the fledgling season (Table 3). Technicians found two nests within 45 min of the initial detection, one of which was conducted during the nestling season and the other during the fledgling season. The nest at WY-BT-NOGO49 was found during the second nest search ten days after the initial detection. Technicians found the nest at WY-BT-NOGO88 during the third nest search over a month after the initial detection.

Of the four new nests found, three had confirmed young present (Table 3). During the initial detections, technicians reported three fledglings at PSUs WY-BT-NOGO33 and WY-BT-NOGO88 and one fledgling at WY-BT-NOGO49. Technicians were unable to count the number of young in the nest at WY-BT-NOGO5 at the time of discovery; however, they did see movement in the nest. When the technicians went back on the 24th of August to collect habitat data, no birds were seen in the area.

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

Two of the four newly discovered nests were in lodgepole pine trees, one was in a Douglas-fir and one was in a limber pine (Table 4). All new nest trees were found at elevations between 2,510 and 2,595 m on gentle to moderate slopes and with northerly to northeasterly facing aspects. The plot area (0.217 ha circular plot) around each nest tree consisted primarily of lodgepole pine and Douglas-fir forests. Some plots also contained subalpine fir

(*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmanii*). The understory consisted of coniferous seedlings and low growing (≤12.7 cm) forbs at all sites. The WY-BT-NOGO49 and WY-BT-NOGO88 nest sites had denser understory (4,207 seedlings per ha and 4,622 seedlings per ha, respectively) than WY-BT-NOGO5 and WY-BT-NOGO33 (3,613 seedlings per ha and 2,041 seedlings per ha, respectively).

We combined new and historical nest data to provide descriptive statistics for the elevation, aspect and slope variables. All nests were found at elevations between 2,453 and 2,604 m with an average of 2,543 m (SE = 45.1). Slope averaged 13° (SE=1.7) and nest aspect was between 340 to 67° (NNW to ENE).

According to the LANDFIRE layer (2006*a*), only one of the historic nest sites was located in a Douglas-fir stand; all other nest sites were located in Engelmann spruce stands (Table 5). However, all the historic nest trees were lodgepole pine, Douglas-fir trees, or subalpine fir (one nest only). Furthermore, according to the LANDFIRE layer, all of the new nest sites were located in Engelmann spruce stands, but habitat data show none of the nest trees were Engelmann spruce nor were most of the nests located in Engelmann spruce-dominated stands. Only one new nest site, WY-BT-NOGO33, had a spruce tree component. Because of these inconsistencies, we compared the NWGAP layer to new and historic nest data and found the NWGAP matched the nest tree species to the stand designation four times, whereas the LANDFIRE layer matched the species only one time.

DISCUSSION

The number of PSUs surveyed for the season was less than expected (55 PSUs) but still greater than the minimum estimate of 22 surveys. The average time it took to survey each PSU (4.7 survey days) was higher than predicted (4.0 survey days), which overestimated the completion of about five PSUs. The largest factor increasing the PSU survey time and decreasing the number of surveyed PSUs was the impact of the Fontenelle Fire, which prevented each crew from working for about 5 days (10 survey days). Technicians were able to work while the fire was actively burning, but had to leave the study area at times because of evacuations, smoke, and logistical planning needs. Not only did technicians spend more time hiking in and out of PSUs because of the fire, they also surveyed together more often for safety reasons.

While the technical guide establishes methods to determine occupancy using broadcast acoustical surveys, it also provides two methods for nest searches, one of which is conducting area nest searches. This method is used in deciduous forests early in the nesting season. This method was not considered for this project because the Wyoming Range is primarily covered in coniferous forests (LANDFIRE 2006*a*). The other method is conducting intensive search surveys. This method requires the identification of primary forest stands most likely to contain nesting goshawks. Once the forest stands are identified, teams of technicians walk along pre-determine transects broadcasting goshawk calls at 250 m intervals. Although research suggests goshawks in the Greater Yellowstone Area prefer Douglas-fir and lodgepole pine stands, there is no current definitive research on nest-habitat preference in the Wyoming Range. About 4% of the study area is classified as Douglas-fir and lodgepole pine (LANDFIRE 2006*a*). Furthermore, the cover type in the Wyoming Range study area is predominantly Engelmann spruce-subalpine fir (36.7%) and some of these stands are over a thousand hectares in size (LANDFIRE 2006*a*). If survey effort concentrated only in the Douglas-fir and lodgepole pine stands, a significant portion of potentially suitable habitat within the study area would be ignored. Furthermore, preliminary results indicated GIS would misidentify potential nest locations. There would also a be significant loss of cost effectiveness if technicians were to survey only the smaller, widely-spaced Douglas-fir and lodgepole pine stands randomly across the study area.

Road-based selection can be used to maximize cost effectiveness between high- and low-cost survey units. Because of the scale of the 600.25-ha PSUs, the size and location of the study area, and road coverage, almost all PSUs were within 1.6 km or less of a road. Therefore, cost-stratification or selection based on roads was not relevant. Furthermore, this design did not include road/trail stratification because research suggests that goshawks prefer nesting away from human disturbance (Bosakowski 1994, Morrison et al. 2011).

The nest search protocol was effective once a detection was made. Four of six detections resulted in a found nest in, on average, less than two site visits. We did not expect a nest in the PSU where technicians detected the sub-adult goshawk. Although sub-adult goshawks are capable of breeding, successful nest attempts are unlikely (Squires and Reynolds 1997). Combined with the bird's lack of defensive behavior, we believe there was no nest in that PSU. Adjusting for the sub-adult detection, four of five detections resulted in a found nest. Technicians did conduct a nest search after a fledgling was detected at WY-BT-NOGO35, but the nest search was conducted at the end of the day and technicians were unable to spend an appropriate amount of time conducting a thorough search. Technicians were unable to return to the PSU before the end of the field season. Technicians will resurvey that PSU in 2013.

Since nest searches were successful after a detection was made, increasing the total number of nests found could be achieved with an increased detection rate or by prioritizing survey effort within the suitable nesting habitat. Since detection probabilities and rates vary within populations season-to-season and most factors are beyond control (e.g., fire, weather, species productivity), we recommend concentrating on methods to prioritize survey effort (MacKenzie et al. 2002, Reich et al. 2004, Patla 2005).

Since finding new goshawk nests is the primary objective of this project and complex, statistical analyses are not, we have the ability to adjust our sampling design to improve our chances of finding additional sites while still maintaining unbiased methods. Changing some of the protocols may be a favorable approach especially since the Fontenelle Fire decreased the amount of suitable habitat to survey within the study area. We recommend using a different vegetation layer (NWGAP or BTNF vegetation layer) for habitat ranking and isolating sites by using aspect and elevation layers for the 2014 field season. We initially used the LANDFIRE layer because we thought it better differentiated between vegetation coverage/non-coverage and specific tree species. However, in the field, very few of the LANDFIRE attributes matched what was seen at the nest sites; the NWGAP vegetation layer appears to match actual habitat more accurately. We will also assess a BTNF vegetation layer as a potential tool to help to improve the habitat criteria. We believe we can improve detection rates by determining specific locations within the study area where we are more likely to find goshawks. Based on summary statistics from new and historic nests, there is evidence we are likely to find goshawk nests between about 2,454 and 2,636 m on NNW to ENE facing slopes with mild to moderate slopes (Table 6). Although we do not recommend changing the PSU ranking system or eliminating call stations in response to the topographical variables, we recommend prioritizing survey locations within the PSUs based on those variables. We do not recommend prioritizing call stations by GIS based on cover type because remote sensing layers may not be accurate (as seen with this year's habitat data collection). However, once technicians are in the field, they can plan their survey route to target lodgepole pine and Douglas-fir stands before other forest types.

Finally, we do not recommend changing slope elimination procedures. We believe the GIS-determined call station elimination was an effective tool for increasing the cost effectiveness and safety of the fieldwork without significantly decreasing the likelihood of a technician surveying at suitable locations. While in the field, technicians agreed with GIS designations more often than not and when inconsistencies arose, GIS was conservative with the elimination. For example, there was one call station eliminated by GIS because of tree cover that was actually within 150 m of tree cover. There were 213 call stations labeled by GIS as safe and within 150 m of suitable habitat that were actually more than 150 m from tree cover. In addition, only 1 of the 11 nests (historical and new) was located on a hill with a slope >36%.

ACKNOWLEDGEMENTS

S. Patla (Wyoming Game and Fish Department) was essential in the development and funding of this monitoring effort. She provided technical support for the sampling design and field logistics, as well as field assistance. Several people within Rocky Mountain Bird Observatory provided input, expertise, services and support; these individuals include: R. Sparks, who oversaw the GRTS ranking process and D. Pavlacky, who provided modeling and statistical knowledge. Field studies could not be completed without field technicians; we thank J. Benson, G. Henne, K. Nolan, M. Roes, and A. Rosenberg for completing their work with enthusiasm, eagerness, and attention to detail. Finally, this report benefitted greatly from peer reviews by S. Patla and C. White (RMBO).

LITERATURE CITED

Anderson, D. E., S. DeStefano, M. I. Goldstein, K. Titus, D. C. Crocker-Bedford, J. J. Keane, R. G. Anthony, and R. N. Rosenfield. 2005. Technical review of the status of northern goshawks in the Western United States. Journal of Raptor Research 39:192-209.

Berven, J. M., and D. C. Pavlacky. 2010. Northern Goshawk Monitoring in the Bridger-Teton National Forests: 2009 Field Season Report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Bosakowski, T., and R. Speiser. 1994. Macrohabitat selection by nesting Northern Goshawks: implications for managing eastern forests. Studies in Avian Biology 16:46-49.

Bright-Smith, D. J., and R. W. Mannan. 1994. Habitat use by breeding male Northern Goshawks in northern Arizona. Studies in Avian Biology 16:58-65.

ESRI. 2006. ArcGIS. Environmental Systems Research Institute, Inc., Redlands, California, USA.

ESRI. USA Topographic Map. 2011. National Geographic Society. http://services.arcgisonline.com/ArcGIS/rest/services/USA_Topo_Maps/MapServer (accessed January 2012).

Greenwald, D. N., D. C. Crocker-Bedford, L. Broberg, K. F. Suckling, and T. Tibbits. 2005. A review of Northern Goshawk habitat selection in the home range and implications for forest management in the western United States. Wildlife Society Bulletin 33:120-129.

LANDFIRE. LANDFIRE.US_110EVT_LF_1.1.0. 2006*a*. Existing vegetation cover layer. US Department of the Interior, Geological Survey. http://landfire.cr.usgs.gov/viewer/ (accessed January 2012).

LANDFIRE. LANDFIRE.US_SLP_LF_1.0.0. 2006*b*. Slope. US Department of the Interior, Geological Survey. http://landfire.cr.usgs.gov/viewer/ (accessed March 2012).

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MacKenzie, D. I., and J. D. Nichols. 2004. Occupancy as a surrogate for abundance estimation. Animal biodiversity and conservation 27:461-467.

Morrison, M. L., R. J. Young, J. S. Romsos, and R. Golightly. 2011. Restoring Forest Raptors: Influence of human disturbance and forest condition on Northern Goshawks. Restoration Ecology 19:273-279.

Patla, S. M. 1997. Nesting ecology and habitat of the Northern Goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Thesis. Idaho State University, Pocatello, USA.

Patla, S. M. 2005. Monitoring results of Northern Goshawk nesting areas in the Greater Yellowstone Ecosystem: is decline in occupancy related to habitat change? Journal of Raptor Research 39:324-334.

Patla, S. M., and S. Derusseau. 2010. Wyoming Range raptor inventory and monitoring study completion report. Pages 104-121 in Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Reich, R. M., S. M. Joy, and R. T. Reynolds. 2004. Predicting the location of Northern Goshawk nests: modeling the spatial dependency between nest locations and forest structure. Ecological Modelling 176:109-133.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the southwestern United States. US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Reynolds, R. T., and S. M. Joy. 1998. Distribution, territory occupancy, dispersal, and demography of Northern Goshawks on the Kaibab Plateau, Arizona. Final report for Arizona Game and Fish Heritage Project Number 194045. http://www.rmrs.nau.edu/wildlife/research/northern_goshawks.shtml.

Reynolds, R. T., R. T. Graham, and D. A. Boyce. 2008. Northern Goshawk habitat: an intersection of science, management, and conservation. Journal of Wildlife Management 72:1047-1055.

Shuster, W. C. 1980. Northern Goshawk nest site requirements in the Colorado Rockies. Western Birds 11:89-96.

Squires, J. R., and L. F. Ruggiero. 1996. Nest-site preference of Northern Goshawks in southcentral Wyoming. Journal of Wildlife Management 60:170-177.

Squires, J. R., and R. T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). *In* The Birds of North America (A. F. Gill, Editor). The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA and the American Ornithologists' Union, Washington, D.C., USA.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Woodbridge, B., and C. D. Hargis. 2006. Northern Goshawk inventory and monitoring technical guide. United States Department of Agriculture, Forest Service, Washington, D.C., USA.

Table 1. Surveyed Primary Survey Units (PSU) and call stations during the June-August 2012 Northern Goshawk (*Accipiter gentilis*) nest search and monitoring field season. Technicians or GIS eliminated call stations that were located in unsuitable, unsafe areas or inaccessible due to surrounding terrain. PSUs can have a maximum of 120 call stations, but less are possible if the PSUs were located on the study area boundary and clipped by GIS.

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

Table 2. Call stations identified as "not to survey" by GIS and reason(s) for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, Wyoming for the 2012 field season. GIS identified call stations within 2.4 km of a known Northern Goshawk nest, located on a slope >36°, or >150 m from tree cover.

Reason	Number of call stations
Historic Nest	1,174
Historic Nest and Slope	240
Historic Nest, Slope and Tree Cover	1
Historic Nest and Tree Cover	12
Slope	4,453
Slope and Tree Cover	161
Tree Cover	276
Total number of calls stations identified by GIS	6,317

Table 3. Summary of Northern Goshawk (*Accipiter gentilis*) detections and nests found during 2012 field season. Locations are considered sensitive and have not been included in this report. [a] Two defensive adults; movement seen in nest but unable to count nestlings. [b] False detection (mimicking jays). [c] Non-defensive sub-adult. UTMs in Zone 12 NAD 83. Wyoming Range, Wyoming.

PSU ID	Initial detection	Detection type	Nest found	No. young
WY-BT-NOGO5	7/3/2012	Active Nest, Visual	7/3/2012	unk[a]
WY-BT-NOGO33	8/6/2012	Aural, Visual	8/6/2012	3
WY-BT-NOGO49	8/7/2012	Active Nest, Aural, Visual	8/17/2012	1
WY-BT-NOGO88	7/16/2012	Aural, Visual	8/23/2012	3
WY-BT-NOGO2	6/11/2012	Aural[b]		
WY-BT-NOGO36	7/9/2012	Aural, Visual[c]		
WY-BT-NOGO35	8/21/2012	Aural, Visual		1

Table 4. Northern Goshawk (*Accipiter gentilis*) nest tree habitat data collected after the 2012 field season in the Wyoming Range, Wyoming. Elevation, slope aspect, and slope were determined using GIS. All GIS elevation figures are within 50 ft of GPS readings. All GIS slope aspect figures are within 10° of compass readings by technicians. All GIS slope figures are within 5° of clinometer reading by technicians. Note: table is presented in English rather than metric units because these type of data are typically used by the US Forest Service in English units.

PSU ID	Nest tree species	Nest tree alive?	Age (years)	DBH (in)	Tree height (ft)	Nest height (ft)	Live canopy height (ft)	Elevation (ft)	Slope aspect	Slope
WY-BT-NOGO5	Douglas-fir	Yes		24.2	69	44	42	8,343	353°	13° (23%)
WY-BT-NOGO33	Limber pine	Yes	31	24.7	77	46	48	8,287	356°	16° (29%)
WY-BT-NOGO49	Lodgepole pine	No	65	12.7	75	57	n/a	8,514	50°	16° (29%)
WY-BT-NOGO88	Lodgepole pine	Yes	13	14.9	68	35	35	8,235	39°	8° (14%)

Table 5. Comparison of Northern Goshawk (*Accipiter gentilis*) nest tree and plot (0.217 ha) field data to GIS layers. Wyoming Range, Wyoming. Douglas-fir (DF), Engelmann spruce (ES), lodgepole pine (LLP), limber pine (LMP), subalpine fir (SAF).

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

Table 6. Wyoming Range, Wyoming new and historical Northern Goshawk (*Accipiter gentilis*) nest (*n*=11) topographical summaries (SE=standard error, SD=standard deviation). All data were determined using ArcGIS. Nests have been active at least 1 year between 2009 and 2012.

Variable	Average	SE	SD	Minimum/maximum	Range
Elevation (m)	2,543	13.7	45.6	2,453/2,604	151
Aspect (°)	18	7.8	25.8	340/67	87
Slope (%)	23	3.2	10.5	5/45	40

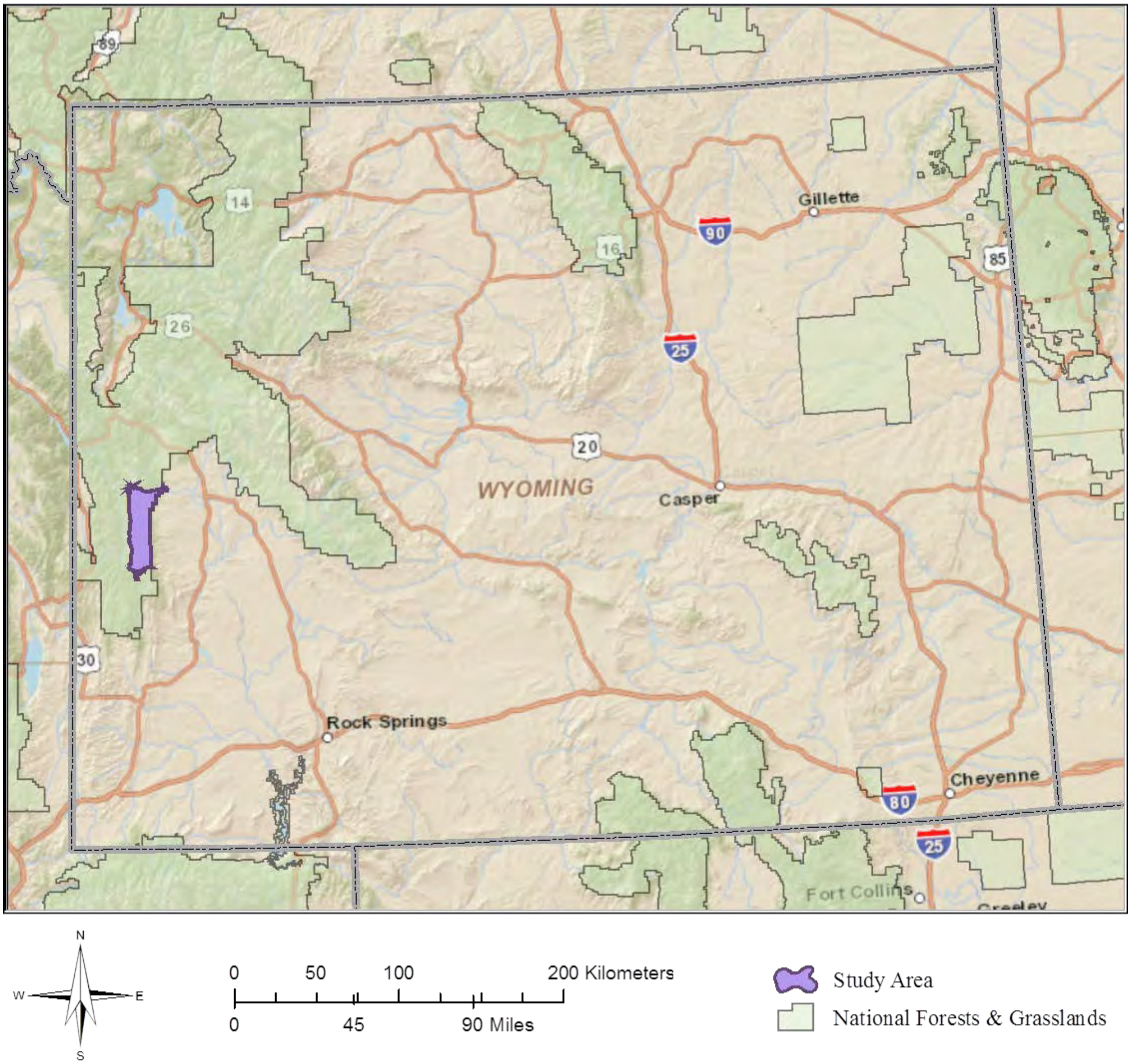

Figure 1. The Wyoming Range, Wyoming Northern Goshawk (*Accipiter gentilis*) nest search and monitoring study area, 2012-2013. Scale is 1:3,500,000.

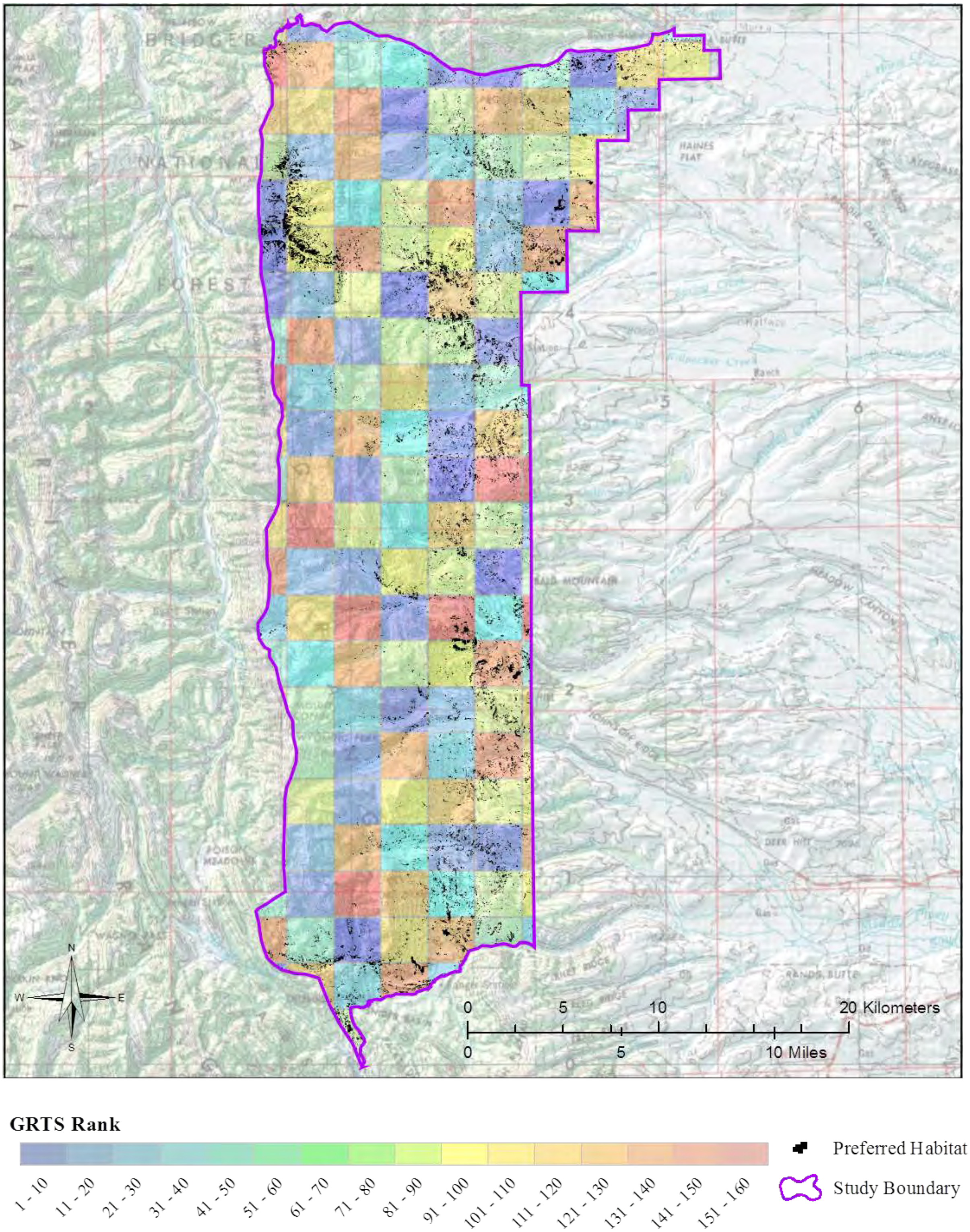

Figure 2. Primary Sampling Unit (PSU) ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by GRTS function in R. Wyoming Range, Wyoming, 2012. Scale is 1:265,000.

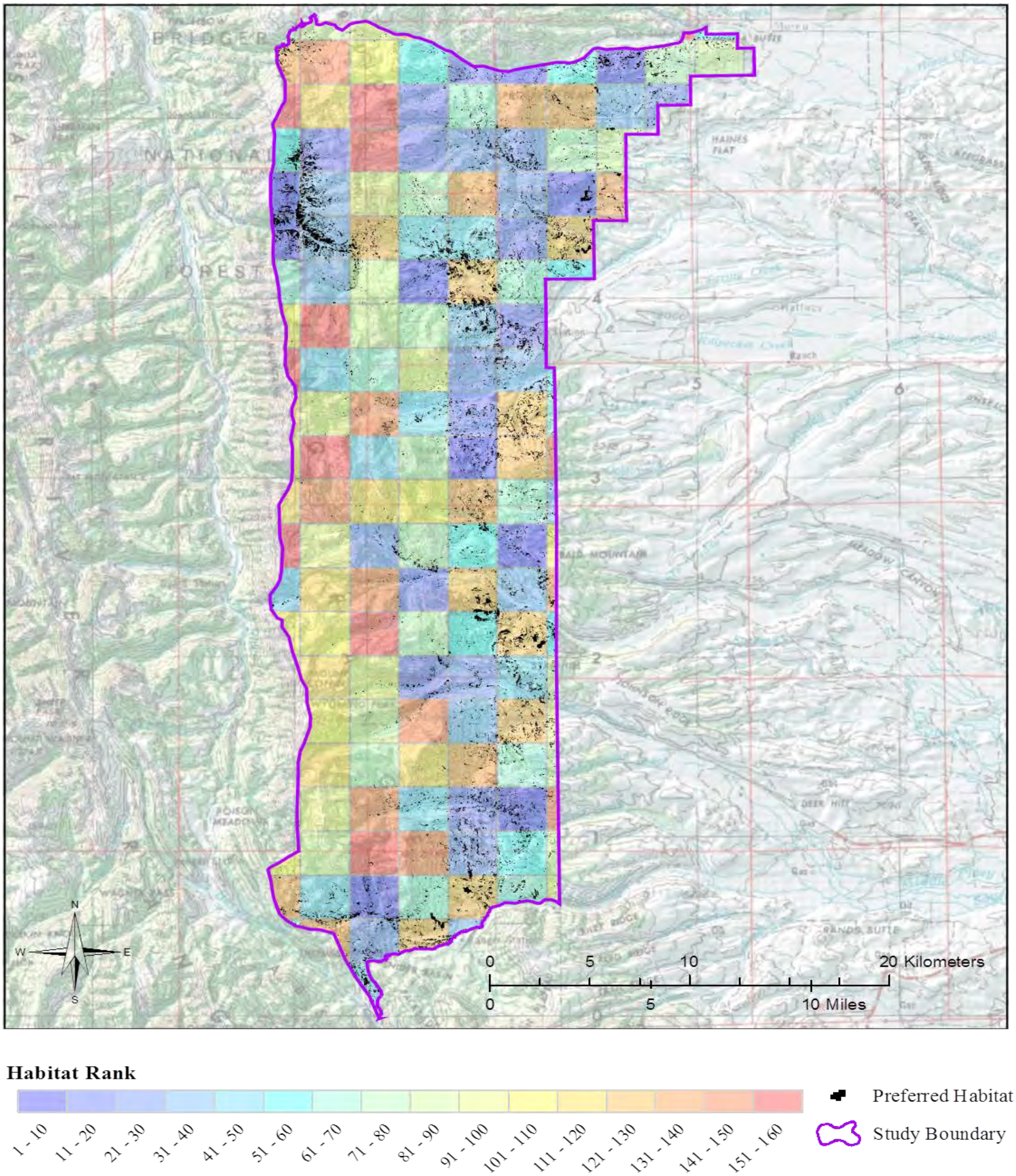

Figure 3. Primary Sampling Unit (PSU) ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by generalized random-tessellation stratification (GRTS) and habitat weighting. Preferred habitat for Northern Goshawks includes Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) stands. Wyoming Range, Wyoming, 2012. Scale is 1:265,000.

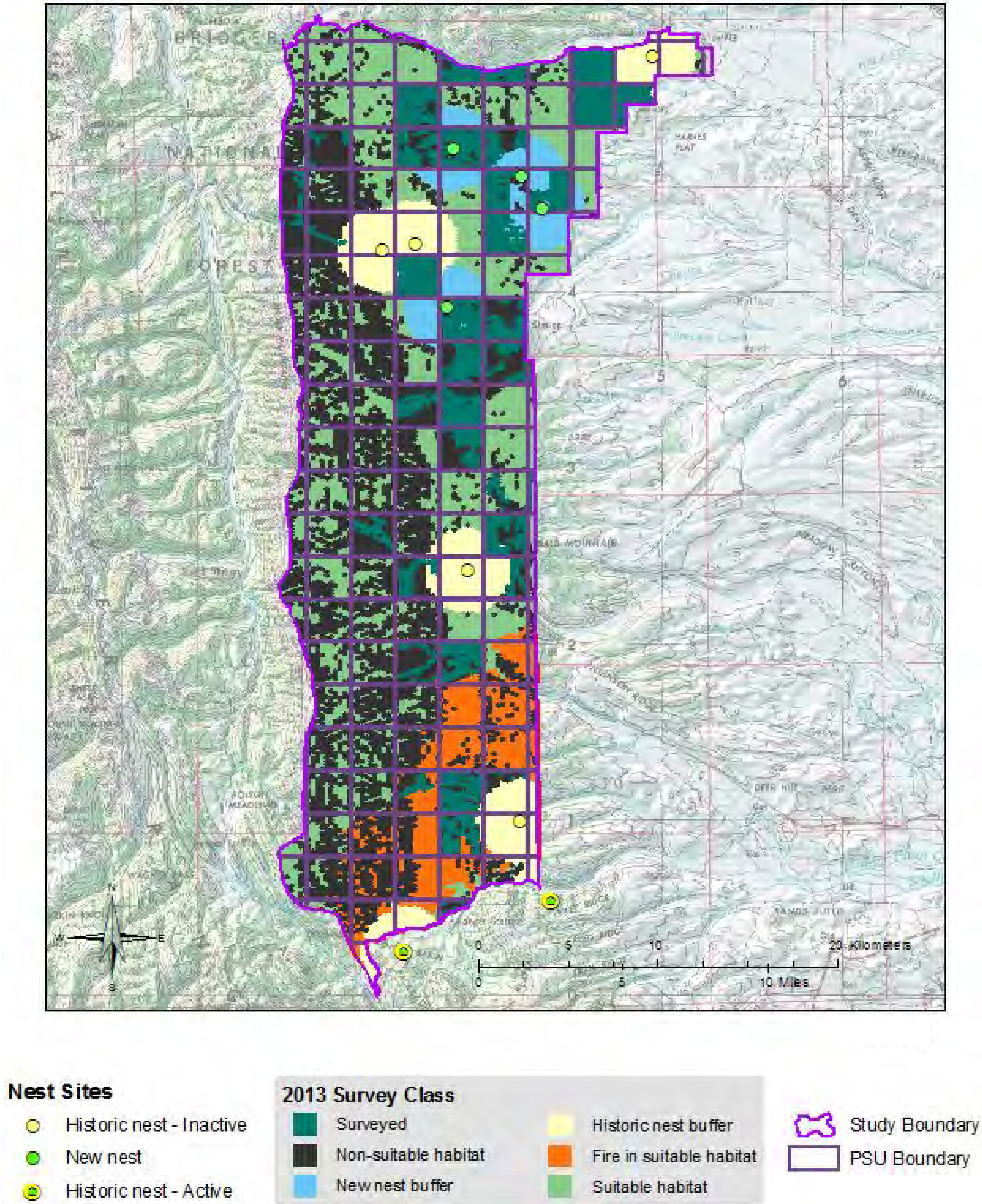

Figure 4. Survey class results determined by Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, Wyoming during the 2012 field season, 10 June-21 August. Scale is 1:265,000.

RESOURCE SELECTION OF FERRUGINOUS HAWKS (*BUTEO REGALIS*) IN WYOMING IN RELATION TO ENERGY DEVELOPMENT: A PRELIMINARY ANALYSIS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Ferruginous Hawk

FUNDING SOURCE: United States Forest Service Rocky Mountain Research Station; Bureau of Land Management; Wyoming Wildlife Heritage Foundation; PacifiCorp; Pathfinder Renewable Wind Energy, LLC; Wyoming Game and Fish Department; Wyoming Governor's Endangered Species Account Funds; Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 January 2010 – 31 December 2013

PERIOD COVERED: 15 April 2011 – 30 September 2012

PREPARED BY: John R. Squires, Rocky Mountain Research Station, Forestry Science Lab
Lucretia E. Olson, Rocky Mountain Research Station, Forestry Science Lab
Bob J. Oakleaf, Nongame Coordinator, Wyoming Game and Fish Department

ABSTRACT

The rapid increase in domestic energy development in Wyoming has heightened concern of potential impacts to prairie-nesting raptors. This concern is most acute for Ferruginous Hawks (*Buteo regalis*), a species known for sensitivity to human-caused disturbance. In 2010, we surveyed 60 random townships (93.3 km^2 each) for occupied nest-sites within the species' distribution in Wyoming. In 2011, we augmented this sample by searching an additional 39 townships. We conducted flights in late April and early May when Ferruginous Hawks occupied nest territories, including laying and incubating eggs. To locate nests, we flew 16 transects the length of the township, each spaced 600 m apart to provide complete search coverage. Aerial surveys provided a representative and unbiased sample of occupied nests for resource selection modeling, regardless of road proximity, land ownership, and terrain access. We built resource selection models based on remotely-sensed covariates across Wyoming. We viewed nest selection as a hierarchical process that included multiple spatial scales, and thus evaluated the environmental features that Ferruginous Hawks select at both the immediate nest area (0.25-1 km) and within a broader landscape context (1.5-25 km). Based on an average of the four top performing nest-site scale models, Ferruginous Hawks selected nest areas with increased amounts of bare ground, lower topographic roughness, and shorter relative shrub heights. Ferruginous Hawks exhibited positive selection to three other variables at the nest-site scale

(proportion of riparian land cover, oil/gas well density, and secondary road density), but these variables occurred only once in the top set of models, suggesting lower model support for each term. We also built a set of 50 combination scale candidate models using variables from both the nest-site and landscape scales. Five combination models were averaged as they were within 2 ΔAIC of the best performing models. Landscape scale topographic roughness (5 km) was the most important variable for predicting Ferruginous Hawk habitat, contributing to all five of the top models. Ferruginous Hawks selected areas with lower roughness that is found in areas that were flatter compared to random expectation. Ferruginous Hawks also selected areas with a greater proportion of bare ground directly around the nest-sites (250 m), which contributed to three of the five top models. Other variables included in the top models were the straight line distances to roads and wells, the proportion of riparian land cover, and shrub height at both small (250 m) and large (25 km) scales. However, the bootstrapped confidence intervals for these variables included zero, indicating a lack of predictive importance. We evaluated model performance using both cross-validation and by calculating predicted RSF values for a withheld (N = 93) nest sample. The cross-validated combined-scale model set performed better than either the nest-site or landscape-scale model set, with a Spearman-rank correlation of 0.96 (SE = 0.03). The second, more rigorous, evaluation of model performance used the model predicted values at withheld nests to closely simulate how models would be used by resource agencies. The Spearman-rank correlation between predicted RSF values of withheld nests and random RSF values at the combined scale was 0.90. The majority of withheld nests were assigned to higher RSF probabilities, suggesting good model performance. We concluded that disturbance associated with energy development was not an important predictor of habitat selection for Ferruginous Hawks when nesting. However, anecdotal observations suggest a non-linear relationship between energy development and habitat suitability; fields with dense development may show a decline in nesting Ferruginous Hawks over time (e.g., Pinedale Anticline, Jonah Infill Drilling Project).

INTRODUCTION

Although denied federal listing under the Endangered Species Act in 1991, Ferruginous Hawk (*Buteo regalis*) management remains controversial in the western United States (Ure et al. 1991, USFWS 1992). In Washington, Ferruginous Hawks were listed as a sensitive species because the number of occupied nesting territories recently declined. In 1987, 54 % of 118 territories surveyed in Washington were occupied by Ferruginous Hawks; in 1995, 36 % of 179 territories were occupied, and in 2002 only 20 % of 241 territories surveyed were occupied (WDFW 1996). The Ferruginous Hawk is classified as a "Species of Special Greatest Conservation Need" in Wyoming and receives similar state classifications in New Mexico ("Imperiled") and Colorado and Montana ("Species of Most Concern").

The 35 trillion cubic feet of recoverable natural gas beneath Wyoming (US Department of Energy 2012) coincides with the state-wide distribution of Ferruginous Hawks (Fig. 1). In 2000, the Wyoming Oil and Gas Conservation Commission estimated that 4,570 producing oil wells and 7,907 producing gas wells were present in the state's 25 largest fields. By 2006, the numbers increased to 6,045 producing oil wells and 25,297 gas wells in these fields. The expansion of coal-bed natural gas (CBNG) development is especially pronounced in the Powder

River Basin of northeastern Wyoming and southeastern Montana, in an area particularly important to nesting Ferruginous Hawks. Over the past decade, CBNG development impacted 24,000 km^2 of prairie habitat, and over 50,000 CBNG wells have been authorized for development on federal mineral reserves in northeastern Wyoming (BLM 2003*a, b*). In addition, each natural gas well typically requires the construction of 2-7 km of roads and 7-22 km of power lines per km^2, plus an extensive array of compressor stations, pipelines, and ponds (BLM 2003*b*). Thus, a pressing conservation need is to understand how Ferruginous Hawks may be impacted by the construction and operation of the many types of energy development across Wyoming.

Ferruginous Hawks are reported to be one of the most sensitive raptors in North America to human disturbance (Olendorff 1993, Bechard and Schmutz 1995, Franson et al. 1995, Lehman et al. 2007, Lehman et al. 2010). However, this perception is based on few data, especially in regards to specific impacts associated with energy development. A large proportion of the hawk's historical range is currently occupied, but range contractions were reported in south-central Canada (Bechard and Schmutz 1995), Utah and eastern Nevada (Olendorff 1993), North Dakota (Stewart 1975), and Arizona (Glinski 1998). Ferruginous Hawks are only found in North America with an estimated population of 6,000-11,000 individuals (Olendorff 1993). Schmutz et al. (1992) estimated the Ferruginous Hawk population at 14,000 for the Great Plains. Thus, Ferruginous Hawk management in Wyoming, a state that may support over 800 nesting pairs, is central to the conservation of this species in the U.S (Oakleaf 1986).

Our goal in this document is to present preliminary results regarding how Ferruginous Hawks respond to energy development when selecting nest-sites in Wyoming; these results will be finalized in a peer-reviewed publication that we plan to submit for consideration later this year. We present these preliminary results as part of a larger on-going study with 4 objectives: 1) determine distribution, abundance, occupancy, and productivity of Ferruginous Hawks in Wyoming relative to oil, gas, and wind-power development and provide a minimum abundance estimate for golden eagles in lowland habitats; 2) use genetic sampling to determine if population vital rates of Ferruginous Hawks are negatively impacted by increased energy development; 3) document the movements of Ferruginous Hawks when foraging in landscapes with abundant energy development (oil/gas and wind); and 4) determine the relative abundance of key prey species of Ferruginous Hawks when nesting at sites that are representative across Wyoming and also relative to energy structures like oil/gas wells, wind turbines, and roads. We have thus far completed two (2011-2012) of three field seasons (2011-2013); fieldwork to accomplish Objective 3 will extend to 2014, funding provided. In this report we focus on the extent to which Ferruginous Hawks avoid oil and gas development when selecting nest territories. We determine how landscape pattern, prey abundance, physical environment and energy development affect the selection of nest-sites used by Ferruginous Hawks. We test 4 predictions that consider whether energy, vegetation, physical environment, or relative prey abundance best explain where Ferruginous Hawks select nest-sites.

METHODS

Terminology

In this report, we used terminology and associated definitions provided by Steenhof and Newton (2007). A nest is defined as the structure where eggs are laid and young sheltered, and a nesting territory is defined as an area that contains, or historically contained, one or more nests of a mated raptor pair and where no more than one pair is known to have bred at one time. We are aware of the many different terms that have been used synonymously and the more restricted ethological definition of a territory as a defended area but agree with Steenhof and Newton (2007) as to the appropriateness of this term. We quantified resource selection only at "occupied" nests based on: 1) one adult was associated with a freshly repaired nest; 2) 2 adults were present at a nest; 3) one adult was incubating or brooding; or 4) we observed eggs or young.

Study Area

Our study area included sagebrush-steppe habitats across Wyoming, but excluded mountain ranges with extensive coniferous forests (Fig. 2); Ferruginous Hawks seldom use contiguous coniferous forests for nesting (Bechard and Schmutz 1995). Big sagebrush (*Artemisia tridentata*) and wheatgrass (*Agropyron spp*.) communities were dominant, intermixed with narrowleaf cottonwood (*Populus angustifolia*) in riparian drainages; Rocky Mountain juniper (*Juniperous scopulorum*) and ponderosa pine (*Pinus ponderosa*) were common on higher ridgelines. Elevation ranged from approximately 930 m to 3,390 m. Temperature exhibited considerable seasonal shifts: in July, summer highs averaged 29 to 35 C and during January, lows averaged -15 to -12 C.

Our 186,693 km^2 study area included a mix of land ownership comprised of 41.5% federal, 6.6% state, and 51.4% private. The harsh dry climate is amenable to cattle grazing, with only approximately 4% of Wyoming in irrigated and non-irrigated cropland. The distribution of Ferruginous Hawks in Wyoming extensively overlapped energy development, including oil, gas, wind, and coal. Energy extraction and associated development was a primary and rapidly expanding land-use across much of the state.

Sampling Ferruginous Hawk Nests

In 2010, we used two fixed-wing aircrafts (Bellanca Scout and Piper PA 18) to search 60 randomly selected townships (93.3 km^2 each) in Wyoming (Fig. 2). We first stratified potential survey townships (n = 1230) by the density of energy development. We then randomly selected townships in a sample size proportional to the area of energy strata. We conducted surveys in April and early May when Ferruginous Hawks were occupying sites, including laying and incubating eggs. In 2011, we expanded the survey area to include 39 additional townships (Fig. 2). Surveying for Ferruginous Hawks by aircraft provided a representative sample of nest-sites regardless of road proximity, land ownership, and terrain access. For each sample, we flew 16 transects, each the length of the township and spaced 600 m apart. This configuration provided complete visual coverage of surveyed townships (Fig. 3).

During flights, the pilot and one observer both searched for nests; flight speed on transects averaged 130 km per hour. Aircrafts were outfitted with GPS to precisely match flight paths to designated transect paths. Survey protocols that we employed (e.g., transect spacing, aircraft speed, minimum qualifications or experience of observers, and timing) were similar to those recommended by Ayers and Anderson (1999) for Ferruginous Hawks, with the exception of the presence of two observers in the airplane. After searching the townships, survey crews flew to historical nests identified by the Wyoming Game and Fish Department (Department) *Wildlife Observation* nest database to assess their occupancy. We also included in the analysis nests found while flying between survey townships.

Model Development

We viewed nest selection as a hierarchical process that included multiple spatial scales. We evaluated the environmental features that Ferruginous Hawks select in the immediate nest area (0.25-1 km) and within a broader landscape context (1.5-25 km). We believed a multi-scale approach to modeling was necessary because the ecological scale most important to Ferruginous Hawks when selecting resources was unknown and selection may occur at more than one scale (Johnson et al. 2004). For the nest-site scale, we quantified selection using 250 m, 500 m, and 1,000 m radii moving windows that radiated hierarchically from nest-sites. We assumed the 250 m window represented selection of resources in the immediate nest area. We then assumed that multiple scales extending to 1 km were biologically meaningful as potentially representing a post-fledging area, similar to other raptors, such as Northern Goshawks (*Accipiter gentilis*) (*R*eynolds et al. 1992, Kennedy et al. 1994). We also expected that Ferruginous Hawks may select environmental features at scales that extend beyond the home range, given the species' mobility and its use of open sagebrush-steppe with long sighting distances. For the landscape scale, we quantified resources using 1.5 km, 5 km, 10 km, and 25 km radii moving windows. We chose the smallest window (1.5 km) to be approximately one half the nearest-neighbor distance between nests based on 11 studies (Bechard and Schmutz 1995); we considered this scale as representational of the spatial extent of a typical home range, as it was approximately the size of the territory defended from conspecifics and other raptors that we observed in the field. We considered spatial extents up to 25 km because of high species mobility and the large scale of energy development.

We developed resource selection functions (RSF) using logistic regression to estimate the selection probability of Ferruginous Hawks for environmental features at multiple spatial scales (Boyce and McDonald 1999, Manly et al. 2002). We compared nest locations found during surveys to random sites across the study area as an unbiased method for ranking habitats (Keating and Cherry 2004, Johnson et al. 2006). We considered nests "used" if we documented site occupancy in 2010, 2011, or 2012. We excluded nests on artificial nest structures (ANS) from this preliminary analysis. For our final analysis, we will quantify environmental resources at ANSs to evaluate resource differences between those and nest-sites found on natural structures. We generated random locations across Wyoming, excluding mountain ranges with conifer-forest cover (Bechard and Schmutz 1995). Thus, we evaluated nest selection (Type 2 selection; Johnson 1980) in sage-steppe habitats that were biologically meaningful and that supported resident nesting populations. We compared environmental features found at nest-sites to random locations ($n = 980$) distributed throughout the inference area. The random locations provided a general measure of availability of environmental features across the species' distribution to allow inference of resource selection. We applied a weighting term in the logistic regression to down-weight the number of random locations so as to be equal to the number of nest-site locations, with the resulting models unbiased in their comparison of use and availability. We assumed the predicted probability of use was correlated to resource value, and consequently could be used to rank habitat quality (Johnson et al. 2004).

Predictor Variables

We chose predictor variables that we believed related to nest-site selection based on species' life history (Bechard and Schmutz 1995). We only considered variables derived from spatial data layers that were readily available and covered the entire species' distribution in Wyoming to facilitate conservation planning. The 19 predictor variables we considered indexed environmental heterogeneity associated with energy development, vegetation, the physical environment, and prey (Table 1); the prey layer is under development and was unavailable for these preliminary analyses (L. Olson pers. comm.). Spatial data layers included a combination of categorical and continuous indices based on satellite imagery. For continuous variables, we calculated the mean and associated standard deviations for variables across moving windows at the appropriate hierarchical scales at used and available locations, and we calculated differences in proportion for categorical values.

Ferruginous Hawks may exhibit sensitivity to human disturbance, especially during nesting (Smith and Murphy 1978, White and Thurow 1985, Olendorff 1993, WDFW 1996). Thus, we measured the density and Euclidean distance to oil and gas wells associated with used and random sites as indices of energy-related disturbance (Table 1). We calculated oil and gas well density for moving windows with data provided by the Wyoming Oil and Gas Conservation Commission, accessed March 2012. Although Ferruginous Hawks may habituate to vehicle traffic (MacLaren et al. 1988), we quantified road density in appropriate moving windows using a road layer recently (2010) developed by the Bureau of Land Management (BLM) from National Agriculture Imagery Program (NAIP) imagery. We quantified secondary roads, including those with dirt, gravel and aggregate surfaces, but excluded both paved interstate and state highways and primitive, non-graded dirt roads. Paved state and federal highways were too low density in Wyoming to provide a meaningful model input, and we assumed that Ferruginous Hawks tolerated dirt two-track roads based on field observations.

We included predictor variables that indexed vegetation structure and composition in sage-steppe grasslands, as they may affect potential prey populations (Table 1; Hanser and Huntly 2006). These prey species include Uinta and Wyoming ground squirrels *(Spermophilus armatus* and *S. elegans*), golden-mantled ground squirrels (*S. lateralis*), thirteen-lined ground squirrel (*S. tridecemlineatus)* white- (*Cynomys leucurus*) and black-tailed prairie dogs (*C. ludovicianus*), and cottontails (*Sylvilagus* spp.) and jackrabbits (*Lepus* spp.; Bechard and Schmutz 1995, Baker et al. 2003, Orabona et al. 2012). We quantified percent sagebrush (*Artemisia spp*.) cover, total shrubs, bare ground, and shrub height (cm) based on remotely-sensed spatial products developed for sage-steppe habitat (Homer et al. 2012). However, as noted by Aldridge et al. (2012), shrub cover estimates are not directly proportional to mean cover values measured in the field using small quadrat plots (Homer et al. 2012). We included the standard deviation of mean sagebrush cover and shrub height as indices of shrub-cover heterogeneity. We used the Normalized Difference Vegetation Index (NDVI) based on Moderate Resolution Imaging Spectroradiometer MODIS data to indicate green growing vegetation (Carlson and Ripley 1997, Pettorelli et al. 2005). High values of NDVI correlate with dense vegetation cover, whereas low values correlate with areas barren of vegetation (e.g., snow, dirt, and rock; Gamon et al. 1995). Although Ferruginous Hawks tolerate grazing and cattle ranching (Bechard and Schmutz 1995), the species is sensitive to conversion of native grasslands to croplands (Dechant et al. 2001). Thus, we assessed nest selection in relation to croplands for moving windows at the landscape level.

We considered predictor variables that indexed the physical environment, as Ferruginous Hawks often use hill tops, ridges, and rock-mud pinnacles for nesting (Bechard and Schmutz 1995). We used surface roughness and topographic position index (TPI) to quantify potential nest structures associated with a highly bisected topography (Table 1). We calculated the average three-dimensional surface area of a given 30x30 m square of ground based on a digital elevation model (DEM), and used a moving window to measure this value at different scales (Jenness 2004). TPI was used to classify landscape slope position (e.g., ridges and valleys; Weiss 2001, Jenness 2006). Positive TPI values represented locations that were higher than the surrounding landscape (ridges), and lower values indicated relatively lower areas (valleys; Weiss 2001). We also indexed soil type, as it may affect the abundance and distribution of fossorial rodents, and average spring temperature and precipitation to identify relatively warmer and wetter regions of Wyoming.

Model Framework

We recognized that Ferruginous Hawks may select resources based on a broad perception of environmental heterogeneity at multiple spatial scales (Orians and Wittenberger 1991, Mayor et al. 2009). Thus, we used a hierarchical model framework to evaluate nest selection using separate sets of competing a priori models at both the nest-site and landscape scales. At each scale, we initially built models using only covariates from a given environmental category (energy, vegetation, and physical environment; Table 2), to determine the best-performing variables within each category. This initial analysis allowed us to understand how Ferruginous Hawks responded to each category of predictor variables. To avoid non-informative variables, we excluded combinations of variables that differed by one variable, but caused no change in log-likelihood (Burnham and Anderson 2002, Arnold 2010). We identified variables with high collinearity ($|r| > 0.70$) using Pearson's pairwise correlations and scatter plots (Hosmer and Lemeshow 2000). If correlated, we considered only one of the correlated variables for further models, based on their biological relevance, interpretability, and data availability to land managers. The top performing variables or combination of variables within each category (those within 2 ΔAIC of the top performing variable, as ranked by Akaike's Information Criterion, AIC), were then carried forward to create the set of final candidate models at each scale (nest-site and landscape; Burnham and Anderson 1998, Anderson et al. 2001, Anderson and Burnham 2002). Among the final set of candidate models, we model-averaged top-performing models (≤ 2 ΔAIC) to reduce model uncertainty and improve model predictions (Anderson and Burnham 2002).

We recognized that Ferruginous Hawks may integrate across scales of selection when choosing nest resources. Thus, we constructed a third set of a priori models composed of a combination of best-performing predictor variables from the nest-site and landscape scale models. This combined model allowed us to evaluate the possibility that Ferruginous Hawks select habitat based on a combination of local and landscape scale features.

Evaluation and Spatial Prediction of RSF Models

We used a five-fold cross-validation procedure to evaluate the predictive ability of models (Boyce et al. 2002). For nest-site, landscape, and combined best models, the actual nest locations were randomly divided into five equal subsets; four subsets were used to train the model and the fifth subset's values were predicted and used for testing. Random locations were also predicted and used to calculate 10 equal sized bins based on the probability of resource selection. Each nest in the testing fold was then evaluated against the random values, and assigned a bin rank. We used Spearman-rank correlations to evaluate the agreement between bin rank (1-10) and the numbers of test nests that fell into each bin. If a model had good predictive ability, test nests will be binned proportionally to probability of resource availability, so that more nests will fall in high probability of use bins than medium bins, and more medium than low.

Our second, more rigorous, model evaluation used an independent sample of recent (≥2000) occupied Ferruginous Hawk nests (n = 93) documented in the Department Wildlife Observation System database. We used the model-averaged final models at each of the three scales (nest-site, landscape, and combined) to predict the probability of nest selection at each independent nest location. We then used the same approach as explained above to determine the amount of agreement between predicted RSF values for each nest and binned random values. If a model had good predictive ability, we would expect a high Spearman-rank correlation. Additionally, we calculated the cumulative percentage of nests that fell within each availability bin (1-10) to provide a measure of predictive ability of each final model. Finally, we used a bootstrap method in which a sample of the independent nests was chosen with replacement and the RSF values of the nests predicted and recorded. We repeated this procedure 1,000 times to create a distribution of predicted RSF values for the independent test nests. If a model had good predictive ability, we would again expect that the majority of predicted RSF values would have a higher probability of selection.

We used GIS to predict the amount and spatial configuration of probable nest habitat for Ferruginous Hawks based on the final model-averaged coefficients for each model scale. We used coefficients from the logistic RSF model to estimate the relative probability of use (w) for each 30x30 m pixel across the species' distribution in Wyoming for the nest-site, landscape, and combined best model, using the equation:

$$w(x) = \exp(x_1 + x_2 + \ldots + x_i)/1 + \exp(x_1 + x_2 + \ldots + x_i), \text{ eqn 1}$$

where x_i is the RSF coefficient for each predictor variable (i), x_i is the value of each predictor variable (i), and $w(x)$ is a predicted value relative to the probability of use as Ferruginous Hawk nest habitat (Boyce et al. 2002). We generated three relative probability maps of nest habitat across Wyoming at the nest-site, landscape and combined spatial scales to clearly delineate preferred nest habitat. Predictive maps provide managers an efficient way to evaluate spatially how proposed management actions may relate to potential nest habitat.

RESULTS

We located 77 occupied nests on survey transects (including transects surveyed by helicopter) in 99 townships randomly distributed across Wyoming. The distribution of nests included 32, 16, and 29 occupied nests in low, medium, and high energy development strata, respectively. Of the 29 nests in the high development strata, 21 occupied nests were located in 18 townships that had greater than 100 wells per township; the maximum number of wells per township included in the sample was 490. In addition, we located 17 nests randomly on flights between survey townships that were added to township nests for a final sample of 94 nests for habitat modeling.

Nest-site Scale Selection

At the nest-site scale, Ferruginous Hawks exhibited selection for six variables or variable combinations within predictor categories based on AIC (Table 3). Within each category, no single variable provided the majority of support; therefore, we considered all variables or terms within 2 ΔAIC of the top-performing model in the final candidate models. Final candidate models at the nest-site scale (Table 4, Table 1 Supplement) showed some model selection uncertainty, with the top-ranked model receiving an $AICw_i$ of 0.39 (Table 5). To allow for stronger predictive ability, we model-averaged over all four models within 2 ΔAIC of the top model. Based on these four models, variables that were important for Ferruginous Hawk nest selection included percent cover of bare ground, shrub height, and topographic surface roughness. The probability of habitat suitability increased with greater amounts of bare ground, decreased with greater topographic roughness, and decreased with increasing shrub height (Table 6; Fig. 4). Ferruginous Hawks exhibited a positive relationship to the other three variables included in the top four models (proportion of riparian landcover, oil and gas well density, and secondary road density), but each of these variables occurred only once in the top set of models, suggesting lower model support for each term. In addition, both well and road density had confidence intervals that included zero, which indicated they contributed little to nest selection.

Landscape Scale Selection

At the landscape scale, our within-category modeling identified nine variables or variable terms of likely importance to Ferruginous Hawk habitat selection, based on AIC (Table 3). We generated parameter coefficients, confidence intervals, and spatial predictions from this set of 15 candidate models.

Selection by Ferruginous Hawks was strongest for areas with less surface roughness (Table 7, Fig. 5). Roughness was the top supported variable among the 15 models in the model-averaged set. While shrub height was also in a majority of the top models, indicating that Ferruginous Hawks may avoid tall shrubs at the landscape level, the bootstrapped confidence interval did not support shrub height as a significant predictor of Ferruginous Hawk habitat at the landscape scale. Six other variables were included at least once in the top set of 15 models: mean spring temperature, distance to roads, distance to wells, density of wells, density of roads, and distance to oilfields (Table 7). All of these variables, however, had confidence intervals that included zero, indicating a lack of support for these variables as predictors of Ferruginous Hawk landscape scale selection.

Although the presence of energy infrastructure appeared to have little effect on nest selection, oil and gas wells were present at or near nest-sites. Eleven of the 94 study nests (12%) had one or more wells within 500 m of the occupied nest, 19 of the 94 (20%) had one or more wells within 1 km, and 52 of 94 (55%) had one or more wells within 5 km. This distribution of wells is not different from that of the random locations used in the study. Of these, 81 of the 980 (8%) had at least one well within 500 m ($\chi^2_1 = 1.29$, $p = 0.26$), 140 (14%) had at least one well within 1 km ($\chi^2_1 = 2.39$, $p = 0.12$), and 441 of the 980 (45%) had at least one well within 5km ($\chi^2_1 = 3.68$, $p = 0.06$).

Combined Nest-site and Landscape Scale Selection

Based on the variables from the best performing nest-site and landscape scale models, we built a set of 50 candidate models using variables of both scales (Table 4, Supplementary Table 3). Of these models, five were within 2 ΔAIC of the best performing model, and there was considerable model uncertainty between them (no single model had weight > 0.9; Table 5). Therefore, we model-averaged over these five models to produce variable coefficients and predictions.

Landscape scale roughness (5 km) appeared to be the most important variable for predicting Ferruginous Hawk habitat, contributing to all five of the top models (Table 8; Fig. 6). The probability of habitat use increased with lower values of roughness, indicating that Ferruginous Hawks prefer flatter, more even terrain when selecting nest-sites. Also important was the proportion of bare ground at a small scale (250 m), which contributed to three of the five top models (Table 8). Ferruginous Hawk habitat use was more likely in areas with a greater proportion of bare ground directly around the nest location. Other variables included in the top models were the straight-line distances to roads and wells, the proportion of riparian landcover, and shrub height at both small (250 m) and large (25 km) scales. These variables contributed to two or fewer models each, however, and bootstrapped confidence intervals all included zero, indicating a lack of predictive importance.

Model Evaluation

The predictive performance of the nest-site model was good, with a Spearman-rank correlation coefficient of 0.91 (SE = 0.04) for five-fold cross-validation averaged over the four top models, similar to the predictive performance of the landscape-scale model-average (r_s = 0.92, SE = 0.04). The combined-scale model set performed better than both the nest-site and landscape-scale models, with a Spearman-rank correlation of 0.96 (SE = 0.03). A more rigorous evaluation of model performance was achieved by comparing an independent set of nests (n = 93) to model predictions (Fig.7). The Spearman-rank correlations between predicted RSF values for these nests and random RSF values across the study area were 0.87 for the nest-site scale, 0.89 for the landscape scale, and 0.90 for the combined scale. We also examined the distribution of independent nests within availability bins to determine the number of nests that fell within higher ranked bins, an indication of model accuracy. The cumulative percentage of nests that fell within each availability bin showed that the landscape scale model performed best, with 73% of nests in bins 8 through 10, while the combined model had 61 % and the nest-site scale model had 43% (Tables 9-11).

The distribution of the bootstrapped RSF values for the out-of-sample nests indicated modest predictive ability for the nest-site model, but good predictive ability for the landscape and combined models, as is evidenced by their more clumped distributions, which show the bulk of independent nests assigned to higher RSF probabilities (Fig.8). The bootstrapped RSF values suggest that Ferruginous Hawk nesting habitat is best predicted with RSF values between 0.55 to 0.85 (Fig.8).

DISCUSSION

Ferruginous Hawks responded consistently to the same environmental covariates across spatial scales. At the nest-site scale, Ferruginous Hawks selected greater amounts of bare ground, less topographic roughness, and lower shrub height compared to random availability. When considered at the landscape scale, Ferruginous Hawks selected sites that were less topographically rough than random expectation. This pattern of selection was similar to Keinath et al. (2010) in that Ferruginous Hawks chose areas with low measures of topographic ruggedness and higher values for bare ground. When both scales were combined, topographic roughness was again selected against, with the larger scale version of the variable (5 km) more predictive of Ferruginous Hawk nest selection, and greater amounts of bare ground preferred, this time at the smaller scale (250 m). We assumed that greater amounts of bare ground and lower shrub heights correlated to either high prey abundance or vulnerability of small mammals to predation. Although Ferruginous Hawks often nest on erosion pinnacles and monadnocks, they selected nest-sites with low topographic roughness compared to the general environment at the nest-site, landscape, and combined spatial scales. Areas with high topographic roughness in our study correspond to complex ridge systems and highly bisected landscapes along the toe-slopes of mountain ranges. Ferruginous Hawks avoided these areas in favor of flatter sage-steppe landscapes, which contain a mix of open foraging area and isolated trees. A study by Keough and Conover (2012) found that Ferruginous Hawks in the Uinta Basin also favored mixed shrubland habitat due to increased presence of favored prey species, such as rabbits, ground squirrels, or prairie dogs, and low abundance of other raptor species.

Of the three spatial scales considered, the model combining large and small scales appears to be the most predictive of Ferruginous Hawk nest selection, based on three of the four measures of model validation we applied. The combined scale model performed better than the nest-site and landscape scale models when predicting ‘test’ nests that were left out of a randomly selected ‘training’ data set composed of the nests that were collected during this study. The combined model also outperformed the other two model scales in its ability to predict out-of-sample nests. The average probability of nest selection for each location, as predicted by the model, was greater for the combined scale model, as was the Spearman-rank correlation between these predicted nest probabilities and random probabilities across the study area. Overall, the nest-site scale model had the worst predictive performance of the three models. The landscape scale model ranked in the middle, and the combined scale model appeared to be the most predictive of Ferruginous Hawk nest selection. This finding indicates that, when planning land use to manage Ferruginous Hawk nesting habitat, both immediate and long distance environmental variables should be considered.

Given the species' reported sensitivity to human disturbance (Olendorff 1993, Lehman et al. 2007), we expected that Ferruginous Hawks would avoid energy infrastructure, such as roads and wells, when selecting nest-sites. However, we found little evidence that Ferruginous Hawks avoided energy development when selecting nest-sites, regardless of spatial scale. At the landscape scale, distance to roads, road density, distance to wells, well density, and distance to oilfields were included at least once in the top performing 15 landscape models. The confidence interval for all these energy variables, however, included zero, which indicates a weak or nonexistent effect on nest selection. We did not evaluate Ferruginous Hawks that selected artificial nest platforms. We excluded this subset of nests in order to avoid conflating nest selection by hawks with that of resource managers. However, we recognize that Ferruginous Hawks often select artificial nest platforms when available, and that these platforms are often placed in areas of high energy development (Neal et al. 2010, Smith et al. 2010). Thus, our analysis of "natural" nests may under represent the true proximity of nesting Ferruginous Hawks to energy when artificial nests are added (see Smith et al. 2010). We are currently extending our RSF analysis to include artificial nest structures to formally model this relationship.

Although Ferruginous Hawks are considered sensitive to human disturbance (Bechard and Schmutz 1995, Franson et al. 1995, Lehman et al. 2007), we found that energy development was not an important factor in nest-site selection. In contrast, Smith et al. (2010) found that in Wyoming, Ferruginous Hawks nesting on natural structures exhibited greater nest cluster use and activity in areas with both less oil and gas development and proportionately more non-energy roads within 0.8 km. However, these relationships diminished when they evaluated selection at the 2 km scale. The study by Smith et al. (2010) was conducted only on nests near heavily developed areas, however. Our study was conducted by evaluating nests that were located in a representative manner across the species' distribution in Wyoming, which provided a statewide sample with which to evaluate resource selection. The insensitivity of Ferruginous Hawks to energy development that we documented may be due to a general lower density of energy infrastructure across the state; however, 55% (52 of 94) of Ferruginous Hawk nests in our study were within 5 km of an oil or gas well and 20% (19 of 94) were within 1 km. Thus, the current density of oil and gas development across Wyoming appears sufficient to potentially affect approximately half of all nest-sites in our study. A more plausible explanation may be that Ferruginous Hawks are somewhat tolerant to human disturbance related to energy development and that other environmental factors are more important to nest selection.

Ferruginous Hawks may exhibit a curvilinear response to oil and gas development at higher densities than we studied. We evaluated reports and associated data of raptor nest surveys in areas with higher densities of oil and gas development (HWA 2012, ACC 2012). One township in the Pinedale Anticline (PAPA) and one in the Jonah Infill Drilling Project Areas

(JIDPA), located in Sublette County, south of Pinedale, Wyoming, had over 1,300 producing wells each (Wyoming Oil and Gas Conservation Commission, accessed 14 January 2013). Both townships combined have 27 historical records of nests classified as Ferruginous Hawks, with clusters indicating over 10 nesting pairs probably occurred prior to development. Despite exhaustive surveys, no occupied Ferruginous Hawk nests were located in these townships. Excluding these two townships, 2012 raptor nest surveys documented six and two occupied Ferruginous Hawk nesting territories in approximately 779 km^2 and 332 km^2 in the PAPA and JIDPA, respectively. The naïve density of Ferruginous Hawks nesting in these high density oil and gas fields was 139 km^2 per occupied nest territory (12 townships combined). This compared to 102 km^2 per occupied territory on the "high energy" strata that we surveyed across Wyoming (33 townships with 29 occupied nesting territories). Thus, the field observation suggests that at the very high well density found in the PAPA and JIDPA, developments may reduce habitat suitability for nesting Ferruginous Hawks.

The lack of avoidance response by Ferruginous Hawks to oil and gas development we found may also be related to an abundance of prey at or near oil and gas disturbance. While Ferruginous Hawks may still be disturbed by energy development, the abundance of prey may be sufficient to keep Ferruginous Hawk in disturbed areas. The majority of prey species important to Ferruginous Hawks in Wyoming are fossorial (Zegers 1984, Clark et al. 1971, Verts and Carraway 2001) and, therefore, exhibit preference for areas with soil types that facilitate digging and tunneling (Grant and French 1980, Leis et al. 2008). The development of land for oil and gas extraction frequently requires extensive soil disturbance; buried pipelines, road creation, and drilling all create areas of loose, non-compacted soil (Keller and Arvidsson 2010). Anecdotal evidence suggests that a variety of prey species take advantage of this loose soil to create new burrows, which may result in an increase of prey in areas with recent energy disturbance. We are currently in the process of conducting a study to directly address the extent to which this occurs; with the results of this study, we hope to be able to increase our understanding of the effect of oil and gas development on prey abundance.

Also of potential importance to Ferruginous Hawks as cover for prey is the presence of vegetation, such as sagebrush, herbaceous ground cover, or other shrubs. Here we used remotely sensed sagebrush and vegetation layers recently created by the United States Geological Survey (USGS; Homer et al. 2012) to assess hawk response to vegetation. A known caveat of the USGS data layers, however, is that they may not directly equal the vegetation that would be found on the ground if a small-scale quadrat or transect sample were taken (Homer et al. 2008, Homer et al. 2012). Thus, while the USGS sagebrush data provides an important index of vegetative cover for modeling, it may not necessarily relate directly to what managers might see on the ground. From field data we collected, however, we found that the USGS bare ground data layer was negatively correlated ($r = -0.74$) with percent cover of grasses and forbs, as measured in a 0.5 m^2 quadrat. The USGS shrub height data layer was positively correlated ($r = 0.62$) with this same field measurement of grasses and forbs. Thus, the sagebrush data layers used in our model appear to accurately reflect the proportion of bare ground actually found at a given location, as well as to indirectly measure the total amount of herbaceous cover.

The presence of the actual physical structure that supports the nest may affect nest-selection of Ferruginous Hawks. The broad-scale data layers used in this analysis were unable to detect nest supporting structures such as isolated cottonwood trees, erosion pinnacles, and small rock outcrops (Gilmer and Stewart 1983, Woffinden and Murphy 1983). The presence of nest structures in areas with adequate prey populations may override the effects of energy disturbance on selection. The tendency of Ferruginous Hawks to adopt ANSs in areas of high energy development supports this view. As with any study based solely on remotely sensed data, the results are dependent in large part on the accuracy of the data used as covariates. The presence of nest structures, however, is not easily assessed via widely available remotely sensed data, such as LandSat or other satellite imagery. Thus, the data layer we used to quantify topographic roughness was not able to identify the isolated erosional features that Ferruginous Hawks often choose to support their nests. Instead, this layer provided a more general index of the topographic relief of an area, ranging from flat areas, such as the Bighorn Basin, to areas with more elevational relief, such as foothills and low mountains. To better understand how Ferruginous Hawks forage in proximity to energy development, we are currently investigating their movements in energy-developed landscapes as another component of this study.

Previous studies have shown the presence of low levels of small-scale agriculture to be a significant predictor of Ferruginous Hawk habitat use (Schmutz 1989, Zelenak and Rotella 1997, Smith et al. 2010). Schmutz (1989) found that Ferruginous Hawks responded positively to agriculture at proportions of 30% or less, but decreased when greater. Likewise, Smith et al. (2010) found a positive effect of agriculture on Ferruginous Hawk habitat use with proportions of agricultural land less than 12%. Our results did not find agriculture to be an important factor for Ferruginous Hawk nest-site selection, at either the nest-site or landscape scale. Agriculture was present at very low levels; for instance, within a 1 km radius, nests in our study averaged approximately 3% (SE = 22%) in cultivated land. When viewed at the landscape scale, more nests were within 5-10 km of agricultural land, but the average proportion on the landscape was similar (3%, SE = 19%). Therefore, we believe that agriculture may not have been present in sufficient quantity to exert a noticeable effect on Ferruginous Hawk nest selection in our study.

ACKNOWLEDEGEMENTS

We received funding and commitments from several sources during the first 2 years of this cooperative study. This research was supported, in part, by funds provided by the Rocky Mountain Research Station, US Forest Service, and US Department of Agriculture. Additional funding sources included Wyoming Wildlife Heritage Foundation; PacifiCorp; Pathfinder Renewable Wind Energy, LLC; Bureau of Land Management; Wyoming Governor's Office; and the Wyoming Game and Fish Department. Department Nongame Program GIS technicians E. Furtaw and S. Cornell provided essential GIS support. P. Kennedy reviewed the proposal and provided a helpful critique with recommendations for improvement. Z. Wallace and M. Wilson served as primary observers for fixed-wing aerial surveys of transects and leaders of the field crews. Other field crew leaders include A. Larned, R. Buchheit and P. Mahoney. Field crews augmented production data and collected genetic samples and data on prey abundance.

LITERATURE CITED

Anderson, D. R., W. A. Link, D. H. Johnson, and K. P. Burnham. 2001. Suggestions for presenting the results of data analyses. The Journal of Wildlife Management 65:373-378.

Anderson, D. R., and K. P. Burnham. 2002. Avoiding pitfalls when using information-theoretic methods. The Journal of Wildlife Management 66:912-918.

Aldridge, C. L., D. J. Saher, T. M. Childers, K. E. Stahlnecker, and Z. H. Bowen. 2012. Crucial nesting habitat for Gunnison sage-grouse: A spatially explicit hierarchical approach. The Journal of Wildlife Management 76:391-406.

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's information criterion. The Journal of Wildlife Management 74:1175-1178.

Aster Canyon Consulting, Inc. [ACC]. 2012. Jonah Infill Drilling project. Area wildlife monitoring final report. BLM.

Ayers, L. W., and S. H. Anderson. 1999. An aerial sightability model for estimating Ferruginous Hawk population size. The Journal of Wildlife Management 63:85-97.

Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, R. S. Hoffman, C. A. Jones, F. Reid, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Occasional Papers, Museum of Texas Technical University, Number 229.

Bechard, M. J., and J. K. Schmutz. 1995. Ferruginous Hawk (*Buteo regalis*). The Birds of North America. Number 172.

Boyce, M. S., and L. L. McDonald. 1999. Relating populations to habitats using resource selection functions. Trends in Ecology and Evolution 14:268-272.

Boyce, M. S., P. R. Vernier, S. E. Nielsen, and F. K. A. Schmiegelow. 2002. Evaluating resource selection functions. Ecological Modelling 157:281-300.

Bureau of Land Management [BLM]. 2003*a*. Final environmental impact statement and proposed plan amendment for the Powder River basin oil and gas project. http://www.blm.gov/wy/st/en/info/NEPA/bfodocs/prb-feis.html (accessed 18 March 2007).

Bureau of Land Management [BLM]. 2003*b*. Montana statewide final oil and gas EIS and amendment of the Powder River and Billings resource management plans. http://www.mt.blm.gov/mcfo/cbm/eis/index.html (accessed 18 March 2007).

Burnham, K. P., and D. R. Anderson. 1998. Model selection and inference: an information-theoretic approach. Spring-Verlag, New York, New York, USA.

Carlson, T. N., and D. A. Ripley. 1997. On the relation between NDVI, fractional vegetation cover, and leaf area index. Remote Sensing of Environment 62:241-252.

Clark, T. W., R. S. Hoffmann, and C. F. Nadler. 1971. *Cynomys leucurus*. Mammalian Species 7:1-4.

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, P. A. Rabie, and B. R. Euliss. 2001. Effects of management practices on grassland birds: Ferruginous Hawk. Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

Franson, J. C., L. Sileo, and N. J. Thomas. 1995. Causes of eagle deaths. Pages 69-69 *in* Our living resources: a report to the nation on the distribution, abundance and health of US plants, animals, and ecosystems (E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, Editors). US Department of the Interior, National Biological Service, Washington, D.C., USA.

Gamon, J. A., C. B. Field, M. L. Goulden, K. L. Griffin, A. E. Hartley, G. Joel, J. Peñuelas, and R. Valentini. 1995. Relationships between NDVI, canopy structure, and photosynthesis in three Californian vegetation types. Ecological Applications 5:28-41.

Glinski, R. L. 1998. Ferruginous Hawk. Pages 105-108 *in* The raptors of Arizona (R. L. Glinski, Editor). University of Arizona Press, Tucson, USA.

Grant, W. E., and N. R. French. 1980. Evaluation of the role of small mammals in grassland ecosystems: a modelling approach. Ecological Modelling 8:15-37.

Hanser, S. E., and N. J. Huntly. 2006. The biogeography of small mammals of fragmented sagebrush-steppe landscapes. Journal of Mammalogy 87:1165-1174.

Hayden-Wing Associates, LLC [HWA]. 2012 Raptor monitoring of the Pinedale Anticline Project Area, Sublette County, Wyoming. Bureau of Land Management.

Homer, C. G., C. L. Aldridge, D. K. Meyer, M. J. Coan, and Z. H. Bowen. 2008. Multiscale sagebrush rangeland habitat modeling in southwest Wyoming. US Geological Survey Open-File Report, 2008-1027.

Homer, C. G., C. L. Aldridge, D. K. Meyer, and S. J. Schell. 2012. Multi-scale remote sensing sagebrush characterization with regression trees over Wyoming, USA: Laying a foundation for monitoring. International Journal of Applied Earth Observation and Geoinformation 14:233-244.

Hosmer D. W., and S. Lemeshow. 2000. Applied logistic regression. John Wiley and Sons, New York, New York, USA.

Jenness, J. S. 2004. Calculating landscape surface area from digital elevation models. Wildlife Society Bulletin 32:829-839.

Jenness, J. S. 2006. Topographic Position Index (tpi_jen.avx) extension for ArcView 3.x. Version 1.3a. Jenness Enterprises, Flagstaff, Arizona, USA.

Johnson, C. J., S. E. Nielsen, E. H. Merrill, T. L. McDonand, and M. S. Boyce. 2006. Resource selection functions based on use-availability data: theoretical motivation and evaluation methods. The Journal of Wildlife Management 70:347-357.

Johnson, C. J., D. R. Seip, and M. S. Boyce. 2004. A quantitative approach to conservation planning: using resource selection functions to map the distribution of mountain caribou at multiple spatial scales. Journal of Applied Ecology 41:238-251.

Keating, K. A., and S. Cherry. 2004. Use and interpretation of logistic regression in habitat selection studies. Journal of Wildlife Management 68:774-789.

Keinath, D. A., M. D. Anderson, and G. P. Beauvais. 2010. Range and modeled distribution of Wyoming's Species of Greatest Conservation Need. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department, Cheyenne, and the U,S, Geological Survey, Fort Collins, Colorado, USA.

Keller, T., and J. Arvidsson. 2010. Soil disturbance and soil fragmentation during tillage i*n* Soil Engineering (A. P. Dedousis and T. Bartzanas, Editors). Volume 20. Springer.

Keough, H. L., and M. R. Conover. 2012. Breeding-site selection by Ferruginous Hawks within Utah's Uintah Basin. Journal of Raptor Research 46:378-388.

Kennedy, P. L., J. M. Ward, G. A. Rinker, and J. A. Gessaman. 1994. Post-fledging areas in northern goshawk home ranges. Studies in Avian Biology 16:75-82.

Lehman, R.N., P.L. Kennedy, and J.A. Savidge. 2007. The state of the art in raptor electrocution research: a global review. Biological Conservation 136:159-174.

Lehman, R. N., J. A. Savidge, P. L. Kennedy, and R. E. Harness. 2010. Raptor electrocution rates for a utility in the intermountain western United States. The Journal of Wildlife Management 74:459-470.

Leis, S. A., D. M. Leslie, D. M. Engle, and J. S. Fehmi. 2008. Small mammals as indicators of short-term and long-term disturbance in mixed prairie. Environmental monitoring and assessment 137:75-84.

MacLaren, P. A., S. H. Anderson, and D. E. Runde. 1988. Food habits and nest characteristics of breeding raptors in southwestern Wyoming. Great Basin Naturalist 48:548-553.

Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Kluwer Academic Publishers, Boston, Massachusetts, USA.

Mayor, S. J., D. C. Schneider, J. A. Schaefer, and S. P. Mahoney. 2009. Habitat selection at multiple scales. Ecoscience 16:238-247.

Oakleaf, B. 1986. The distribution and population status of the Ferruginous Hawk. Pages 48-51 *in* Endangered nongame bird investigations (B. Oakleaf, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Olendorff, R. R. 1993. Status, biology, and management of Ferruginous Hawks: a review. Raptor Research and Technical Assistance Center, Special Report. US Department of the Interior, Bureau of Land Management, Boise, Idaho, USA.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, reptiles, and amphibians in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Orians, G. H., and J. F. Wittenberger. 1991. Spatial and temporal scales in habitat selection. The American Naturalist 137 supplement:S29-S49.

Pettorelli, N., J. O. Vik, A. Mysterud, J. M. Gaillard, C. J. Tucker, and N. C. Stenseth. 2005. Using the satellite-derived NDVI to assess ecological responses to environmental change. Trends in Ecology and Evolution 20:503-510.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. US Department of Agriculture, US Forest Service General Technical Report RM-217, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Schmutz, J. K. 1989. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor 91:362–371.

Schmutz, J. K., S. H. Brechtel, K. D. De Smet, D. G. Hjertaas, G. L. Holroyd, C. S. Houston, and R. W. Nero. 1992. Recovery plan for the Ferruginous Hawk in Canada. Prepared for Recovery of Nationally Endangered Wildlife (RENEW), Ottawa, Canada.

Smith, D. G., and J. R. Murphy. 1978. Biology of the Ferruginous Hawk in central Utah. Sociobiology 3:79-95.

Steenhof, K., and I. Newton. 2007. Assessing nesting success and productivity. Pages 181-190 *in* Raptor research and management techniques (D.M. Bird and K.L. Bildstein, Editors). Hancock House Publishing, Blaine, Washington, USA.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies, Fargo, North Dakota, USA.

Ure, J., P. Briggs, and S. W. Hoffman. 1991. Petition to list as endangered the Ferruginous Hawk (*Buteo regalis*), as provided by the Endangered Species Act of 1973, as amended in 1982. Ferruginous Hawk Project, Salt Lake City, Utah, USA.

US Energy Information Administration. 2012. Natural Gas Reserves Summary as of December 31. http://www.eia.gov/dnav/ng/ng_enr_sum_a_EPG0_R11_BCF_a.htm (accessed 30 January 2013).

Verts, B. J., and L. N. Carraway. 2001. *Tamias minimus*. Mammalian Species 653:1-10.

Washington Department of Fish and Wildlife [WDFW]. 1996. Washington state recovery plan for the Ferruginous Hawk. Washington Department of Fish and Wildlife, Olympia, USA.

Weiss, A. D. 2001. Topographic Positions and Landforms Analysis (Poster). ESRI International User Conference. San Diego, California, USA.

White, C. M,. and T. L. Thurow. 1985. Reproduction of Ferruginous Hawks exposed to controlled disturbance. Condor 87:14-22.

Zegers, D. A. 1984. *Spermophilus elegans*. Mammalian Species 214:1-7.

Zelenak, J. R., and J .J. Rotella. 1997. Nest success and productivity of Ferruginous Hawks in northern Montana. Canadian Journal of Zoology 75:1035-1041.

Table 1. Predictor variables used to quantify resource selection of Ferruginous Hawks (*Buteo regalis*) at the nest-site scale in Wyoming, 2010-2012. Variables quantified for Nest-site and Landscape models at the following spatial scales: Nest-site – a) 250 m radii circle, b) 500 m, c) 1,000 m; Landscape – d) 1.5 km, e) 5 km, f) 10 km, and g) 25 km.

Type	Variable name	Description	Scale	Source
Energy	WELL_DEN	Density of oil/gas wells per km^2	a, b, c, d, e, f, g	Wyoming Oil and Gas Conservation Commission, accessed March 2012
	ROAD_DEN	Density of secondary roads including dirt, gravel and aggregate-surfaced roads per km^2; excludes interstate and state highways and primitive non-graded dirt roads.	a, b, c, d, e, f, g	BLM road layer
	WELL_DIST	Distance to oil/gas wells (km)	d, e, f, g	Wyoming Oil and Gas Conservation Commission, accessed March 2012
	WELL_DIST_D	Distance to well exponential decay function (km)	a, b, c, d, e, f, g	Wyoming Oil and Gas Conservation Commission, accessed March 2012
	ROAD_DIST	Distance to secondary roads including dirt, gravel and aggregate-surfaced roads (km); excludes interstate and state highways and primitive non-graded dirt roads.	d, e, f, g	
	ROAD_DIST_D	Distance to road exponential decay function (km)	a, b, c, d, e, f, g	
	OIL_FIELD_DIST	Distance to oil field with > 5 wells / km^2	d, e, f, g	Wyoming Oil and Gas Conservation Commission, accessed March 2012
Vegetation	NDVI	Normalized difference vegetation index, MODIS data, 2010	a, b, c, d, e, f, g	Pettorelli et al. 2005
	BARE	Mean % bare ground	a, b, c, d, e, f, g	Homer et al. 2009, Homer et al. 2012
	BARE_SD	Standard deviation of mean % bare ground	a, b, c, d, e, f, g	Homer et al. 2009, 2012
	SAGE	Mean % sagebrush cover	a, b, c, d, e, f, g	Homer et al. 2009, 2012
	SAGE_SD	Standard deviation of mean % sagebrush	a, b, c, d, e, f, g	Homer et al. 2009, 2012

Table 1. Continued.

Type	Variable name	Description	Scale	Source
	SHRUB_HT	Mean shrub height	a, b, c, d, e, f, g	Homer et al. 2009, 2012
	SHRUB_HT_SD	Standard deviation of mean shrub height	a, b, c, d, e, f, g	Homer et al. 2009, 2012
	JUNIPER	Mean % index of juniper probable presence, from 0 to 1	a, b, c, d, e, f, g	GAP Land Cover Analysis Program 2010, Keinath et al. 2010
	RIPARIAN	Proportion of riparian vegetation	a, b, c, d, e, f, g	LandFire v. 1.1.0, 2008, US Forest Service
	CROP	Mean % agricultural crop cover	a, b, c, d, e, f, g	National Agricultural Statistics Service, Cropland Data Layer 2010
Physical	ROUGH	Mean surface area based on digital elevation model	a, b, c, d, e, f, g	Jenness 2004
	TPI	Topographic position index	a, b, c, d, e, f, g	Weiss 2001, Jenness 2006
	SOIL	Soils texture classified into 6 categories from fine to coarse	d, e, f, g	Keinath et al. 2010.
	SP_PRECIP	Average spring precipitation (cm; April – May, 1981 – 2010)	d, e, f, g	PRISM Climate Group 2006
	SP_TEMP	Average spring temperature (^{o}C; April – May, 1981 – 2010)	d, e, f, g	PRISM Climate Group 2006
Prey	PREY	Modeled index of prey abundance (prairie dogs, ground squirrels, cottontails, jackrabbits, chipmunks)	a, b, c, d, e, f, g	Olson et al. 2012

Table 2. Candidate *a priori* models of Ferruginous Hawks (*Buteo regalis*) selecting nest-sites in Wyoming, 2010-2012. Nest-site (A) and landscape (B) models evaluated at 3 (250 m, 500 m, 1,000 m) and four (1.5 km, 5 km, 10 km, 25 km) spatial scales, respectively.

Model	Predictor variables	Tier	Explanation
Null	Intercept only		Null model with intercept only
	Prediction 1 – energy development		
1	WELL_DEN	A,B	well density most important
2	ROAD_DEN	A,B	road density most important
3	WELL_DEN + WELL_DIST_D	A,B	well density and proximity important
4	ROAD_DEN + ROAD_DIST_D	A,B	road density and proximity important
5	WELL_DEN + ROAD_DEN	A,B	cumulative impact of well and road density most important
6	WELL_DEN + ROAD_DEN + (WELL_DEN x ROAD_DEN)	A,B	cumulative impact plus interaction important
7	OIL_FIELD	B	Location of oil fields most important at landscape scale
8	OIL_FIELD + WELL_DIST + ROAD_DIST	B	proximity to oil fields and nearest energy development most important
9	OIL_FIELD + WELL_DIST + ROAD_DIST +(OIL_FIELD x WELL_DIST)	B	proximity to oil fields and nearest energy development most important with interaction
	Prediction 2 - vegetation		
10	NDVI	A,B	index of vegetation cover most important
11	BARE	A,B	index of bare ground most important
12	BARE_SD	A	heterogeneity of proportion of bare ground most important
13	SAGE	A,B	sage brush cover most important
14	SAGE_SD	A	heterogeneity of sage brush most important
15	SHRUB_HT	A,B	shrub structure, regardless of plant species, most important
16	SHRUB_HT_SD	A	
17	JUNIPER	A,B	presence of pinion-juniper important
18	RIPARIAN	A,B	Association with riparian vegetation including narrowleaf cottonwood, with sagebrush and wheat grass cover usually taller than upland vegetation.

Table 2. Continued.

Model	Predictor variables	Tier	Explanation
20	CROP	B	avoidance of crop land most important
21	CROP + PJ_COVER	B	avoidance of croplands and the presence of pinion-juniper forests
22	BARE*SAGE	A,B	interaction effect of bare ground and sagebrush
23	RIPARIAN+ JUNIPER	A,B	presence of riparian and juniper vegetation, indices of potential nest structure
24	BARE + SAGE + SHRUB_HT	A,B	proportion of bare ground, plus an index of shrub height and presence
25	RIPARIAN + NDVI	A,B	presence of riparian vegetation plus an index of vegetation biomass
26	SAGE + NDVI	A,B	sage brush presence and vegetation cover most important
27	SAGE + NDVI + (SAGE x NDVI)	A,B	sage brush presence, vegetation cover, and interaction most important
28	SAGE + NDVI + CROP	B	sage brush presence, vegetation cover, and presence of crops important
29	SAGE + SHRUB_HT + SHRUB_HT_SD	A,B	sage brush presence and shrub structure and heterogeneity most important
30	BARE + SAGE	A,B	Bare ground and sagebrush cover
31	BARE + SHRUB_HT	A,B	Bare ground and shrub height
32	BARE + SHRUB_HT + JUNIPER	A,B	Bare ground, shrub height, and juniper forest cover
33	BARE + SAGE + SHRUB_HT + JUNIPER + CROP + RIPARIAN	A,B	Bare ground combined with all vegetation types important
34	RIPARIAN + SHRUB_HT	A,B	Association with riparian vegetation and height of surrounding shrubs
35	RIPARIAN + SHRUB_HT + BARE	A,B	Association with riparian vegetation, shrub height, and the amount of bare ground
	Prediction 3 – physical environment		
36	ROUGH	A,B	surface roughness most important
37	TPI	A,B	landform complexity of ridges and valleys most important
38	SOIL	B	soil type most important
39	SP_PRECIP	B	spring precipitation most important

Table 2. Continued.

Model	Predictor variables	Tier	Explanation
40	SP_TEMP	B	spring temperature important
41	ROUGH + SOIL	B	surface roughness and soil type most important
42	TPI + ROUGH	A, B	Landform complexity and surface roughness important
43	TPI + SOIL + SP_PRECIP	B	landform complexity, soil type and spring precipitation most important
44	SP_PRECIP + SP_TEMP	B	spring local weather important
45	TPI + SP_PRECIP	B	landform complexity and the amount of spring precipitation most important
46	ROUGH + SP_PRECIP	B	topographic roughness and the amount of spring precipitation most important
47	TPI + SP_TEMP	B	landform complexity and spring temperature most important
48	ROUGH + SP_TEMP	B	topographic roughness and spring temperature most important
49	TPI + SP_TEMP + SP_PREC	B	all topographic attributes important except topographic roughness
50	ROUGH + SP_TEMP + SP_PREC	B	all topographic attributes important except landform complexity
51	TPI+ ROUGH + SOIL + SP_PRECIP + SP_TEMP	B	cumulative attributes of physical environment most important
		Prediction 4 – prey	
52	PREY	A,B	index of prey abundance most important

Table 3. Within-category best performing candidate *a priori* models by scale (nest-site and landscape) for nesting Ferruginous Hawks (*Buteo regalis*) in Wyoming, 2010-2012.

	Model	Scale	Explanation
Nest-site	**Prediction 1 – energy development – nest-sites**		
	WELL_DEN	1,000	Well density most important
	ROAD_DEN	1,000	Road density most important
	Prediction 2 – vegetation – nest-sites		
	RIPARIAN + SHRUB_HT + BARE	250	Association with riparian vegetation, shrub height, and the amount of bare ground
	RIPARIAN + SHRUB_HT	500	Association with riparian vegetation and height of surrounding shrubs
	BARE + SHRUB_HT	250	Bare ground and shrub height
	Prediction 3 – physical environment – nest-sites		
	ROUGH	1,000	Surface roughness most important
Landscape	**Prediction 1 – energy development – landscape**		
	ROAD_DIST	NA	Distance to road most important
	ROAD_DEN	1.5K	Road density within a 1.5 km radius most important
	WELL_DIST	NA	Distance to oil/gas wells most important
	WELL_DEN	5K	Well density within a 5 km radius most important
	OILFIELD_DIST	NA	Distance to dense cluster of oil wells most important
	Prediction 2 – vegetation – landscape		
	SHRUB_HT	25K	Height of shrubs at the 25 km radius most important
	BARE + SAGE + SHRUB_HT + JUN + CROP + RIPARIAN	25K	Combination of all vegetation variables at the 25 km radius most important
	Prediction 3 – physical environment – landscape		
	ROUGH	5K	Topographic roughness at the 5 km scale most important
	ROUGH + SPRING_TEMP	5K	Combination of topographic roughness at the 5 km scale and spring temperature most important

Table 3. Continued.

	Model	Scale	Explanation
Combination	**Prediction 1 – energy development – landscape**		
	ROAD_DEN	1K	Road density at the nest-site scale most important
	ROAD_DEN	1.5K	Road density at the landscape scale most important
	WELL_DEN	1K	Well density at the nest-site scale most important
	WELL_DEN	5K	Well density at the landscape scale most important
	ROAD_DIST	NA	Distance to roads most important
	WELL_DIST	NA	Distance to wells most important
	OILFIELD_DIST	NA	Distance to clusters of oil/gas wells most important
	Prediction 2 – vegetation – landscape		
	RIPARIAN	250M	Nest-site scale riparian vegetation most important
	BARE	250M	Nest-site scale proportion of bare ground most important
	SHRUB_HT	250M	Nest-site scale shrub height most important
	SHRUB_HT	25K	Landscape scale shrub height most important
	Prediction 3 – physical environment – landscape		
	ROUGH	1K	Nest-site scale surface roughness most important
	ROUGH	5K	Landscape scale surface roughness most important
	SPRING_TEMP	5K	Landscape scale spring temperature most important

Table 4. Summary of candidate final models. Each line represents the variable category used in the model, with the number of variables for each category in parentheses. The total number of models derived from each combination of categories is given in the second column.

Variable combination	Rationale	Nest-site		Landscape		Combination	
		No. of terms	No. of models	No. of terms	No. of models	No. of terms	No. of models
Energy	Only energy important	2	3	5	9	7	8
Vegetation	Only vegetation important	3	3	2	2	4	6
Topography	Only topography important	1	1	2	2	3	4
Energy X Vegetation	Combination of energy and vegetation important	3 X 3	9	5 X 2	10	7 X 4	8
Energy X Topography	Combination of energy and topography important	3 X 1	3	5 X 2	10	7 X 3	7
Vegetation X Topography	Combination of vegetation and topography important	3 X 1	3	2 X 2	4	4 X 3	8
Energy X Vegetation X Topography	Combination of all three categories most predictive	3 X 3 X 1	9	5 X 2 X 2	22	7 X 4 X 3	9
Interactions	Interactions between energy and topography or energy and vegetation important		4		4		
Total no. of models			35		63		50

Table 5. Best performing final candidate models of Ferruginous Hawks (*Buteo regalis*) at nest-site, landscape, and combined scales.

Scale	Model	AICc	ΔAICc	AICc Wt	Log-likelihood
Nest-site	BARE_250 + SHRUB_HT_250 + ROUGH_1,000	120.14	0	0.39	-56.05
	RIPARIAN250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000	120.75	0.62	0.29	-55.35
	WELL_DEN_1,000 + BARE_250 + SHRUB_HT_250 + ROUGH_1,000	121.85	1.72	0.16	-55.9
	ROAD_DEN_1,000 + BARE_250 + SHRUB_HT_250 + ROUGH_1,000	121.9	1.77	0.16	-55.92
Landscape	SHRUB_HT_25km + ROUGH__5km	114.981	0	0.125	-54.479
	ROUGH__5km	115.472	0.492	0.097	-55.731
	ROUGH_5km + SPRING_TEMP_5km	115.652	0.671	0.089	-54.815
	ROAD_DIST + SHRUB_HT_25km + ROUGH__5km	115.716	0.735	0.086	-53.839
	SHRUB_HT_25km + ROUGH_5km + SPRING_TEMP_5km	116.057	1.077	0.073	-54.01
	WELL_DIST + SHRUB_HT_25km + ROUGH__5km	116.32	1.34	0.064	-54.141
	ROAD_DIST + ROUGH__5km	116.441	1.461	0.06	-55.209
	WELL_DEN_5km + SHRUB_HT_25km + ROUGH__5km	116.483	1.503	0.059	-54.223
	WELL_DIST + ROUGH__5km	116.637	1.657	0.054	-55.307
	WELL_DEN_5km + ROUGH_5km + SPRING_TEMP_5km	116.703	1.723	0.053	-54.333
	WELL_DEN_5km + ROUGH__5km	116.717	1.736	0.052	-55.347
	WELL_DIST + SHRUB_HT_25km + ROUGH__5km+SPRING_TEMP_5km	116.881	1.9	0.048	-53.412
	ROAD_DIST + SHRUB_HT_25km + ROUGH__5km+ SPRING_TEMP_5km	116.924	1.943	0.047	-53.434
	ROAD_DEN_1.5km + SHRUB_HT_25km + ROUGH__5km	116.963	1.982	0.046	-54.463
	OILFIELD_DIST + SHRUB_HT_25km + ROUGH__5km	116.973	1.992	0.046	-54.468
Combined scale	SURFACE_AREA_500 + BARE_250 + WELL_DIST + ROAD_DIST	114.15	0	0.35	-52.05
	ROUGH_5km + RIPARIAN250 + BARE_250 + SHRUB_HT_250	114.88	0.73	0.25	-52.41
	ROUGH_5km	115.47	1.32	0.18	-55.73
	ROUGH_5km + ROAD_DIST	116.44	2.29	0.11	-55.21
	ROUGH_5km + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km	116.56	2.41	0.11	-53.25

Table 6. Coefficients, unconditional standard errors (SE), and 95% confidence intervals (CI) for the variables included in the model averaged nest-site model.

Variable	Model averaged β	Model averaged SE	Lower CI	Upper CI
Bare ground	0.0278	0.0066	0.0150	0.0413
Shrub height	-0.0190	0.0063	-0.0327	-0.0080
Roughness	-0.0857	0.0204	-0.1355	-0.0548
Riparian	0.9778	0.4196	0.1503	1.6508
Well density	0.0185	0.0229	-0.0191	0.0710
Road density	0.0298	0.0260	-0.0186	0.0817

Table 7. Coefficients, unconditional standard errors (SE), and 95% confidence intervals (CI) for the variables included in the model averaged landscape scale model.

Variable	Model averaged β	Model averaged SE	Lower CI	Upper CI
Shrub height	-0.0376	0.0216	-0.071	0.015
Roughness	-0.1493	0.0536	-0.277	-0.068
Distance to road	-0.00004	0.00003	-0.00010	0.00002
Distance to well	-0.000004	0.000003	-0.000010	0.000004
Well density	0.0501	0.0281	-0.025	0.081
Road density	0.0042	0.0052	-0.010	0.011
Distance to oilfield	0.0000002	0.0000002	-0.0000003	0.0000004
Spring temperature	-0.0575	0.0288	-0.09	0.018

Table 8. Coefficients, unconditional standard errors (SE), and 95% confidence intervals (CI) for the variables included in the model averaged combined scale model.

Variable	Model averaged β	Model averaged SE	Lower CI	Upper CI
Roughness 5 km	-0.155	0.054	-0.280	-0.071
Bare ground 250 m	0.019	0.008	0.002	0.034
Distance to well	-0.00000923	0.0000131	-0.0000373	0.0000129
Distance to road	-0.00010	0.0000906	-0.0003032	0.0000481
Riparian 25 km	0.917	0.540	-0.144	1.986
Shrub height 250 m	-0.007	0.004	-0.013	0.001
Shrub height 25 km	0.000	0.003	-0.006	0.006

Table 9. Nest-site scale cutoffs for 10 bins determined by 'available' RSF scores.

Bin	Upper cutoff	# nests	Cumulative nests	Cumulative %
10	0.81	21	21	22.58
9	0.69	10	31	33.33
8	0.63	9	40	43.01
7	0.56	15	55	59.14
6	0.50	18	73	78.49
5	0.44	8	81	87.10
4	0.39	3	84	90.32
3	0.32	6	90	96.77
2	0.24	3	93	100.00
1	0.11	0	93	100.00

Table 10. Landscape scale cutoffs for 10 bins determined by 'available' RSF scores.

Bin	Upper cutoff	# nests	Cumulative nests	Cumulative %
10	0.82	21	21	22.58
9	0.68	29	50	53.76
8	0.63	18	68	73.12
7	0.58	6	74	79.57
6	0.54	3	77	82.80
5	0.48	4	81	87.10
4	0.39	5	86	92.47
3	0.30	4	90	96.77
2	0.18	2	92	98.92
1	0.06	1	93	100.00

Table 11. Combined scale cutoffs for 10 bins determined by 'available' RSF scores.

Bin	Upper cutoff	# nests	Cumulative nests	Cumulative %
10	0.80	21	21	22.58
9	0.68	23	44	47.31
8	0.62	13	57	61.29
7	0.57	17	74	79.57
6	0.52	3	77	82.80
5	0.45	5	82	88.17
4	0.38	5	87	93.55
3	0.28	4	91	97.85
2	0.15	1	92	98.92
1	0.05	1	93	100.00

Table 1 Supplement. Listing of final candidate models of Ferruginous Hawks (*Buteo regalis*) at the nest-site scale.

Category	#	Model
Energy	1	WELL_DEN_1,000
	2	ROAD_DEN_1,000
	3	WELL_DEN_1,000 + ROAD_DEN_1,000
Vegetation	4	RIPARIAN_250 + SHRUB_HT_250 + BARE_250
	5	RIPARIAN_500 + SHRUB_HT_500
	6	BARE_250 + SHRUB_HT_250
Topography	7	ROUGH_1,000
Energy + Vegetation	8	WELL_DEN_1,000 + RIPARIAN_250 + SHRUB_HT_250 + BARE_250
	9	WELL_DEN_1,000 + RIPARIAN_500 + SHRUB_HT_500
	10	WELL_DEN_1,000 + BARE_250 + SHRUB_HT_250
	11	ROAD_DEN_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250
	12	ROAD_DEN_1,000 + RIPARIAN_500 + SHRUB_HT_500
	13	ROAD_DEN_1,000 + BARE_250 + SHRUB_HT_250
	14	WELL_DEN_1,000 + ROAD_DEN_500 + RIPARIAN_250 + SHRUB_HT_250 + BARE_250
	15	WELL_DEN_1,000 + ROAD_DEN_500 + RIPARIAN_500 + SHRUB_HT_500
	16	WELL_DEN_1,000 + ROAD_DEN_500 + BARE_250 + SHRUB_HT_250
Energy + Topography	17	WELL_DEN_1,000 + ROUGH_1,000
	18	ROAD_DEN_1,000 + ROUGH_1,000
	19	WELL_DEN_1,000 + ROAD_DEN_1,000 + ROUGH_1,000
Vegetation + Topography	20	RIPARIAN250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000
	21	RIPARIAN_500 + SHRUB_HT_500 + ROUGH_1,000
	22	BARE_250 + SHRUB_HT_250 + ROUGH_1,000
Energy + Vegetation + Topography	23	WELL_DEN_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000
	24	WELL_DEN_1,000 + RIPARIAN_500 + SHRUB_HT_500 + ROUGH_1,000
	25	WELL_DEN_1,000 + BARE_250 + SHRUB_HT_250 + ROUGH_1,000
	26	ROAD_DEN_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000
	27	ROAD_DEN_1,000 + RIPARIAN_500 + SHRUB_HT_500 + ROUGH_1,000
	28	ROAD_DEN_1,000 +BARE_250 + SHRUB_HT_250 + ROUGH_1,000

Table 1 Supplement. Continued.

Category	#	Model
Energy + Vegetation + Topography	29	WELL_DEN_1,000 + ROAD_DEN_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000
	30	WELL_DEN_1,000 + ROAD_DEN_1,000 + RIPARIAN_500 + SHRUB_HT_500 + ROUGH_1,000
	31	WELL_DEN_1,000 + ROAD_DEN_1,000 + BARE_250 + SHRUB_HT_250 + ROUGH_1,000
Interactions	32	WELL_DEN_1,000*ROUGH_1,000
	33	WELL_DEN_1,000*ROUGH_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250
	34	ROAD_DEN_1,000*ROUGH_1,000 + RIPARIAN250 + SHRUB_HT_250 + BARE_250
	35	WELL_DEN_1,000*BARE250 + WELL_DEN_1,000*SHRUB_HT_250
Global model	36	WELL_DEN_1,000 + ROAD_DEN_1,000 + RIPARIAN_250 + SHRUB_HT_250 + BARE_250 + ROUGH_1,000 + WELL_DEN_1,000*ROUGH_1,000 + WELL_DEN_1,000*BARE250 + WELL_DEN_1,000*SHRUB_HT_250

Table 2 Supplement. Final candidate models of Ferruginous Hawks(*Buteo regalis*) considered at the landscape scale.

Category	#	Model
Energy	1	WELL_DEN_5km
	2	WELL_DIST
	3	ROAD_DEN_1.5km
	4	ROAD_DIST
	5	OILFIELD_DIST
	6	WELL_DEN_5km + ROAD_DEN_1.5km
	7	ROAD_DIST + OILFIELD_DIST
	8	WELL_DIST + ROAD_DIST + OILFIELD_DIST
	9	ROAD_DIST + ROAD_DEN_1.5km
Vegetation	10	SHRUB_HT_25km
	11	SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
Topography	12	ROUGH__5km
	13	ROUGH_5km + SPRING_TEMP_5km
Energy + Vegetation	14	WELL_DEN_5km + SHRUB_HT_25km
	15	WELL_DIST + SHRUB_HT_25km
	16	ROAD_DEN_1.5km + SHRUB_HT_25km
	17	ROAD_DIST + SHRUB_HT_25km
	18	OILFIELD_DIST + SHRUB_HT_25km
	19	WELL_DEN_5km + ROAD_DEN_1.5km + SHRUB_HT_25km
	20	WELL_DIST + ROAD_DIST + OILFIELD_DIST + SHRUB_HT_25km
	21	WELL_DIST + ROAD_DIST + OILFIELD_DIST + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	22	ROAD_DIST + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	23	ROAD_DIST + ROAD_DEN_1.5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km

Table 2 Supplement. Continued.

Category	#	Model
Energy + Topography	24	WELL_DEN_5km + ROUGH__5km
	25	WELL_DIST + ROUGH__5km
	26	ROAD_DEN_1.5km + ROUGH__5km
	27	ROAD_DIST + ROUGH__5km
	28	ROAD_DIST + ROAD_DEN_1.5km + ROUGH__5km
	29	OILFIELD_DIST + ROUGH__5km
	30	WELL_DEN_5km + ROUGH_5km + SPRING_TEMP_5km
	31	ROAD_DEN_1.5km + ROUGH_5km + SPRING_TEMP_5km
	32	WELL_DIST + ROAD_DIST + OILFIELD_DIST + ROUGH__5km
	33	WELL_DIST + ROAD_DIST + OILFIELD_DIST + ROUGH__5km + SPRING_TEMP_5km
Vegetation + Topography	34	SHRUB_HT_25km + ROUGH__5km
	35	SHRUB_HT_25km + ROUGH_5km + SPRING_TEMP_5km
	36	SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km + ROUGH__5km
	37	SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km + ROUGH_5km + SPRING_TEMP_5km
Energy + Vegetation + Topography	38	WELL_DEN_5km + SHRUB_HT_25km + ROUGH__5km
	39	ROAD_DEN_1.5km + SHRUB_HT_25km + ROUGH__5km
	40	WELL_DIST + SHRUB_HT_25km + ROUGH__5km
	41	ROAD_DIST + SHRUB_HT_25km + ROUGH__5km
	42	OILFIELD_DIST + SHRUB_HT_25km + ROUGH__5km
	43	ROAD_DIST + ROAD_DEN_1.5km + SHRUB_HT_25km + ROUGH__5km
	44	WELL_DEN_5km + ROAD_DEN_1.5km + SHRUB_HT_25km + ROUGH__5km+ SPRING_TEMP_5km
	45	ROAD_DEN_1.5km + ROAD_DIST + SHRUB_HT_25km + ROUGH__5km+ SPRING_TEMP_5km
	46	WELL_DIST + SHRUB_HT_25km + ROUGH__5km+ SPRING_TEMP_5km
	47	ROAD_DIST + SHRUB_HT_25km + ROUGH__5km+ SPRING_TEMP_5km
	48	OILFIELD_DIST + SHRUB_HT_25km + ROUGH__5km + SPRING_TEMP_5km
	49	WELL_DEN_5km + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km

Table 2 Supplement. Continued.

Category	#	Model
Energy + Vegetation + Topography	50	ROAD_DEN_1.5km + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	51	WELL_DIST + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	52	ROAD_DIST + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	53	ROAD_DIST + ROAD_DEN_1.5km + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	54	OILFIELD_DIST + ROUGH__5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	55	WELL_DEN_5km + ROUGH__5km + SPRING_TEMP_5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	56	ROAD_DEN_1.5km + ROUGH__5km + SPRING_TEMP_5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	57	WELL_DIST + ROUGH__5km + SPRING_TEMP_5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	58	ROAD_DIST + ROUGH__5km + SPRING_TEMP_5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
	59	OILFIELD_DIST + ROUGH__5km + SPRING_TEMP_5km + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km
Interactions	60	ROAD_DIST*WELL_DIST + SHRUB_HT_25km + ROUGH__5km
	61	WELL_DEN*ROAD_DEN + SHRUB_HT_25km + ROUGH__5km
	62	WELL_DEN*ROUGH_5km + SHRUB_HT_25km
	63	ROAD_DEN*ROUGH_5km + SHRUB_HT_25km
Global model	64	WELL_DEN_5km + ROAD_DEN_1.5km + WELL_DIST + ROAD_DIST + OILFIELD_DIST + SHRUB_HT_25km + SAGE_25km + BARE_25km + JUNIPER_25km + CROP_25km + RIPARIAN_25km + ROUGH__5km + SPRING_TEMP_5km +

Table 3 Supplement. Listing of final candidate models of Ferruginous Hawks (*Buteo regalis*) at a combination of scales.

Category	#	Model
Energy + Vegetation + Topography	1	ROUGH_5km + BARE_250 + WELL_DIST + ROAD_DIST
	2	ROUGH_5km + SHRUB_HT_25km + ROAD_DEN_1,000 + OILFIELD_DIST
	3	ROUGH_1,000 + SHRUB_HT_250 + ROAD_DIST
	4	ROUGH_5km + SHRUB_HT_250 + WELL_DIST + WELL_DEN_5km
	5	ROUGH_5km + SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DEN_1,000 + WELL_DEN_1,000
	6	ROUGH_1,000 + BARE_250 + SHRUB_HT_25km + WELL_DEN_5km + ROAD_DEN_1.5km
	7	ROUGH_1,000 + SPRING_TEMP_5km + RIPARIAN250 + OILFIELD_DIST
	8	ROUGH_1,000 + RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DEN_1,000 + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST
	9	SPRING_TEMP_5km + SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DIST
Energy + Topography	10	ROUGH_5km + SPRING_TEMP_5km + ROAD_DIST + WELL_DIST
	11	ROUGH_1,000 + OILFIELD_DIST + ROAD_DEN_1,000 + WELL_DEN_1,000 + WELL_DIST
	12	ROUGH_1,000 + SPRING_TEMP_5km + ROAD_DIST + ROAD_DEN_1.5km
	13	ROUGH_5km + ROAD_DIST
	14	SPRING_TEMP_5km + ROAD_DEN_1.5km
	15	ROUGH_1,000 + ROAD_DEN_1,000
	16	ROUGH_1,000 + ROAD_DEN_1,000 + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST + WELL_DEN_5km + OILFIELD_DIST
Vegetation + Topography	17	ROUGH_1,000 + RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km
	18	ROUGH_5km + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km
	19	SPRING_TEMP_5km + SHRUB_HT_25km
	20	ROUGH_1,000 + SHRUB_HT_25km
	21	ROUGH_5km + SHRUB_HT_250
	22	ROUGH_5km + SPRING_TEMP_5km + RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km
	23	ROUGH_1,000 + SPRING_TEMP_5km + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km
	24	ROUGH_5km + RIPARIAN250 + BARE_250 + SHRUB_HT_250

Table 3 Supplement. Continued.

Category	#	Model
Energy + Vegetation	14	BARE_250 + SHRUB_HT_250 + WELL_DIST + WELL_DEN_5km + ROAD_DIST + ROAD_DEN_1.5km
	26	RIPARIAN250 + SHRUB_HT_25km + ROAD_DEN_1,000 + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST
	27	RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DIST + WELL_DIST
	28	ROAD_DEN_1.5km + SHRUB_HT_25km
	29	WELL_DEN_1,000 + SHRUB_HT_250 + BARE_250
	30	BARE_250 + SHRUB_HT_25km + ROAD_DEN_1,000 + WELL_DIST
	31	SHRUB_HT_250 + SHRUB_HT_25km + WELL_DEN_5km + ROAD_DEN_1.5km
	32	SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DIST + WELL_DIST + OILFIELD_DIST
Vegetation	33	RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km
	34	RIPARIAN250
	35	BARE_250
	36	SHRUB_HT_250
	37	SHRUB_HT_250 + BARE_250
	38	SHRUB_HT_25km
Topography	39	ROUGH_1,000 + SPRING_TEMP_5km
	40	ROUGH_1,000
	41	ROUGH_5km
	42	SPRING_TEMP_5km
Energy	43	ROAD_DEN_1,000 + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST + WELL_DEN_5km + OILFIELD_DIST
	44	ROAD_DEN_1,000
	45	WELL_DEN_1,000
	46	ROAD_DIST
	47	WELL_DIST
	48	WELL_DEN_5km
	49	ROAD_DEN_1.5km
	50	OILFIELD_DIST

Table 3 Supplement. Continued.

Category	#	Model
Global model	51	ROUGH_1,000 + SPRING_TEMP_5km + RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km + ROAD_DEN_1,000 + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST + WELL_DEN_5km + OILFIELD_DIST
	52	ROUGH_5km + SPRING_TEMP_5km + RIPARIAN250 + BARE_250 + SHRUB_HT_250 + SHRUB_HT_25km + WELL_DEN_1,000 + ROAD_DIST + WELL_DIST + WELL_DEN_5km + ROAD_DEN_1.5km + OILFIELD_DIST

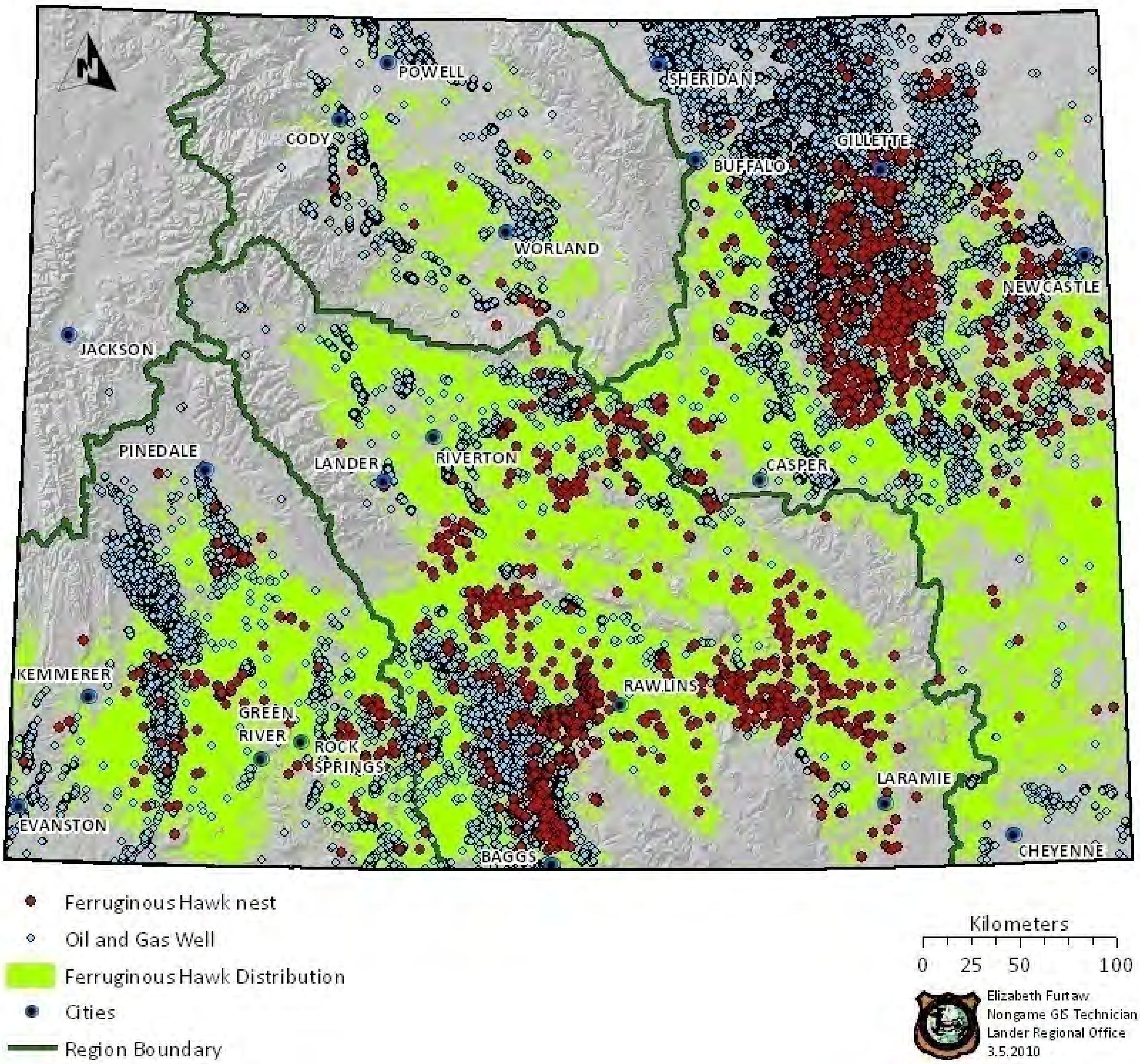

Figure 1. Ferruginous Hawk (*Buteo regalis*) distribution relative to oil and gas development in Wyoming, 2010-2011. Red dots indicate hawk nests; blue dots are oil and gas wells.

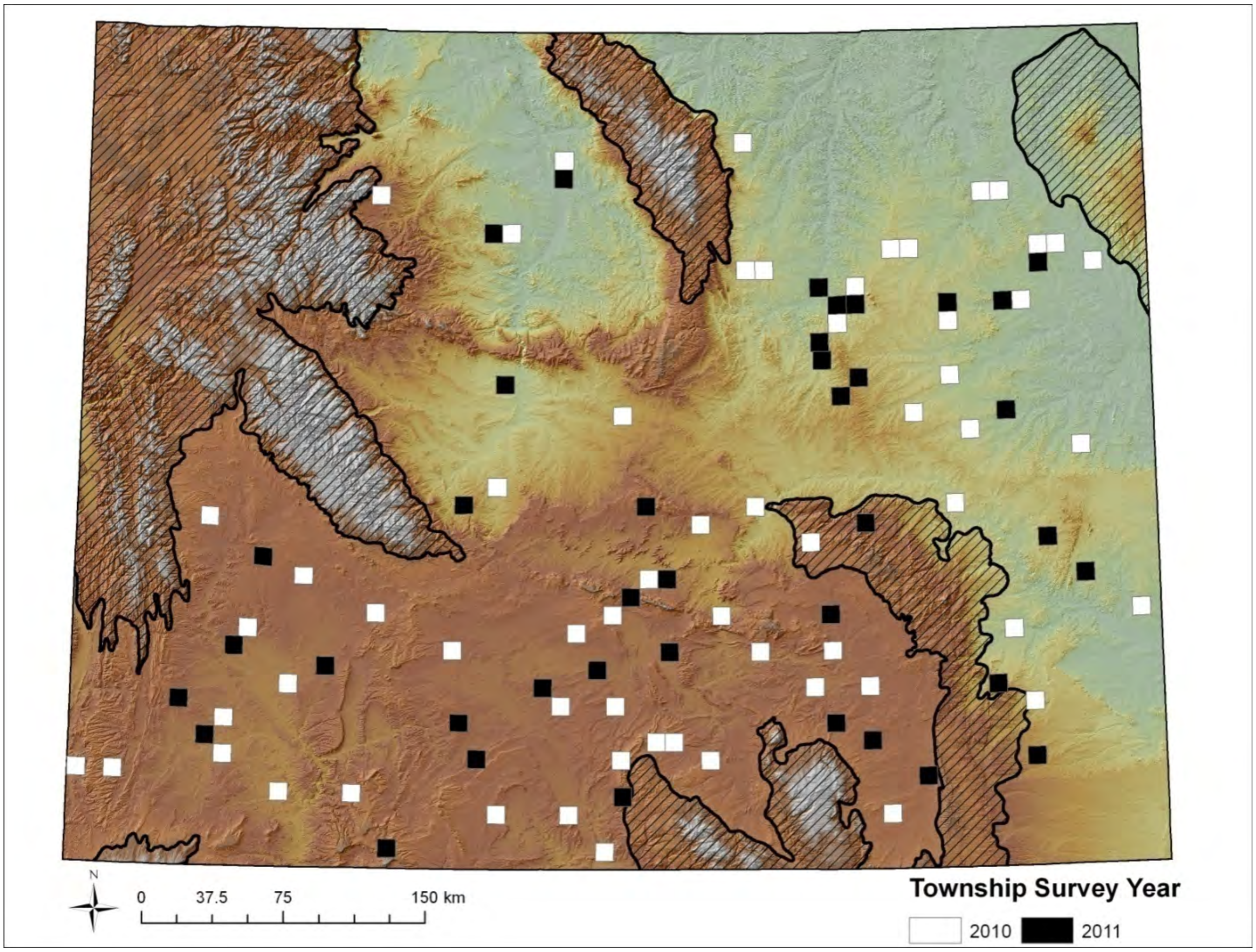

Figure 2. The Ferruginous Hawk (*Buteo regalis*) study area shown across Wyoming; cross-hatched areas are mountainous and were excluded from the analysis. Surveyed townships are represented as squares; white squares were surveyed in 2010 and black squares were surveyed in 2011.

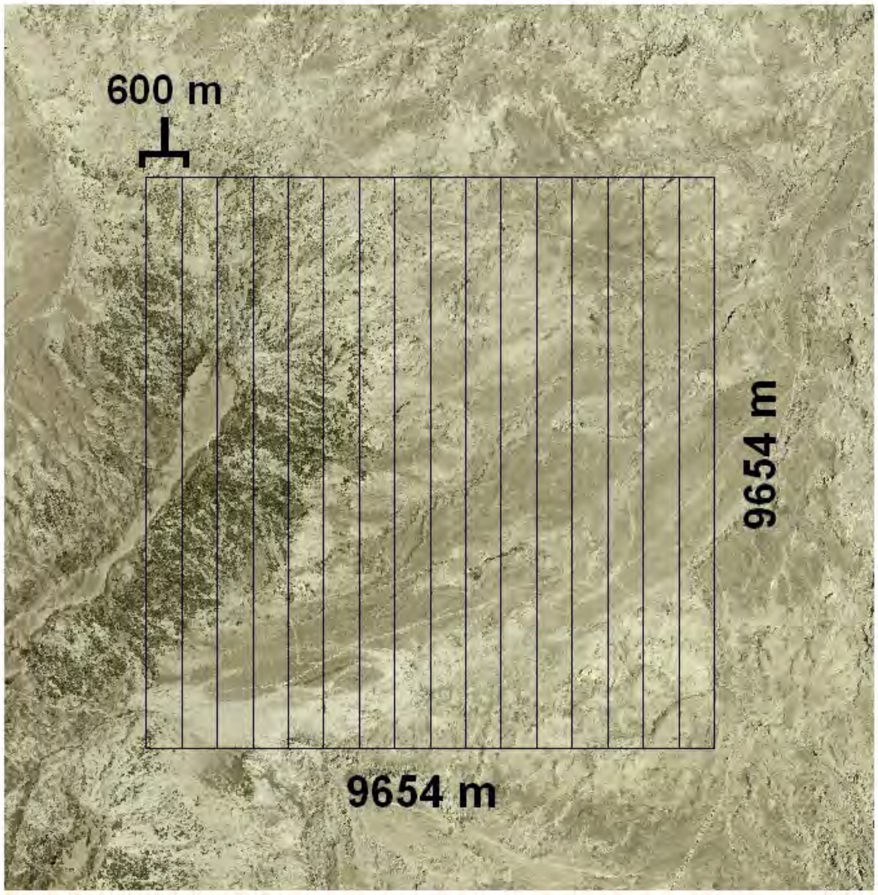

Figure 3. Aerial survey flight lines for Ferruginous Hawk (*Buteo regalis*) nests in Wyoming, 2010-2011, depicted in a survey township (9,654 m = 6 mi).

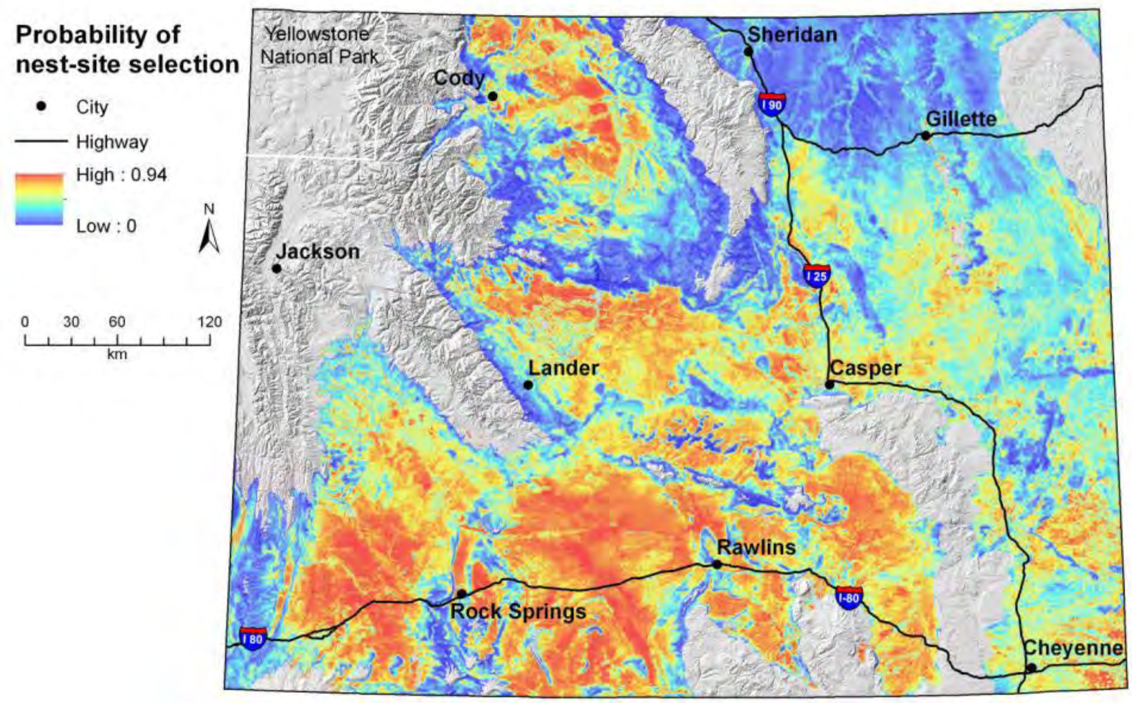

Figure 4. The predicted probability surface for Ferruginous Hawk (*Buteo regalis*) nest-site selection across non-mountainous areas of Wyoming.

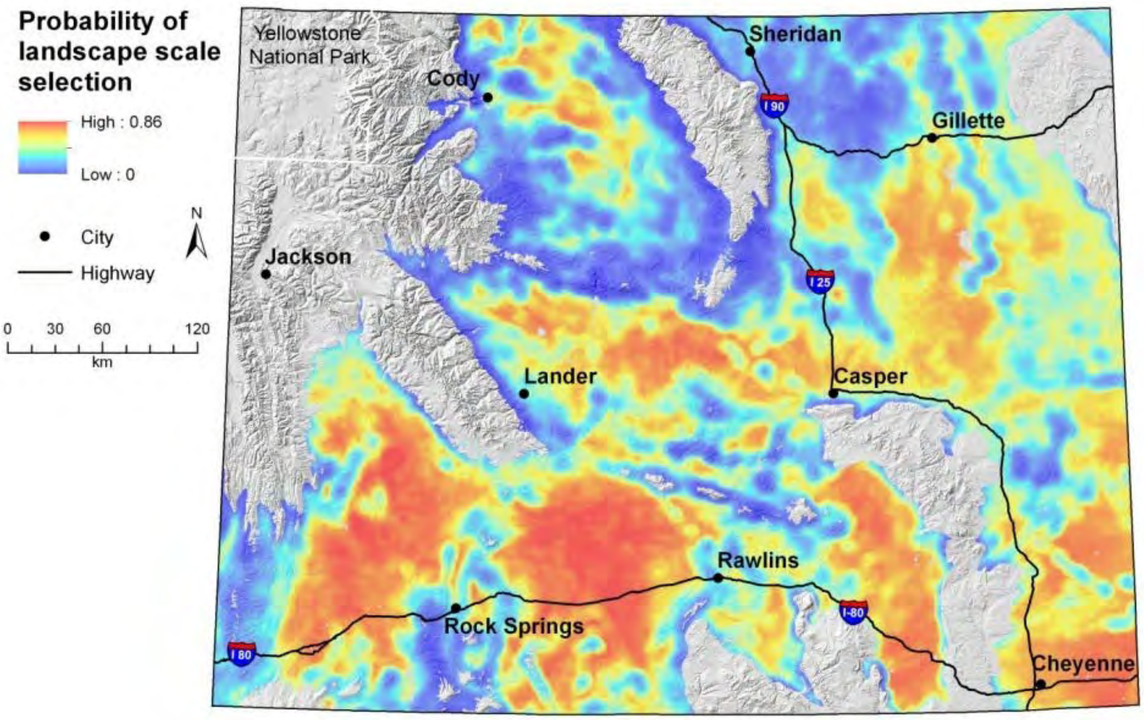

Figure 5. The predicted probability surface for Ferruginous Hawk (*Buteo regalis*) landscape scale selection across non-mountainous areas of Wyoming.

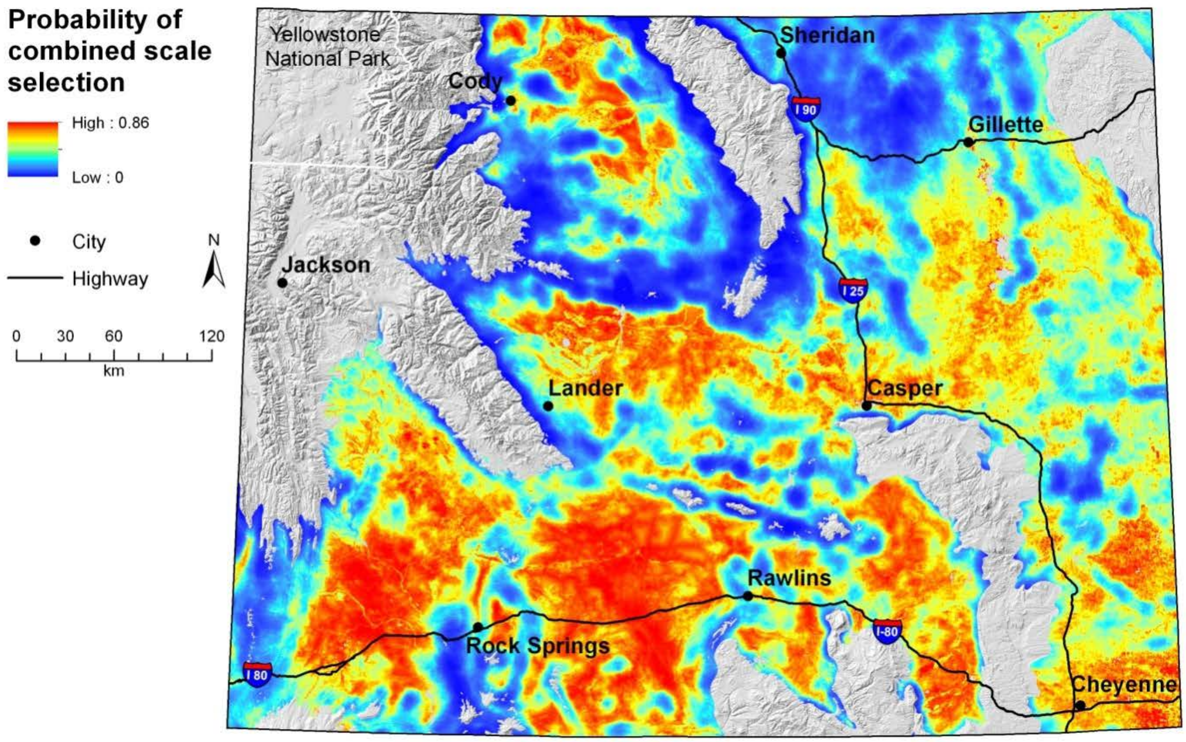

Figure 6. The predicted probability surface for Ferruginous Hawk (*Buteo regalis*) at a combined spatial scale across non-mountainous areas of Wyoming.

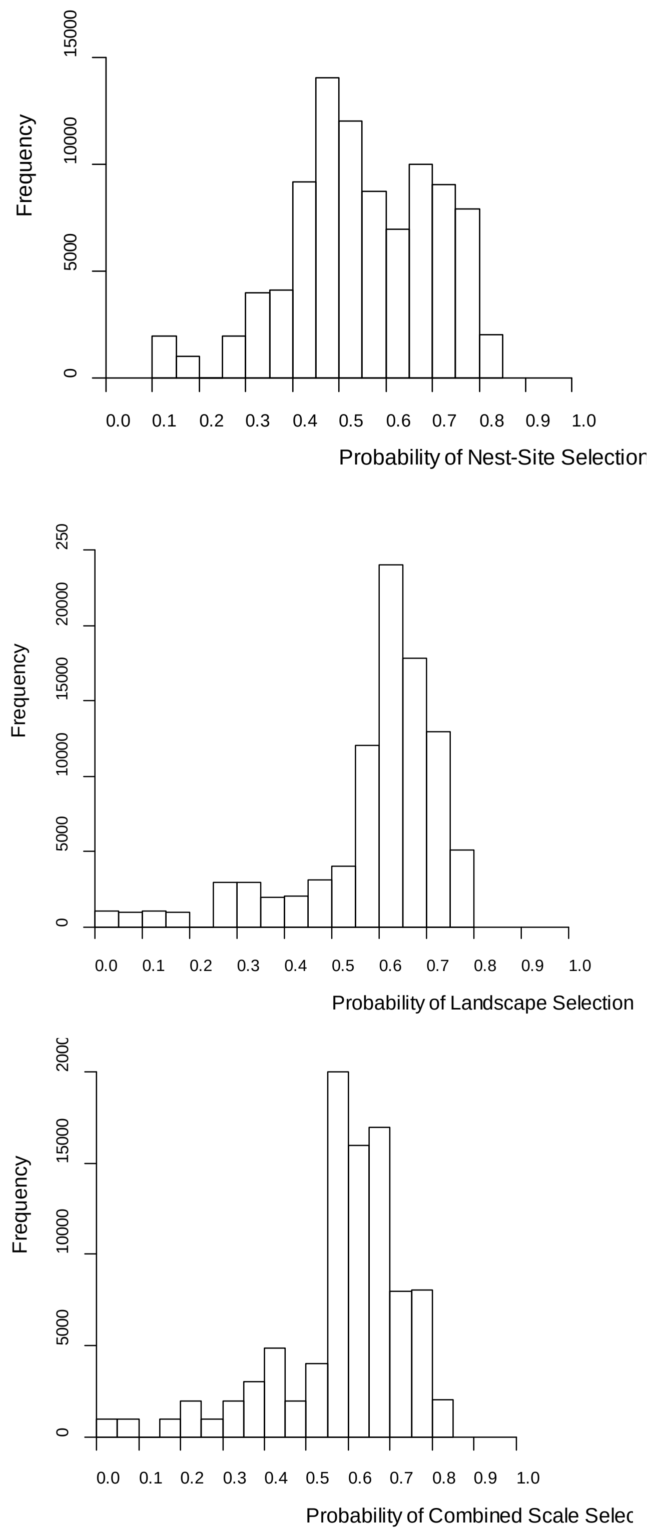

Figure 7. The bootstrapped distribution of RSF values for nest-site (top), landscape (middle), and combined scale (bottom) models, calculated for an independent sample of 93 nests, collected from 2000-2009 across Wyoming.

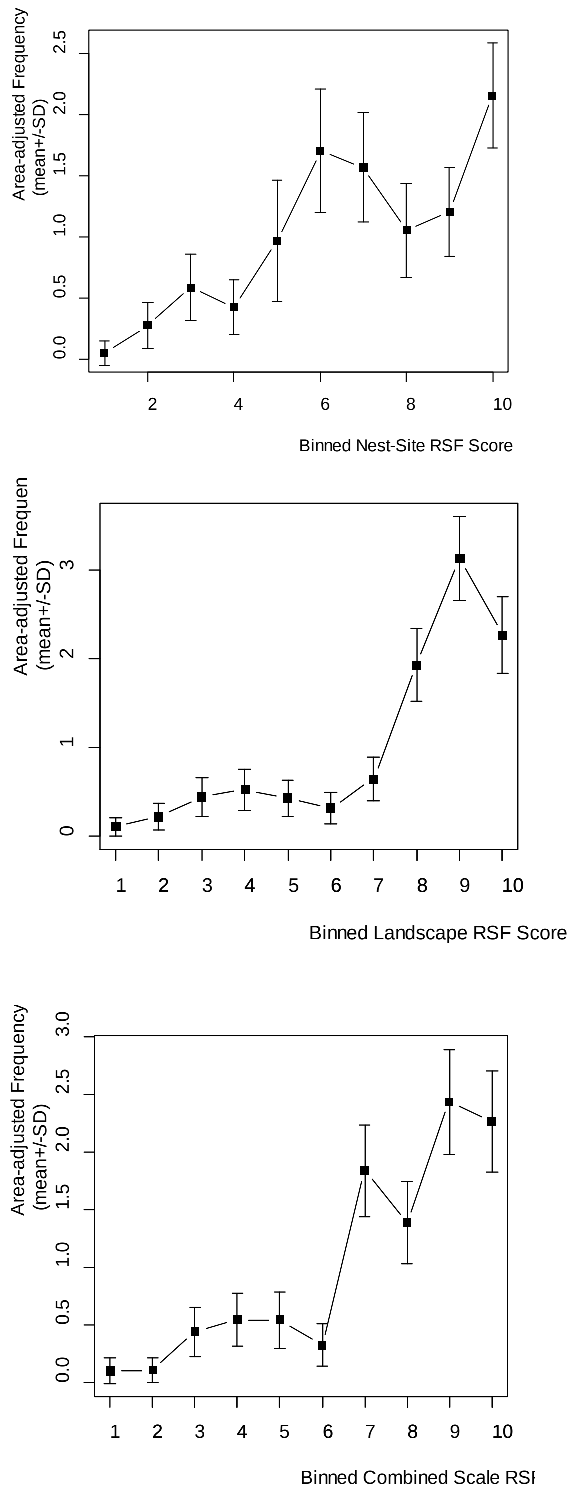

Figure 8. A comparison between the nest-site (top), landscape (middle), and combined scale (bottom) RSF scores for 93 independent nests and the RSF scores for the 'available' points used to construct the model. The available points are binned into 10 groups, and the independent nest scores are divided into those groups. Good agreement between bins and groups good predictive ability of the model. Whiskers show bootstrapped standard errors for each bin.

THE STATUS OF FERRUGINOUS HAWKS (*BUTEO REGALIS*) IN WYOMING: A PRELIMINARY REVIEW

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Ferruginous Hawk.

FUNDING SOURCE: United States Forest Service Rocky Mountain Research Station; Bureau of Land Management; Wyoming Wildlife Heritage Foundation; PacifiCorp; Pathfinder Renewable Wind Energy, LLC; Wyoming Game and Fish Department; Wyoming Governor's Endangered Species Account Funds; Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 January 2010 – 31 December 2013

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Bob J. Oakleaf, Nongame Coordinator, Wyoming Game and Fish Department
Lucretia E. Olsen, Rocky Mountain Research Station, Forestry Science Lab
John R. Squires, Rocky Mountain Research Station, Forestry Science Lab

ABSTRACT

In 2010, we implemented a range-wide survey of Ferruginous Hawks (*Buteo regalis*) and Golden Eagles (*Aquila chrysaetos*) in Wyoming to evaluate the effects of energy development on occupancy and productivity nest-site selection, and prey availability. The purpose of this paper is to compile available information and provide a preliminary evaluation of the status of the Ferruginous Hawk in Wyoming. We selected our study area by first estimating Ferruginous Hawk distribution across Wyoming using an updated nest database, and modeled suitable habitat. Within that estimated distribution, we conducted a randomized, systematic survey to locate nesting Ferruginous Hawks and Golden Eagles. We used two fixed-wing aircraft to search for hawk and eagle nests in April and May, 2010. Surveys were conducted in 60 randomly selected townships with 16 north-south transects spaced 600 m apart. An additional five townships were surveyed to address objectives of other projects. We also conducted duplicate surveys on randomly selected transects by helicopter in 2010 and located 50 nests occupied by Ferruginous Hawks. We surveyed an additional 39 townships in April and May 2011, and detected 18 nests occupied by Ferruginous Hawks on transects in survey townships. We evaluated the probability of detecting nests using mark-recapture and DISTANCE programs on various combinations of species and nest status. Overall, we estimate that there are 1,165 (95% CI: 928-1,565) nesting pairs of Ferruginous Hawks in Wyoming, similar to crude estimates made in the 1980s. We evaluated the number of nesting pairs in different strata of well density

and found no indication that Ferruginous Hawks were avoiding oil and gas development. However, in our study, we may not have included well densities high enough to detect effects on nesting. We also evaluated the abundance of nesting Ferruginous Hawks in different Ecoregions and study areas of Wyoming. We found large differences in estimated nesting densities that appeared related to differences in prey abundance and management of nest structures, confounding evaluations of the effects of energy development on the abundance of nesting Ferruginous Hawks. Our preliminary findings indicate that oil and gas development is currently not having widespread negative impacts on the abundance of nesting Ferruginous Hawks in Wyoming. However, our findings emphasize the importance of continuing evaluations of prey availability, importance of nest structures, occupancy modeling, and use of foraging areas with energy development by nesting adults.

INTRODUCTION

Ferruginous Hawks (*Buteo regalis*) nest in sagebrush and grassland habitats throughout the western United States and adjacent portions of Canada. Their breeding range is very restricted compared to that of other North American buteos. The species is considered to be highly sensitive to landscape changes, fluctuations in prey abundance, and human disturbance during the nesting season, and typically receives special management attention to minimize potential impacts (Olendorff 1993, Bechard and Schmutz 1995, Lehman et al. 2007).

The Wyoming Game and Fish Department (Department) has partnered with federal agencies to conduct surveys and maintain a database for nesting raptors since 1977. Proposed water development projects and coal mines were the primary emphasis for these surveys in the 1970s and 1980s. Oakleaf (1981) evaluated these surveys and resulting records of 198 occupied nest territories of Ferruginous Hawks. A crude estimate of a minimum of 800-1,053 nesting pairs in Wyoming was calculated based on the portion of surveyed habitat to the portion of potential habitat not surveyed. Oakleaf (1986) updated this minimum estimate with 483 nesting locations to provide an estimate of 800-1,600 nesting pairs in Wyoming.

The US Fish and Wildlife Service (Service) petitioned the Ferruginous Hawk for listing in 1991 due to apparent declines in localized areas in the states of Idaho, Nevada, and New Mexico (USFWS 1992). The Service found that listing was not warranted. Recent petitions for listing of species with similar habitat associations and distribution suggest that we should anticipate renewed efforts to list the Ferruginous Hawk. In Canada, Ferruginous Hawks may have vacated close to half of their breeding range in northern prairies, and the Committee on the Status of Endangered Wildlife classified the species in 2008 as threatened (Schmutz et al. 2008). In Washington, the Ferruginous Hawk is classified as a sensitive species because occupied nesting territories continue to decline. In 2002, only 20 percent of 241 territories surveyed were occupied (http://wdfw.wa.gov/science/index.html, Fish and Wildlife Science online magazine, Washington Department Fish and Wildlife). State Wildlife Action Plans for other states show similar classifications varying from “Imperiled” in New Mexico or “Species of Most Concern” in Colorado to “Species of Concern” in Montana. In Wyoming, the Ferruginous Hawk is classified as a Species of Greatest Conservation Need (WGFD 2010).

Current and potential oil and gas development coincides almost entirely with the distribution of Ferruginous Hawks in Wyoming (Copeland et al. 2009; Fig. 1). Recent and proposed wind energy development is expected to greatly increase in areas lacking the overlap of current development and hawk distribution (Copeland et al. 2011). We initiated a cooperative study in 2010 to improve our understanding of Ferruginous Hawks and Golden Eagles (*Aquila chrysaetos*) nesting in similar habitats. We present these preliminary results as part of a larger on-going study with four objectives: 1) determine distribution, abundance, occupancy, and productivity of Ferruginous Hawks in Wyoming relative to oil, gas, and wind-power development and provide a minimum abundance estimate for Golden Eagles in lowland habitats; 2) use genetic sampling to determine if population vital rates of Ferruginous Hawks are negatively impacted by increased energy development; 3) document the movements of Ferruginous Hawks when foraging in landscapes with abundant energy development (oil/gas and wind); and 4) determine the relative abundance of key prey species of Ferruginous Hawks when nesting at sites that are representative across Wyoming and relative to energy development.

Preliminary reports have focused on completion of objective 1 (Oakleaf et al. 2011, 2012). We summarize those results and previous studies. Squires et al. (2013) provides a preliminary report on resource selection function modeling of nesting Ferruginous Hawks in Wyoming. The purpose of this paper is to compile available information and provide a preliminary evaluation of the status of the Ferruginous Hawk in Wyoming. In 2013, we will complete evaluations of data sets collected during the 2010-2013 field seasons on prey abundance for nest site selection, occupancy modeling, and productivity of Ferruginous Hawks, as well as the movements of nesting males as they relate to energy development. All of these evaluations may modify the preliminary findings of this report and Squires et al. (2013). In addition, we will conduct intensive inventories for Golden Eagles in 2013 and present a status assessment of this species in 2014.

METHODS

Raptor studies have been plagued by a long history of ambiguous terms that sometimes preclude the comparison of data over time and space. In this study, we used terminology and associated definitions provided by Steenhof and Newton (2007). A nest is defined as the structure where eggs are laid and young sheltered, and a nesting territory is defined as an area that contains, or historically contained, one or more nests of a mated raptor pair and where no more than one pair is known to have bred at one time. We are aware of the many different terms that have been used synonymously and the more restricted ethological definition of a territory as a defended area but agree with Steenhof and Newton (2007) as to the appropriateness of this term. In order to classify a nest as occupied, one or more of the following observations were necessary: one adult associated with a freshly repaired nest, two adults associated with a nest, one adult incubating or brooding, or the presence of eggs or young. A nesting territory was classified as occupied if it contained an occupied nest. We often use the term nesting pair interchangeably with the term occupied nest.

We further defined a nesting territory as the area that included all nests within 1 km of a nest or the centroid of a cluster of nests. This radius was selected based on analyses of

Ferruginous Hawk nests classified as occupied and using the "Near" analysis in ArcMap (Oakleaf et al. 2012). We also use the term naïve occupancy and naïve density to indicate occupancy and density rates that were calculated without consideration of detection rates.

In 2010, we updated the Ferruginous Hawk database. We used the updated nest database with over 9,500 nesting records and modeling completed by the Wyoming Natural Diversity Database to determine Ferruginous Hawk distribution across Wyoming (Keinath et al. 2010). Within that distribution, we conducted an aerial survey of nesting Ferruginous Hawks. Surveys were designed to provide a statistically valid statewide estimate of the abundance of nesting Ferruginous Hawks in 2010 and 2011 (Oakleaf et al.2012) that could be used to monitor future trends or changes in statewide abundance.

Our statewide study area included sagebrush-steppe and grassland habitats across Wyoming, but excluded mountain ranges with extensive coniferous forests (Fig. 2). Big sagebrush (*Artemisia tridentata*) and wheatgrass (*Agropyron spp*.) communities were dominant, intermixed with narrowleaf cottonwood (*Populus angustifolia*) in riparian drainages; Rocky Mountain juniper (*Juniperous scopulorum*) and ponderosa pine (*Pinus ponderosa*) were common on higher ridgelines. Elevation ranged from approximately 930 m to 3,390 m. Temperature exhibited considerable seasonal shifts: in July, summer highs averaged 29 to 35^{o} C and during January, the coldest month, lows averaged -15 to -12^{o} C.

Our 186,693 km^2 study area included a mix of land ownerships comprised of 41.5% Federal, 6.6% State, and 51.4% private. The harsh, dry climate is amenable to cattle grazing, with only approximately 4% of Wyoming in irrigated and non-irrigated cropland. The distribution of Ferruginous Hawks in Wyoming extensively overlapped energy development, including oil, gas, wind, and coal. Energy extraction and associated development was a primary and rapidly expanding land-use across much of the State. There were 66,993 producing wells according to the Wyoming Oil and Gas Conservation Commission (http://wogcc.state.wy.us/ accessed January 2013).

Chapman et al. (2004) classified the state into ecoregions and published detailed descriptions of each ecoregion. Ecoregions are designed to serve as a special framework for research, management, and monitoring and denote areas of general similarities of environmental factors and resources. Our Ferruginous Hawk studies were focused in the Wyoming Basin, Bighorn Basin, Northwestern Great Plains, and High Plains ecoregions (Fig. 2). A detailed assessment and additional description of the Wyoming Basins, including the Bighorn Basin subecoregion, was provided by Hanser et al. (2011). We delineated the Bighorn Basin subecoregion separately because it has long been noted for its scarcity of nesting Ferruginous Hawks, even though it appears to have suitable nesting habitats (Bulger et al. 1979, Oakleaf 1986). In addition to Chapman et al. (2004), portions of Northwestern Great Plains Ecoregion has recently received detailed published descriptions (Doherty et al. 2008) and grassland habitats of both the Great Plains and High Plains were described in Knight (1994) and WGFD (2006, 2010).

We randomly selected townships (93.3 km^2, 9.66 km on a side) from a stratified sample based on degree of energy development, and surveyed 16 transects running the length of the township and spaced 600 m apart, thus allowing complete coverage of each township. Only townships with centroids contained within the known distribution of Ferruginous Hawks were considered for selection (n = 1,230), as well as any additional townships containing Ferruginous Hawk nest records. Within that distribution, we conducted an aerial survey of nesting Ferruginous Hawks. We used two fixed-wing aircraft (Bellanca Scout and Piper PA 18) to search for raptor nests in 60 townships during April and May 2010. An additional five townships were surveyed to address objectives of other projects. While these townships were included in efforts to calculate detection probabilities, we only include results from randomly selected townships in abundance estimates. We used a chi-squared goodness-of-fit test to evaluate the number of occupied nests by density of wells (low, medium, and high). We also conducted duplicate surveys on randomly selected transects by helicopter in 2010 and aggressively searched for nests during flights between townships. We surveyed an additional 39 townships in April and May 2011.

In each township, we flew 16 north/south transects the length of the township and spaced 600 m apart. This configuration provided complete visual coverage of surveyed townships. During flights, the pilot and one observer both searched for nests; flight speed on transects averaged 130 km per hour. Aircrafts were outfitted with GPS to precisely match flight paths to designated transect paths and to record the helicopter transect between random townships. Survey protocols that we employed (e.g., transect spacing, aircraft speed, minimum qualifications or experience of observers, and timing) were similar to those recommended by Ayers and Anderson (1999) for Ferruginous Hawks, with the exception of the presence of two observers in the airplane. After searching the townships, survey crews also flew to historical nests identified by the Department's *Wildlife Observation* System nest database to assess their occupancy.

We used an independent observer mark-recapture technique (DOBSERV) to estimate detection probability and bird abundance (Pollock and Kendall 1987, Nichols et al. 2000). This method provides an estimate of absolute detection probability for each observer or species (Laake et al. 2008). We used the methods detailed in Nichols et al. (2000) to estimate detection probabilities for Ferruginous Hawks for observation teams one and two in fixed-wing planes. We then used this estimate to calculate the number of km^2 of survey area per occupied nest.

We also used program DISTANCE v. 6.0 (Thomas et al. 2009) to provide a comparative estimate of detection probabilities and nest density. Distance methods provide a relative measure of detection probability, since they use the distribution of nest locations within transects to infer the number of nests likely missed by observers (Laake et al. 2008). We selected half-normal or hazard-rate key functions and cosine or hermite polynomial series expansion terms as possible models. We fit these models to the data and used AIC to determine the model with the best fit. We used only occupied Ferruginous Hawk nests for this analysis and truncated the highest 5% of the data to avoid problems fitting the model to a long-tailed distribution (Thomas et al. 2010).

The Department has conducted, funded, or participated in other cooperative studies of Ferruginous Hawks since 1978. We reviewed and summarized data archived from three of these other studies, which include surveys of the Medicine Bow Study Area (MBSA) located in an area of Albany and Carbon County; the Baggs Study Area (BSA) located approximately 14 km north of Baggs, Wyoming; and the Powder River Basin (PRB) cooperative surveys conducted in northeast Wyoming. Because the distribution of nesting pairs per township was not random, we used a Wilcoxon signed rank test to evaluate the change in the number of nests per township within study areas. We report means (±SE) where applicable. These studies all provided a snap shot of Ferruginous Hawk abundance prior to energy development, with follow up surveys providing a comparison and offering some comparative data for our current statewide study.

The Medicine Bow Study Area (MBSA) is located in the Wyoming Basins Ecoregion and an area of Albany and Carbon County with high potential for wind power development (BLM 1995). Abundance levels of nesting raptors were monitored during 1978 (Phase I; Oakleaf 1978) and between 1997 and 2000 (Phase II) and 2009 (Phase III; Young et al 2010). The MBSA lies east of Walcott Junction and west of the Laramie Mountains. The study area extends north of the town of Arlington, Wyoming and south of the Freezeout Mountains. It encompasses approximately 3,215 km^2, mostly comprised of scrub-shrub land cover (84.2%) followed by grassland (8%). Pasture/hay, woody wetlands, and emergent wetlands all comprised 6% of land cover. Low, medium, and high intensity development comprised less than 1% of all land use. The study area was variable throughout all three phases. Phase I study area was determined by potential wind turbine placement sites throughout the entire Medicine Bow/Rock River basin, which was part of an alternative energy research project headed by the United States Department of Energy and the United States Geological Survey (USGS). Phase II (1997-2000) study area was established as part of the pre-construction Wildlife Monitoring Studies for the SeaWest Windpower Project. The SeaWest Windpower Project considered two potential sites for placement of a wind energy facility: Simpson Ridge Wind Resource Area (SR) and the eventually completed Foote Creek Rim facility (FCR). The Phase II raptor nest survey area included the proposed project areas and a 16-km buffer. In 2009 during Phase III, surveys were initiated to determine long-term trends of focal species within the central areas of the first two Phases. Due to multiple study areas, some survey areas from Phase I and II extended beyond the boundaries of Phase III. In order to analyze abundance trends, a study area boundary was determined by the area surveyed during all three Phases. We eliminated nests located in areas outside the consistent boundary from the abundance trend analysis but used them in calculating naïve occupancy and productivity rates.

We first surveyed the MBSA by helicopter in 1978. The objective was to determine the abundance of Golden Eagles, Prairie Falcons (*Falco mexicanus*) and Ferruginous Hawks. However, Ferruginous Hawks did not receive the intensity of survey effort as did eagles and falcons during Phase I. Surveys were conducted by flying to all known nests and searching potential nesting habitats with increasing attention toward Ferruginous Hawks during Phase II and III.

The 783 km^2 Baggs Study Area (BSA) is also located in the Wyoming Basins Ecoregion and approximately 14 km north of Baggs, Wyoming. Study area boundaries were identical in 1993, 1994, and 2008. Ayers et al (2009) established the original placement in 1993 based on records indicating a high nesting density of Ferruginous Hawks. However, boundaries were delineated prior to conducting field surveys. Elevation ranged from 1,830-2,350 m. The southwest portion of the study area contained extensive soil cliffs and spurs that ranged from approximately 2-150 m tall. Most of these features were devoid of vegetation. Soils in the eastern portion of the study area were sandy loams, and the topography consisted of moderate to steep hills, ridges, and escarpments <(150 m in height. The hills and ridges of the northeast and southeast corners tapered into sagebrush flats toward the central portion of the study area. These flats contained numerous small rock piles, hills, and narrow ephemeral drainages. Drainage patterns outside these flats consisted of rocky, steep draws that emptied into shallow, meandering drainages. Vegetation on the BSA included desert shrub, sagebrush-steppe, and juniper cover types. Dominant plant species are described by Compton (1975) and Knight (1994). Desert shrub covered approximately 40% of the BSA around the base of ridges and spurs of the western portion of the study area. Sagebrush vegetation types were dominant in the eastern portion of the study area (totaling ~45% of the area) and Utah juniper (*Juniperus osteosperma*) mainly corresponded with the hilly northeastern and southeastern regions, which comprised 15% of the study area.

Intensive aerial and ground surveys were conducted in 1993 and 1994 in an attempt to locate all nesting pairs in the BSA for evaluating detection rates associated with diverse variables inherent with aerial surveys for nesting Ferruginous Hawks (Ayers and Anderson 1999). Department Nongame Program biologists resurveyed the BSA in 2008 using techniques developed to maximize detection rates during the original study. North/south transects were flown at 400 m intervals with two observers (Ayers et al 2009). All known nesting territories from the previous study received special attention. We also surveyed two of these townships as part of our statewide study in 2010.

Powder River Basin Area (PRBA) is located in northeast Wyoming. Department Nongame Program biologists conducted aerial transects with aircraft and techniques similar to those used in our 2010/2011 survey. These surveys have been conducted in northeast Wyoming since 1996 in cooperation with the Bureau of Land Management (BLM) and the Thunder Basin National Grassland, US Forest Service (Orabona 2010). North/south transects were flown at 800 m spacing with one observer and the pilot recording all raptor nest observations. Typically, transect length extended to more than one township. Most townships have been surveyed only once and the total size of the survey area has varied considerably from year to year. Observers have also varied and no detection rates were developed. The primary purpose of these surveys was to build a database that can assist timing and placement of anticipated oil and gas development. We compared geographically similar subsets (13 townships) of our recent statewide study with results of these surveys in 1998.

We also reviewed and summarized data that could add perspective to our results. These data include the number of producing oil and gas wells 1996-2012 for each ecoregion and study area, according to the Oil and Gas Conservation Commission, accessed April 2012. We reviewed hunter harvest results of cottontail rabbits (*Sylvilagus* spp.), a major prey item (Bechard and Schmutz 1995). These results are published annually (WGFD 2012). We also reviewed the Palmer drought severity index, since Steenhof et al. (1999) suggests a correlation with ground squirrel abundance. In addition, we present monitoring data from annual reports by five coal mines to provide us with a perspective as to where our studies might relate to naturally occurring fluctuations or cycles in abundance of nesting Ferruginous Hawks. Three mines (North Antelope, Rochelle, and Black Thunder) are located in southeast Campbell County and two mines (Bridger and Black Butte) are located east of Rock Springs in Sweetwater County.

RESULTS

We compiled >9,000 nest records of Ferruginous Hawks in Wyoming. We are continuing analysis of these data to eliminate duplicate data and identify nest territories and repeated observations of the same territory over >1 year. In addition, we are continuing to add new data and edit questionable records.

In 2010, we recorded 50 occupied nests of Ferruginous Hawks during surveys of transects in randomly selected townships that were eligible for calculation of detection rates and estimates of statewide abundance. We surveyed an additional 39 townships in 2011, and detected 18 Ferruginous Hawk occupied nests while surveying transects in random townships. We combined the two years for a total of 68 Ferruginous Hawk nesting pairs in 99 townships for a naïve density of 136 km^2 per occupied Ferruginous Hawk nest. Our random sample of townships was stratified as low (0), medium (1-30), and high (>30) density of active wells, with 33 townships in each strata. Using the 2 years of pooled data and additional nests located by helicopter on random transects, we located 77 occupied nests during surveys of transects in these 99 random townships. Within the low, medium, and high strata, 32, 16, and 29 occupied nests were located, respectively. The number of occupied nests did not significantly differ among well strata ($\chi^2 = 3.16$, $df = 2$, $P = 0.206$). Of the 29 nests in the high development strata, 21 occupied nests were located in 18 townships that had >100 wells per township, although this difference was also not significant ($\chi^2 = 1.19$, $df = 1$, $P = 0.274$).

We used the double observer data collected in 2010 to revise the probability of detection calculated for each observer and each species. We did this to account for potential differences in detection probability based on species, which we did not account for in 2010 (Dechant et al. 2003). For teams 1 and 2, we used only occupied Ferruginous Hawk nests that were found on transects surveyed by both fixed-wing and helicopter in 2010. Using this dataset, the estimated detection probability for team 1 was 0.82 (95% CI: 0.72-0.92) for Ferruginous Hawks. For team 2, we estimated a detection probability of 0.63 (95% CI: 0.6-0.66) for Ferruginous Hawks. We then used these estimates of detection probability averaged over both observers (hawks: 0.725, 95% CI: 0.54-0.91); to determine the density for each year as well as an overall estimate of density of 98 km^2 (95% CI: 73-123) per occupied nest of Ferruginous Hawks (Table 1). Using program DISTANCE, our truncated data set resulted in 43 occupied nests and we estimated 107.2 km^2 (95% CI: 63.1-182.1) per occupied nest of Ferruginous Hawks (Table 2).

We used density estimates from both distance-sampling (Buckland et al. 1993) and the DOBSERV density calculation of number of nests found over area surveyed, weighted by probability of detection as determined by the double observer survey, to evaluate statewide abundance (Table 3). We calculated statewide abundance based on the total number of townships we considered Ferruginous Hawk habitat (consisting of 1,230 townships, each approximately 93 km^2; 114,390 km^2 total), as determined by the species distribution model performed by the Wyoming Natural Diversity Database (Keinath et al. 2010). The mark-recapture calculations provided smaller confidence intervals and probably more reliable abundance estimates. Overall, based on the density calculation, we estimate that there are 1,165 (95% CI: 928-1654) nesting pairs of Ferruginous Hawks in Wyoming (Table 3).

In addition, we located 17 nests randomly on helicopter flights between survey townships. We viewed these flights as random transects since they started and ended at randomly selected townships. These flights totaled 3,328 km and, if we assume effective observation of nests within 300 m or a 600-m wide transect, we surveyed 1,996.8 km^2, or a naïve density of 117 km^2 per nesting pair of Ferruginous Hawks, half way between the naïve density from fixed-wing transects (136 km^2) and calculated density considering a detection rate (98 km^2).

To account for differences in population density based on location, we also divided the State into ecoregions, as defined by the USGS (Chapman et al. 2004), and calculated density separately for each ecoregion (Fig. 2) using the area divided by the number of occupied nests and weighted by probability of detection (Table 4). Estimated density indexes varied considerably among ecoregions from 77.3 km^2 to 337.1 km^2 per occupied nest in the Wyoming Basin and the Bighorn Basin, respectively. The High Plains and NW Great Plains had intermediate densities estimated with 94.4 km^2 and 144.5 km^2 per occupied nest, respectively. Two townships were actually within the boundaries of the Southern Rockies Ecoregion and did not have any occupied nests.

We present trends of oil and gas development, as represented by the number of producing wells, in random statewide townships in each ecoregion (Figs. 3-5). There were no producing wells in sampled townships in High Plains or Southern Rockies ecoregions. The number of townships and producing wells were minimal in the Bighorn Basin (Fig 3). Sixteen of 30 (53.3%) townships in the NW Great Plains were classified in the high well strata. We recorded 13 of 20 (65%) occupied nests in these townships. The number of producing wells in our sample townships increased rapidly from 1,512 in 2001 to 3,185 in 2008 and has leveled off at approximately 3,200 wells for an average of 107 wells per sample township (Fig. 4). During the same period, the number of producing wells in the Wyoming Basin increased from 1,234 to 1,634 but continues to increase, with 1,827 recorded in 2011 for an average of 33 producing wells per sampled township (Fig. 5). We surveyed 15 (27.3%) townships classified in the high strata of the 55 townships and found 16 (31 %) of 51 occupied nests in the Wyoming Basin.

We compiled trends for the number of producing wells in the BSA and PRB (Figs. 6-7). Oil and gas development in MBSA is minimal and not presented. Young et al. (2010) calculated 3.2% of the MBSA had been developed for wind energy projects. The number of producing wells in the eight townships included in the BSA remained steady at less than 122 after the 1993/1994 study until 2001, but increased to 384 by 2008 and continued a rapid increase to 509 by 2011, which averages 63.6 producing well per township in the study area (Fig. 6). The number of producing wells in the PRB study area trends parallels trends in the NW Great Plains Ecoregion with a rapid increase from 358 wells in 1998 to approximately 1,500 producing wells in 2006, a leveling off to 1,555 wells for an average of 119.6 wells per township in 2011(Fig 7).

We also present trends of cottontail rabbit harvest as an indication of abundance of an important prey species for Ferruginous Hawks (Figs. 8-11). All trends were similar and indicate low abundance approximately every 8 years and that 2010 and 2011 were certainly low years in the cottontail rabbit cycle in Wyoming in all Ecoregions studied. Although the Palmer Drought Severity Index was extreme statewide in 2012, 9 of the 10 regions monitored in Wyoming were at or above normal during 2008-2011 (http://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers.php). The southwest region was ranked as severe to extreme drought from 2006 through 2010, possibly affecting ground squirrel abundance in the southwestern portion of the Wyoming Basin and the BSA.

We summarized our calculations from three other Ferruginous Hawk datasets (Table 5). The number of occupied Ferruginous Hawk nests increased in the MBSA from 22 in the 1978 Phase 1 to an average of 25.5 during the 1990s/2000 Phase II to 34 occupied nests in 2009. The number of nesting pairs in the BSA decreased from 39 nesting pairs (4.33 ± 1.38 nesting pairs per township) in 1994 to 11 nesting pairs (1.22 ± 0.32 nesting pairs per township) in 2008 (Z = 2.21, P = 0.031). However, Ayers et al. (2009) used detection rates calculated during the 1994 study to estimate that there may have been as high as 18 occupied nests in the BSA during 2008. We surveyed portions of three townships where seven occupied nests were recorded in 1993/1994 and only one in 2008. We located four occupied Ferruginous Hawk nests in the same area in 2010. Our random selection of townships for the 2010/2011 study included 13 townships of 89 townships surveyed in the PRB during 1998. Although the number of nesting pairs in the PRB decreased from 17 nesting pairs (1.31 ±0.49 nesting pairs per township) in 1998 to 9 nesting pairs (0.70 ±0.21 nesting pairs per township) in 2010/2011, this difference was not significant (Z = 1.00, P = 0.383).

Naïve occupancy rates varied from 0.179 in the PRB to 0.624 in our 2012 statewide surveys. Even in the MBSA where the number of nesting pairs appeared to be increasing or at least stable, Department surveys of known nesting territories in 2009 only found a naïve occupancy rate of 0.3. The number of nesting pairs in the BSA increased from 24 pairs in 1993 to 39 pairs in 1994; yet only 8 (0.333) of the 24 nesting territories were occupied 1 year later. The 1994 occupancy rate was probably an actual number as opposed to the other naïve rates due to the intensity of study (Ayers and Anderson 1999). Department surveys 14 years later found only 6 (0.113) of the 53 nesting territories documented in 1993/1994 occupied. Only three (0.057) nesting territories were occupied all 3 years of the study and seven (0.132) nesting territories no longer contained nests or any indication of previous nesting. The 13 study townships in the PRB included 39 nesting territories located prior to our 2010/2011 surveys. Seventeen of these territories were located during the 1998 survey and 22 additional territories from other sources. We recorded 7 (0.179) of these 39 territories as occupied and noted that 15 (0.385) of these territories no longer contained nests.

Trends of occupied Ferruginous Hawk nests associated with three coal mines in Campbell County within the NW Great Plains Ecoregion were similar with highs occurring in 2007 or 2008 and lows occurring in 2010 (Figs. 9-11; TWC 2010; ICF 2010a, b). The combined highs of the three study areas totaled 32 occupied nests. The combined 2010 results totaled four occupied nests. Results of surveys at Sweetwater County mines in the Wyoming Basin Ecoregion suggested that the number of occupied nests may have been increasing in 2010 but clearly had not crashed (Figs. 12-13).

DISCUSSION

We presented a summary of our 2010-2012 study and review of available data on the status of Ferruginous Hawks in Wyoming. We were constantly challenged with low sample sizes, number of nesting pairs, study design or years of study, and several possible variables that could affect results.

We compared two methods of calculating density and estimating statewide abundance of Ferruginous Hawks. Both methods produced similar results. We believe that estimates from mark-recapture calculations are more reliable than estimates from distance sampling due to tighter confidence-intervals. We used the mark-recapture estimates of detection probability averaged over both observers (0.725, 95% CI: 0.54-0.91) and the naïve densities of 136 km^2 per occupied nest to estimate that there were 1,165 (95% CI: 928-1,565) nesting pairs of Ferruginous Hawks in Wyoming. However, use of a helicopter adds significantly to costs of the survey. The estimate using fixed-wing aircraft and distance sampling of 1,067 (95% CI: 628-1813) nesting pairs of Ferruginous Hawks may be adequate and lend itself to future surveys.

Although previous estimates of 800-1,600 nesting pairs were subjective, we believe our 2010/2011 results suggest Ferruginous Hawk nesting populations have remained stable even during the years of rapid energy development. Our stratified random sample of townships had a total of 2,396 producing wells in 1996 and increased to 5,215 wells by 2012 (Wyoming Oil and Gas Conservation Commission, accessed 25 March 2012). We found no difference in Ferruginous Hawk nesting abundance among different densities of producing wells. At current rates of energy development, our results indicate the abundance of nesting Ferruginous Hawks has not been highly impacted. However, we believe that Ferruginous Hawk nesting activity may have a curvilinear response to oil and gas development at higher densities than we studied.

We evaluated reports and associated data of raptor nest surveys in oil and gas development with higher densities (Hayden-Wing Associates, LLC 2012; Aster Canyon Consulting, Inc. [ACC] 2012). One township in the Pinedale Anticline (PAPA) and one in the Jonah Infill Drilling Project Areas (JIDPA), located in Sublette County south of Pinedale, Wyoming, had over 1,300 producing wells each (Wyoming Oil and Gas Conservation Commission, accessed 14 January 2013). Both townships combined have 27 records of nests classified as Ferruginous Hawks with clusters indicating over 10 nesting pairs probably occurred prior to development. Despite exhaustive surveys, no occupied Ferruginous Hawk nests were located in these townships. Excluding these two townships, 2012 raptor nest surveys documented six and two occupied Ferruginous Hawk nesting territories in approximately 779 km^2 and 332 km^2 in the PAPA and JIDPA, respectively. These results indicate a naïve density of 139 km^2 per occupied nest territory in the combined 12 townships, which is similar to our statewide naïve density of 136 km^2 per occupied nest.

Density indexes varied considerably among ecoregions from 77.3 km^2 to 337.1 km^2 per occupied nest in the Wyoming Basin and the Bighorn Basin, respectively. We expected to find few nesting pairs of Ferruginous Hawks in the Bighorn Basin based on our past experience and the evaluations of the statewide nest database. Although habitats appear structurally similar between much of the Bighorn Basin and the Wyoming Basin, availability of prey may limit the abundance of nesting pairs of Ferruginous Hawks in the Bighorn Basin. MacLaren et al. (1988) studied food habits of Ferruginous Hawks in a portion of the Wyoming Basin and found that 38% of their diet consisted of ground squirrels (*Spermophilus* spp.) and white-tailed prairie dogs (*Cynomys leucurus*). Uinta (*Spermophilus armatus*), Wyoming (*S. elegans*), Golden-mantled (*S. lateralis*), and thirteen lined ground squirrels (*S. tridecemlimeatus*) are all common in the Wyoming Basin but do not occur in the Bighorn Basin (Thorington et al. 2012, Orabona et al. 2012). Although white-tailed prairie dogs are present in the Bighorn Basin, they are not near as abundant as in the Wyoming Basin (Grenier and Filipi 2009). Thirteen-lined ground squirrels are common in portions of the NW Great Basin Ecoregion, but the Wyoming and Uinta ground squirrel are not known to occur (Orabona et al. 2012). Only the black-tailed prairie dog occurs in the NW Great Pains and High Plains Ecoregions, while both species occur in a range overlap west of Casper in the northeast sliver of the Wyoming Basin. Grenier (2010) reported high abundance levels of black-tailed prairie dogs in 2007 and an apparent decrease in 2009 due to widespread sylvatic plague and toxicant applications.

We estimated a density of 77.3 km^2 per nesting pair of Ferruginous Hawks in the Wyoming Basin, indicating that the ecoregions has the highest abundance of nesting in the State. Grenier and Filipi (2009) noted that the bulk of the white-tailed prairie dog colony acreage in Wyoming occurs in Carbon and Albany Counties, or the east half of the Wyoming Basin. This is also the area managed by the Rawlins Field Office (RFO) of the BLM, which installed over 105 artificial nest structures (ANS) between1987 and 2004 and continues to manage ANS to offset potential impacts of energy development(Smith et al. 2010). Neal et al. (2010) found higher productivity on ANSs as opposed to nests on the ground or rock features. We located 37 occupied Ferruginous Hawk nests in the RFO area. Thirteen (35%) of these nests were on ANS in the RFO area, while only five (9%) occupied nests were on ANS in the rest of the State.

Only three (21%) of the nests we located in the NW Great Plains Ecoregion were on ANS. Although coal mining companies commonly use ANS for mitigating potential impacts of development, the BLM, USFWS, USFS, Thunder Basin National Grasslands, and oil and gas companies operating in the NW Great Basin do not promote the use of ANS. While a buffer (800 m) is applied to an occupied nest during the nesting season to preclude disturbance, management to encourage nesting in following years typically does not occur. In fact, in a policy memo dated 15 April 2003, Steve Williams, then Director of the USFWS states, “The MBTA does not contain any prohibition that applies to the destruction of a migratory bird nest alone (without birds or eggs), provided that no possession occurs during the destruction.” Thirty-eight percent of the known territories in the PRB no longer contained nests and we have noticed that some nests were destroyed, likely to discourage nesting at sites where buffers would be problematic for oil and gas operations. Lower prey abundance and the lack of active nest site management may contribute to a lower abundance of nesting Ferruginous Hawks in the NW Great Plains.

In addition, our statewide study was initiated in 2010 during extreme lows in cottontail rabbit abundance, as indicated by hunter harvest data. Fedy and Doherty (2011) found that cottontails were cycling on an approximate 8-year cycle in Wyoming. However, the recent low that we are observing has lasted for 4 to 5 years, a duration not included in their models of past years (1983-2008). If cottontail cycles affect occupancy rates of Ferruginous Hawks, we would expect it to be most severe in the Bighorn Basin with ground squirrel prey lacking. The NW Great Basin provides habitat for only one species of ground squirrel and is experiencing a severe reduction in black-tailed prairie dog abundance. An all-time low in cottontail abundance occurring at the same time with lows in prairie dog abundance would have a profound effect on the availability of Ferruginous Hawk prey in the NW Great Plains. The Wyoming Basin, with four species of ground squirrels and areas where white-tailed prairie dogs are abundant, is buffered from low cycles of one or two prey species.

Not only did we estimate a lower density index for the NW Great Basin, but we also documented a complete nesting failure of occupied nests in 2010. Nest abandonment was closely associated with spring snow storms occurring during 5-15 May 2010, when we documented 12 nest failures and 36 failures by the end of June. Similar failure rates were reported by other monitoring efforts in northeast Wyoming (G. McKee, pers. comm., T. Byer, pers. comm.).

Oil and gas development preceded our study in the NW Great Basin at a more intense level than what has occurred in our study townships in the Wyoming Basin. However, we are reluctant to suggest that development contributed to our lower estimates of Ferruginous Hawk nesting in this ecoregion because of the variables, including nest structures, prey abundance, and weather, that we have not fully evaluated. In addition, we found no difference in the number of nesting pairs in the different strata of well density, and Squires et al. (2013) did not find well density to be important in nest site selection.

Naïve density calculations may not be comparable among the different studies, as study areas were selected by differing criteria. In addition, numbers of nesting pairs were attained with different survey techniques with undoubtedly differing but unknown detection rates. However, we suggest that data for MBSA (2009) and all years in BSA indicate a high level of Ferruginous Hawk nesting abundance.

In the MSBSA, the number of Ferruginous Hawk nesting pairs remained stable from 1978 through 2009 during development of wind energy facilities. However, facilities in 2009 only occupied 102 km^2 or 3.2% of the MBSA. At this low level of development, no impacts on nesting raptors were identified. Prey transects in the MBSA (Young et al. 2010) and hunter harvest data (Fig. 10) indicated declines in ground squirrel and lagomorph abundance, while white-tailed prairie dogs were increasing.

The abundance of nesting Ferruginous Hawks in the BSA appeared lower in 2008 as compared to 1994. However, this study area was selected for its exceptional density of nesting Ferruginous Hawks (Ayers and Anderson 1999). The relatively small size and artificial designation of the study area, numerous potential nesting structures, and other unique characteristics contributing to a high nesting density may moderate changes in nesting that occurs at a larger landscape scale. Although we consider the 2008 abundance of nesting pairs (naïve density) in the BSA high, the number of nesting pairs appeared less than original surveys in 1994. We do note an increase in oil and gas development and lows in cottontail abundance. In addition, the Palmer Drought Severity Index was ranked as severe to extreme drought during the years 2007-2010 for southwestern Wyoming, possibly contributing to low ground squirrel numbers.

The 13 townships in PRB appeared to have fewer nesting pairs in 2010/2011 than when they were originally surveyed in 1998. However, the difference of this small sample size was not significant and, for reasons discussed relative to the NW Great Basin, it is difficult to sort variables that may influence the abundance of nesting Ferruginous Hawks. In addition, transects in 2010/2011 were closer together—600 m versus 800 m—in 1998, indicating that a larger portion of the actual number of nesting pairs were located in 2010/2011 and results would be less sensitive to declining numbers.

Except for the 2011/2012 statewide results, we found low naïve occupancy rates (0.113-0.333) difficult to explain, especially with the stable abundance in the MBSA and the increase in 1 year from 24 pairs in 1993 to 39 pairs in 1994 but an occupancy rate of 0.333 in the BSA. Even the highest rate of 0.624 in 2012, which was calculated from three aerial surveys of 117 nests determined to be occupied 1 or 2 years prior, seems to indicate low site fidelity, a degree of nomadism, as suggested by (Woffinden and Murphy 1989), or high adult mortality. Additional studies of occupancy are scheduled for 2013, and further evaluations and modeling will be helpful.

Monitoring of nesting Ferruginous Hawks in areas associated with coal mines provided an important perspective for our 2010-2012 results. Most of these data sets are collected in areas where some habitats are removed during mining, additional habitats are monitored, and artificial nest structures or the movement of nests help mitigate impacts, so data can be difficult to interpret. However, these areas are not impacted by oil and gas development and figures 12-14 clearly show a decline of nesting Ferruginous Hawks in Campbell County during 2010-2011, indicating that our results in the NW Great Plains and the PRB need to be viewed with caution. We suspect that our estimates are low for this Ecoregion and the PRB study area compared to what they would have been in 2005 or 2006. Figures 15 and 16 of Ferruginous Hawk trends at two mines approximately 90 km northwest of BSA in southwestern Wyoming suggest that the BSA and Wyoming Basin may not be experiencing the excessive lows such as in the NW Great Basin.

Our preliminary findings indicate that oil and gas development is currently not having widespread negative impacts on the abundance of nesting Ferruginous Hawks in Wyoming. However, our findings emphasize the importance of continuing evaluations of prey availability, the importance of nest structures, occupancy modeling, and use of foraging areas with energy development by nesting adults.

ACKNOWLEDEGEMENTS

The first 3 years of this cooperative study have received funding and commitments from several sources. This research was supported, in part, by funds provided by the Rocky Mountain Research Station, US Forest Service, and US Department of Agriculture. Additional funding sources include the Wyoming Wildlife Heritage Foundation; PacifiCorp; Pathfinder Renewable

Wind Energy, LLC; Bureau of Land Management; Wyoming Governor's Office; and the Wyoming Game and Fish Department. Wyoming Game and Fish Department Nongame GIS technicians E. Furtaw and S. Cornell provided essential GIS support. P. Kennedy reviewed the proposal and provided a helpful critique, with recommendations for improvement. Z. Wallace and M. Wilson served as primary observers for fixed-wing aerial surveys of transects and leaders of the field crews. Other field crew leaders include A. Larned, R. Buchheit, and P. Mahoney. Field crews augmented production data and collected genetic samples and data on prey abundance.

LITERATURE CITED

Aster Canyon Consulting, Inc. [ACC]. 2012. Jonah Infill Drilling project. Area wildlife monitoring final report. US Department of the Interior, Bureau of Land Management. 49 pp.

Ayers, L. W., and S. H. Anderson. 1999. An aerial sightability model for estimating Ferruginous Hawk population size. Journal of Wildlife Management 63:85-97.

Ayers, L.W., B. Oakleaf, and T. Filipi. 2009. Distribution and abundance of breeding Ferruginous Hawk pairs in south-central Wyoming. Pages 72-86 *in* Threatened, endangered, and nongame bird and mammal investigations (A. Orabona, Editor). Wyoming Game and Fish Department, Lander, USA.

Bechard, M. J., and J. K. Schmutz. 1995. Ferruginous Hawk (*Buteo regalis*). The birds of North America. Number 172.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, United Kingdom.

Bureau of Land Management [BLM]. 1995. Final KENETECH/PacifiCorp wind-power project environmental impact statement. FES-95-29. Prepared by US Department of the Interior, Bureau of Land Management, Great Divide Resource Area, Rawlins, Wyoming, and Mariah Associates, Inc., Laramie, Wyoming, USA.

Bulger, J. B., L. Salzer, and S. G. Herman. 1979. Raptors of the Grass Creek Resource Area, Bighorn Basin, Wyoming. US Department of Interior Bureau of Land Management. BioSystem Analysis, Inc. Worland, Wyoming, USA.

Chapman, S. S., S. A. Bryce, J. M. Omernik, D. G. Despain, J. ZumBerge, and M. Conrad. 2004. Ecoregions of Wyoming (color poster with map, descriptive text, summary tables, and photographs). US Geological Survey, Reston, Virginia, USA.

Copeland, H. E., K. E. Doherty, D. E. Naugle, A. Pocewicz, and J. M. Kiesecker. 2009. Mapping oil and gas development potential in the US Intermountain West and estimating impacts to species. PLos One 4(10):e7400. DoI:101371/journal.pone 0007400.

Copeland, H. E., K. E. Doherty, A. Pocewicz, and J. M. Kiesecker. 2011. Geography of energy. Pages 7-22 *in* Energy development and wildlife conservation in Western North America (D. E. Naugle, Editor). Island Press, Washington, DC, USA.

Doherty, K. E., D. E. Naugle, B. L. Walker, and J. M. Grahm. 2008. Sage–grouse wintering habitat use and energy development. Journal of Wildlife Management 72:187-195.

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, P. A. Rabie, D. R. Diefenbach, D. W. Brauning, and J. A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. The Auk 120:1168-1179.

Fedy, B. C., and K. E. Doherty. 2011. Population cycles are highly correlated over long time series and spatial scales with two unrelated species: Greater Sage-Grouse and cottontail rabbit. Oecologia 165:915-924.

Grenier, M. 2010. Abundance estimate of the black-tailed prairie dog in eastern Wyoming. Pages 187-190 *in* Threatened, endangered, and nongame bird and mammal investigations (A. Orabona, Editor). Wyoming Game and Fish Department, Lander, USA.

Grenier, M., and T. Filipi. 2009. Estimate of abundance for the white-tailed prairie dog in Wyoming. Pages 149-172 *in* Threatened, endangered, and nongame bird and mammal investigations (A. Orabona, Editor). Wyoming Game and Fish Department, Lander, USA.

Hanser, S. E., M. Leu, S. T. Knick, and C. L. Aldridge. 2011. Sagebrush ecosystem conservation and management: ecoregional assessment tools and models for the Wyoming Basins. Allen Press, Lawrence, Kansas, USA.

Hayden-Wing Associates, LLC. 2012. Raptor monitoring of the Pinedale Anticline Project Area, Sublette County, Wyoming. US Department of the Interior, Bureau of Land Management. 22pp.

ICF International [ICF]. 2010a. Black Thunder Mine 2010 wildlife monitoring report. Submitted in the annual report for Wyoming Mining Permit 233. Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, USA.

ICF International [ICF]. 2010b. North Rochelle Mine 2010 wildlife monitoring report. Submitted in the annual report for Wyoming Mining Permit 550. Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, USA.

Keinath, D. A., M. D. Anderson, and G. P. Beauvais. 2010. Range and modeled distribution of Wyoming's Species of Greatest Conservation Need. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department, Cheyenne, and the US Geological Survey, Fort Collins, Colorado, USA.

Knight, D. H. 1994. Mountains and Plains: the ecology of Wyoming Landscapes. Yale University Press, New Haven, Connecticut, USA, and London, England.

Laake, J., M. J. Dawson, and J. Hone. 2008. Visibility bias in aerial survey: mark-recapture, line-transect or both? Wildlife Research 35:299-309.

Lehman, R. N., P. L. Kennedy, and J. A. Savidge. 2007. The state of the art in raptor electrocution research: A global review. Biological Conservation 136:159-174.

MacLaren, P. A., S. H. Anderson, and D. E. Runde. 1988. Food habits and nest characteristics of breeding raptors in southwestern Wyoming. Great Basin Naturalist 48:548-553.

Neal, M. C., J. P. Smith, and S. J. Slater. 2010. Artificial nest structures as mitigation for natural gas development impacts to Ferruginous Hawks (*Buteo reglis*) in Wyoming. Bureau of Land Management Technical Note 43. Bureau of Land Management Technical Note 433. Bureau of Land Management, Salt Lake City, Utah; Cheyenne, Wyoming; and Lakewood Colorado, USA.

Nichols, J. D., J. E. Hines, J. R. Sauer, F. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393-408.

Oakleaf, B. 1978. Medicine Bow raptor nest survey. Unublished report. Wyoming Game and Fish Department, Cheyenne, USA.

Oakleaf, B. 1981. Diurnal raptor inventories. Pages 17-19 *in* Nongame bird inventories (B. Oakleaf, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Oakleaf, B. 1986. The distribution and population status of the Ferruginous Hawk. Pages 48-51 *in* Endangered and nongame bird investigations (B. Oakleaf, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Oakleaf, B. J., J. R. Squires, and L. E. Olson. 2011*a*. Effects of energy development on the productivity and distribution of Ferruginous Hawks and Golden Eagles in Wyoming. Pages 63-86 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, editor). Wyoming Game and Fish Department, Lander, USA.

Oakleaf, B. J., J. R. Squires, and L. E. Olson. 2012. Effects of energy development on the productivity and distribution of Ferruginous Hawks and Golden Eagles in Wyoming Pages 75-102 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, editor). Wyoming Game and Fish Department, Lander, USA.

Olendorff, R. R. 1993. Status, biology, and management of Ferruginous Hawks: a review. Raptor Research and Technical Assistance Center, Special Report. US Department of the Interior, Bureau of Land Management, Boise, Idaho, USA.

Orabona, A. 2010. Raptor nest survey cooperative agreement completion report. Pages 76-94 *in* Threatened, endangered, and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department, Lander, USA.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, amphibians, and reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Pollock, K. H., and W. L. Kendall. 1987. Visibility bias in aerial surveys: a review of estimation procedures. Journal of Wildlife Management 51:502-510.

Schmutz, J. K., T. D. T. Flockhart, S. C. Houston, and P. D. McLoughlin. 2008. Demography of Ferruginous Hawks breeding in western Canada. Journal of Wildlife Management 72:1352-1360.

Smith, J. P., S. J. Slater, and M. C. Neal. 2010. An assessment of the effects of oil and gas field activities on nesting raptors in the Rawlins, Wyoming and Price, Utah Field Offices of the Bureau of Land Management. Bureau of Land Management Technical Note 433. Bureau of Land Management, Salt Lake City, Utah; Cheyenne, Wyoming; and Lakewood Colorado, USA.

Squires, J. R., L. E. Olson, and B. J. Oakleaf. 2013. Resource selection of Ferruginous Hawks in Wyoming in relation to Energy development: a preliminary analysis. Pages 50-99 *in* Species of greatest conservation need and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Steenhof, K., M. N. Kochert, L. B. Carpenter, and R. N. Lehman. 1999. Long term prairie falcon population changes in relation to prey abundance, weather, land uses, and habitat conditions. Condor 101:28-41.

Steenhof, K., and I. Newton. 2007. Assessing nesting success and productivity. Pages 181-190 *in* Raptor research and management techniques (D. M. Bird and K. L. Bildstein, Editors). Hancock House Publishing, Blaine, Washington, USA.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14.

Thomas, L., J. L. Laake, E. Rexstad, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, M. L. Burt, S. L. Hedley, J. H. Pollard, J. R. B. Bishop, and T. A. Marques. 2009. Distance 6.0, Release 2. Research Unit for Wildlife Population Assessment, University of Saint Andrews, Scotland, United Kingdom. http://www.ruwpa.st-and.ac.uk/distance (accessed 1 December 2011).

Thorington, R. W., J. L. Koprowski, M. A. Steele, and J. F. Whatton. 2012. Squirrels of the world. The John Hopkins University Press. Baltimore, Maryland, USA.

Thunderbird Wildlife Consulting [TWC]. 2010. North Antelope Rochelle Mine 2010 wildlife monitoring report. Submitted in the annual report for Wyoming Mining Permit 569. Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, USA.

United States Fish and Wildlife Service [USFWS]. 1992. Endangered and threatened wildlife and plants. Notice of finding on petition to list the Ferruginous Hawk. Federal Register 57(161):37507-37513,

Woffinden, N. D., and J. R. Murphy. 1989. Decline of a Ferruginous Hawk Population: A 20-year summary. Journal of Wildlife Management 53(4):1127-1132.

Wyoming Game and Fish Department [WGFD]. 2006. A plan for bird and mammal Species of Greatest Conservation Need in eastern Wyoming grasslands. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Game and Fish Department [WGFD]. 2012. Annual reports of big and trophy game harvest and annual reports of small and upland game harvest. Wyoming Game and Fish Department, Cheyenne, USA. http://wgfd.wyo.gov/web2011/HUNTING-1000184.aspx (accessed May 2012).

Young, D., C. LeBeau, W. Erickson, S. Nomani, J. R. Boehrs, and R. Oakleaf. 2010. Status of breeding populations of Ferruginous Hawks, Golden Eagles, and Bald Eagles in Albany and Carbon County, Wyoming. Pages 42-75 *in* Threatened, endangered, and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Table 1. Number of nests (*n*), density (km^2 per nest), 95% confidence intervals (95% CI), and number of nests per township of occupied Ferruginous Hawk (*Buteo regalis*) and Golden Eagle (*Aquila chrysaetos*) nests found on random survey transects throughout Wyoming, 2010-2011. Density was calculated by using the probability of detection as calculated with program DOBSERV.

	Ferruginous Hawks				Golden Eagles			
Year	*n*	Density	95% CI	Nests per township	*n*	Density	95% CI	Nests per township
2010	50	80.9	60.3-101.6	0.83	19	171.8	102.8-297.0	0.32
2011	18	165.2	145.5-185.0	0.46	14	129.5	57.7-201.4	0.36
Total	68	98.2	73.1-123.2	0.69	33	163.2	117.2-209.3	0.33

Table 2. Number of nests (*n*), density (km^2 per nest), and 95% confidence interval (95% CI) of occupied Ferruginous Hawk (*Buteo regalis*) and Golden Eagle (*Aquilus chrysaetos*) nests throughout Wyoming, 2010-2011, as determined with distance sampling. Number of nests reflects the number used in analysis, which was truncated at 300 m.

	Ferruginous Hawks			Golden Eagles		
Year	*n*	Density	95% CI	*n*	Density	95% CI
2010	33	167.8	119.0-236.6	18	172.2	95.3-311.2
2011	10	136.8	58.1-321.8	11	265.7	183.0-577.5
Total	43	107.2	63.1-182.1	29	230.1	138.7-381.7

Table 3. Comparison of estimates calculated via distance sampling and mark-recapture (DOBSERV) for density (km^2 per nest), abundance (number of pairs), and 95% confidence interval (95% CI) for Ferruginous Hawks (*Buteo regalis*) and Golden Eagles (*Aquilus chrysaetos*) throughout Wyoming, 2010-2011.

	Ferruginous Hawks			Golden Eagles		
	Density	Abundance	95% CI	Density	Abundance	95% CI
Distance sampling	107.2	1067.3	628.1-1813.4	230.1	497.1	299.7-824.6
DOBSERV	98.2	1165.0	928.4-1564.5	163.2	700.9	546.7-976.2

Table 4. Number of townships surveyed (*n*), total number of townships within Ferruginous Hawk (*Buteo reglais*) distribution (total *n*), total area of townships (km^2), number of nests, density (km^2 per nest), number of nests per township, and abundance (number of pairs) of Ferruginous Hawks throughout Wyoming by ecoregion, 2010-2011.

Ecoregion	*n*	Total *n*	Township area	No. of nests	Density	Nests per township	Abundance
Bighorn Basin	5	88	8184	1	337.1	0.2	24
High Plains	7	99	9207	5	94.4	0.7	98
NW Great Plains	30	315	29295	14	144.5	0.5	203
Wyoming Basin	55	682	63426	48	77.3	0.9	821
Southern Rockies	2			0			
Middle Rockies	0						

Table 5. Naïve density and occupancy of Ferruginous Hawks (*Buteo reglais*) observed in three study areas in Wyoming and statewide survey of random townships.

Study area[a]	Year	km^2	OccNests (N)	km^2/OccNest	NaïveOcc[b] Occ/Total	Rates Rate
MBSA	1978	3215	22	146		
	1997-2000	3215	25.5[C]	126		
	2009	3215	34	94.5	30/100[d]	0.3
BSA	1993	783	24	33		
	1994	783	39	20	8/24	0.333
	2008	783	11	71 (44)[e]	6/53	0.113
PRB	1998	1213	17	71		
	2010/2011	1213	9	135	7/39[f]	0.179
Statewide	2010/2011	9237	68	136 (98)[e]	23/79[g]	0.291
	2011				45/74[h]	0.608
	2012				73/117[h]	0.624

[a] Study areas include Medicine Bow (MBSA), Baggs (BSA), Powder River Basin (PRB) and a statewide sample of 99 randomly selected townships.
[b] Number of occupied territories/Number of previously documented territories.
[c] Average number of occupied nests 1997-2000 includes 28, 26, 24, and 24 occupied nesting attempts, respectively.
[d] Includes all territories documented since 1978 in all three phases of the study.
[e] Number in parentheses ( ) provides an estimate by considering detection rates (see text).
[f] Includes the 17 territories located in 1998 and an additional 22 from other sources and years.
[g] Includes all territories from the nest database
[h] Includes only occupied territories located in 2010/2011 and number occupied based on 3 surveys but not modeled for detection rates.

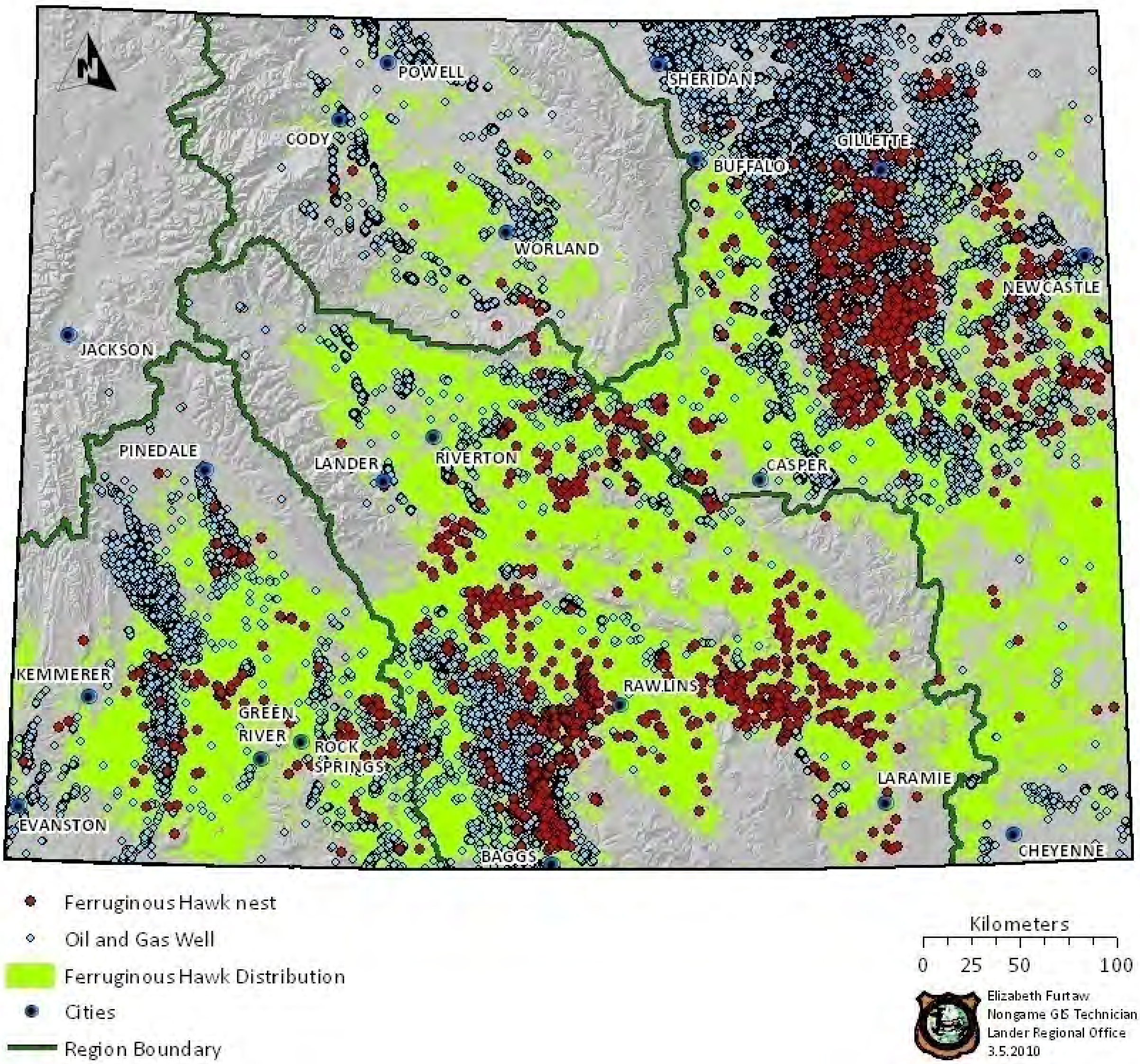

Figure 1. Ferruginous Hawk (*Buteo regalis*) distribution in Wyoming, 2010-2011. Red dots indicate hawk nests; blue dots are oil and gas wells.

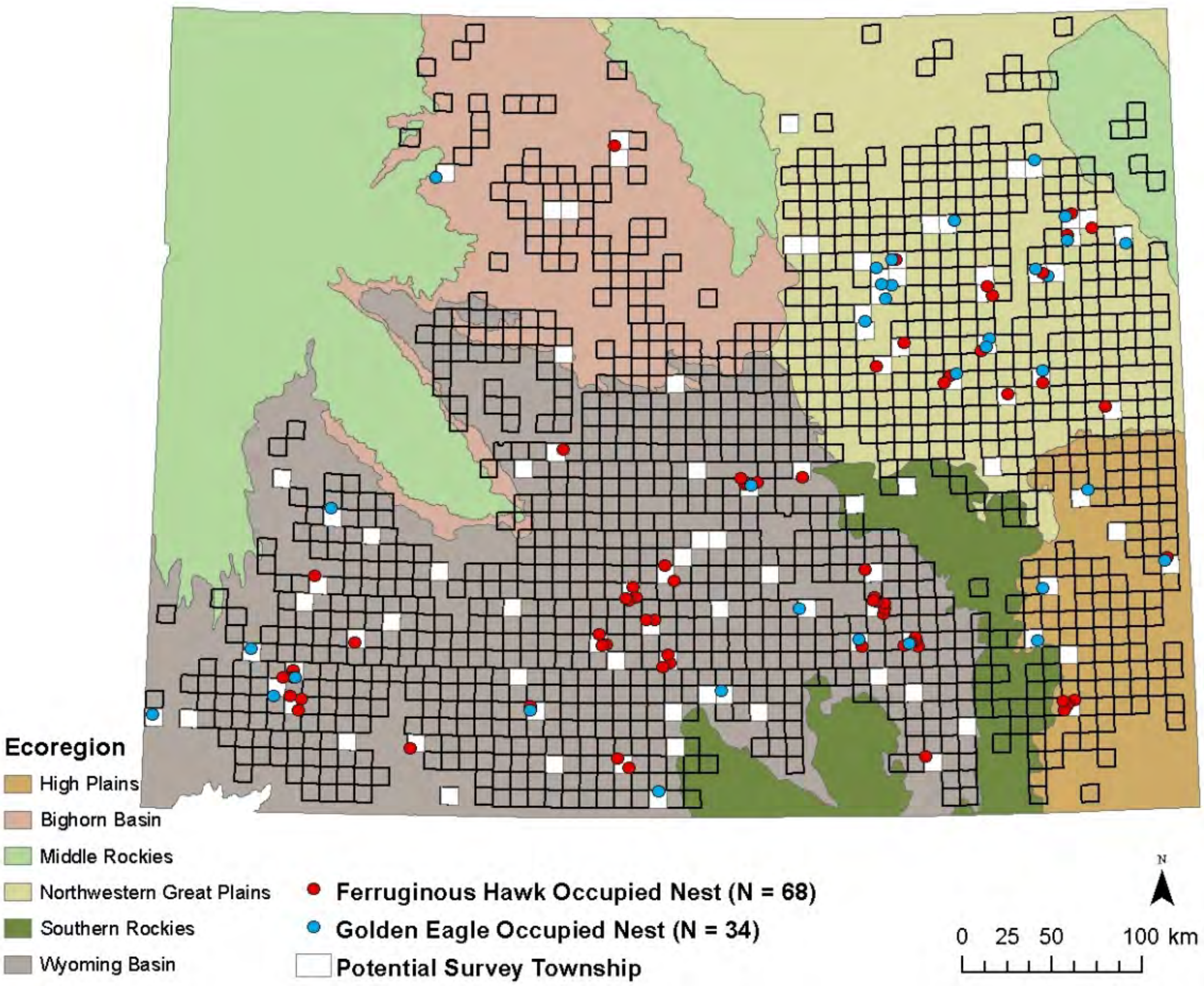

Figure 2. Locations of occupied Ferruginous Hawk (*Buteo regalis*; red dots) and Golden Eagle (*Aquilus chrysaetos*; blue dots) nests detected during transect surveys in Wyoming, 2010-2011. Surveyed townships are shown in white and overlay ecoregions as defined by the USGS (Chapman et al. 2004).

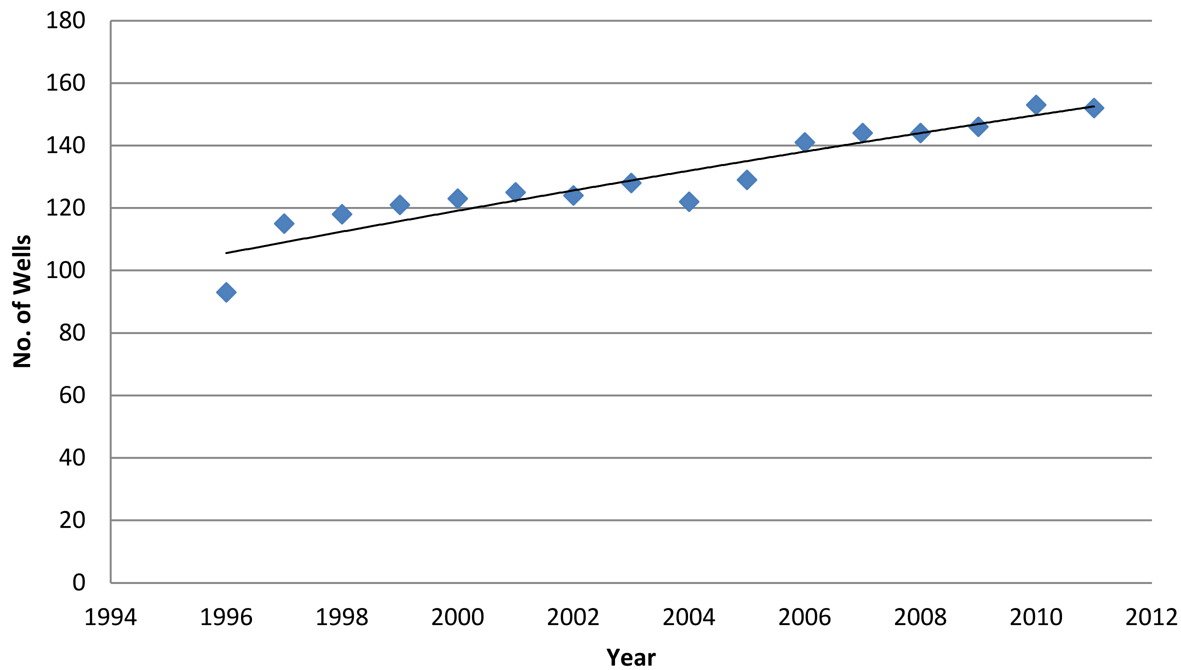

Figure 3. Number of producing wells in sample townships of the Big Horn Basin Ecoregion.

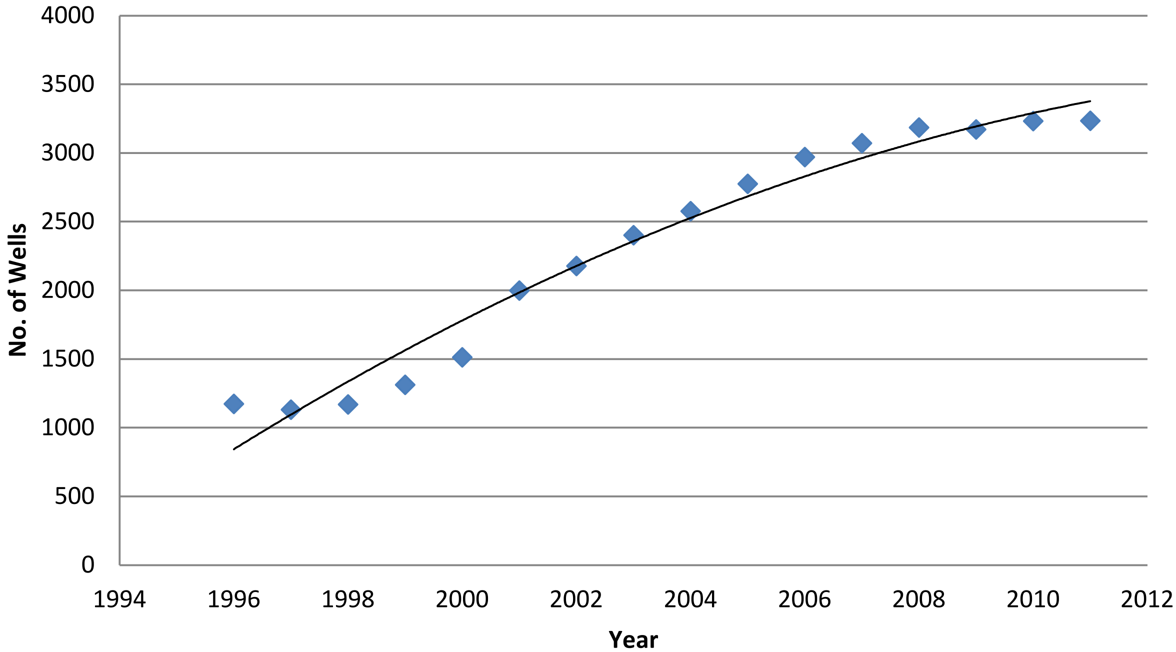

Figure 4. Number of producing wells in sample townships of the NW Great Plains Ecoregion.

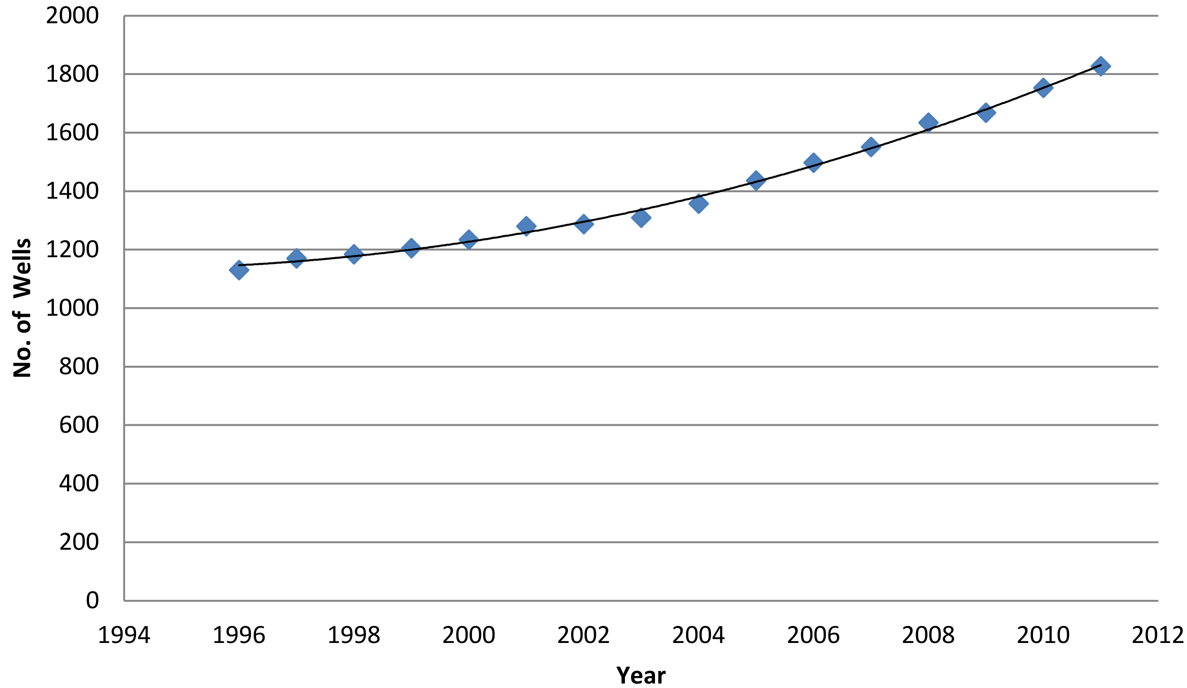

Figure 5. Number of producing wells in sample townships of the Wyoming Basin Ecoregion.

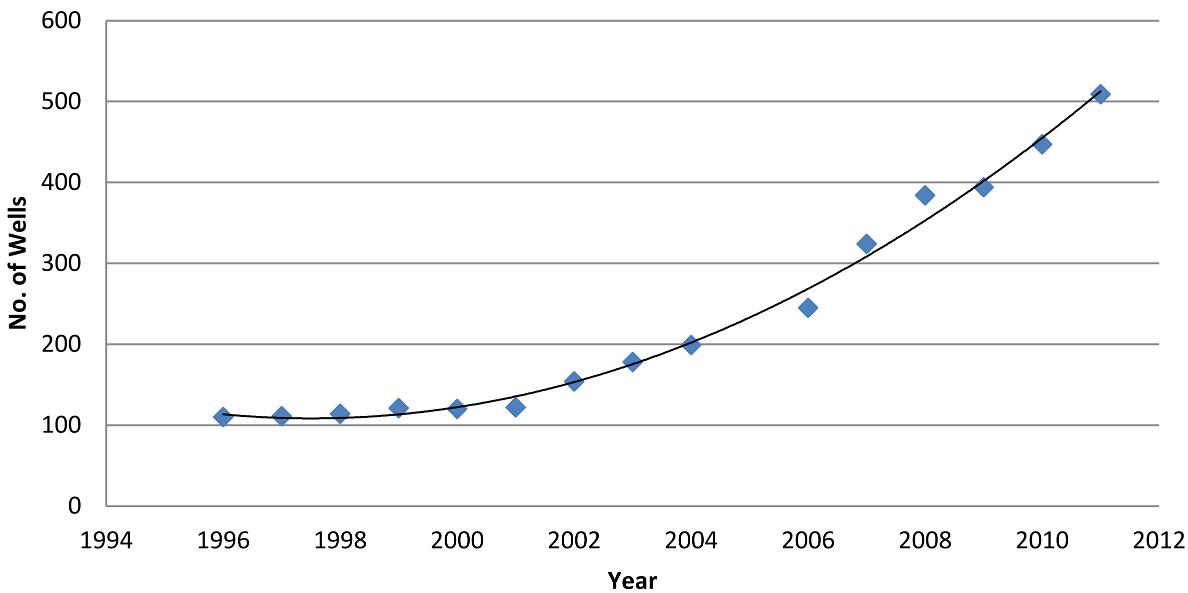

Figure 6. Number of producing wells in the Baggs Study Area.

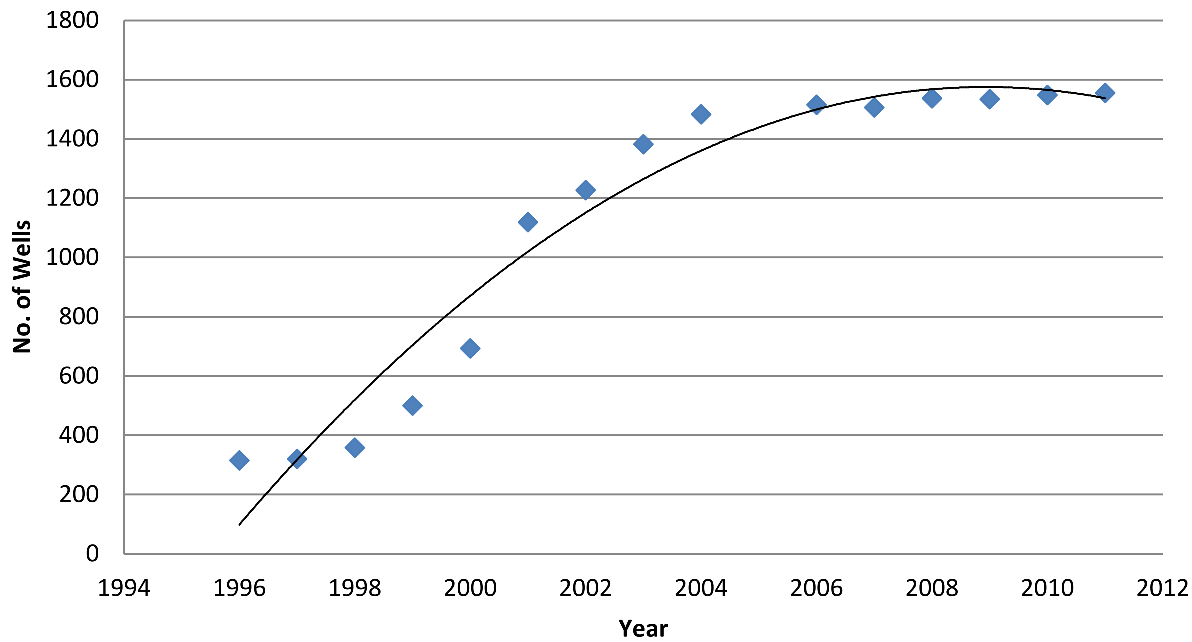

Figure 7. Number of producing wells in sample townships the Powder River Basin Study Area.

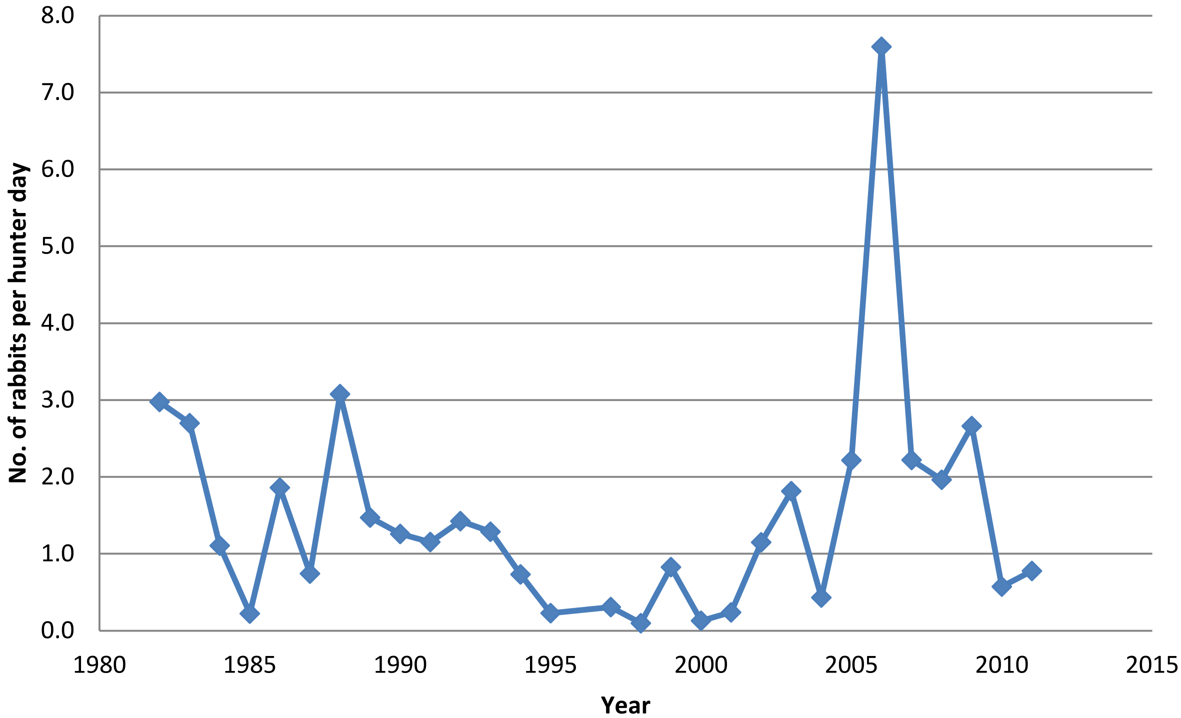

Figure 8. Hunter harvest of cottontail rabbits (*Sylvilagus* spp.) in the Bighorn Basin.

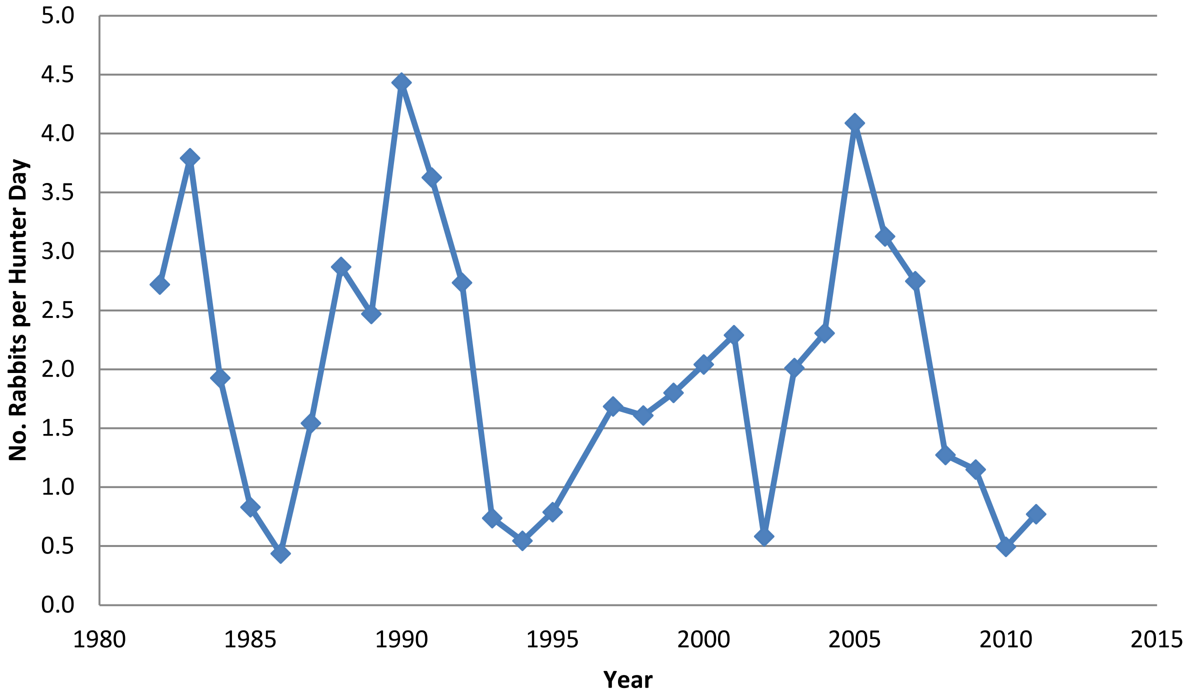

Figure 9. Hunter harvest of cottontail rabbits (*Sylvilagus* spp.) in Mangement Area 3, Northeast Wyoming (NW Great Plains Ecoregion).

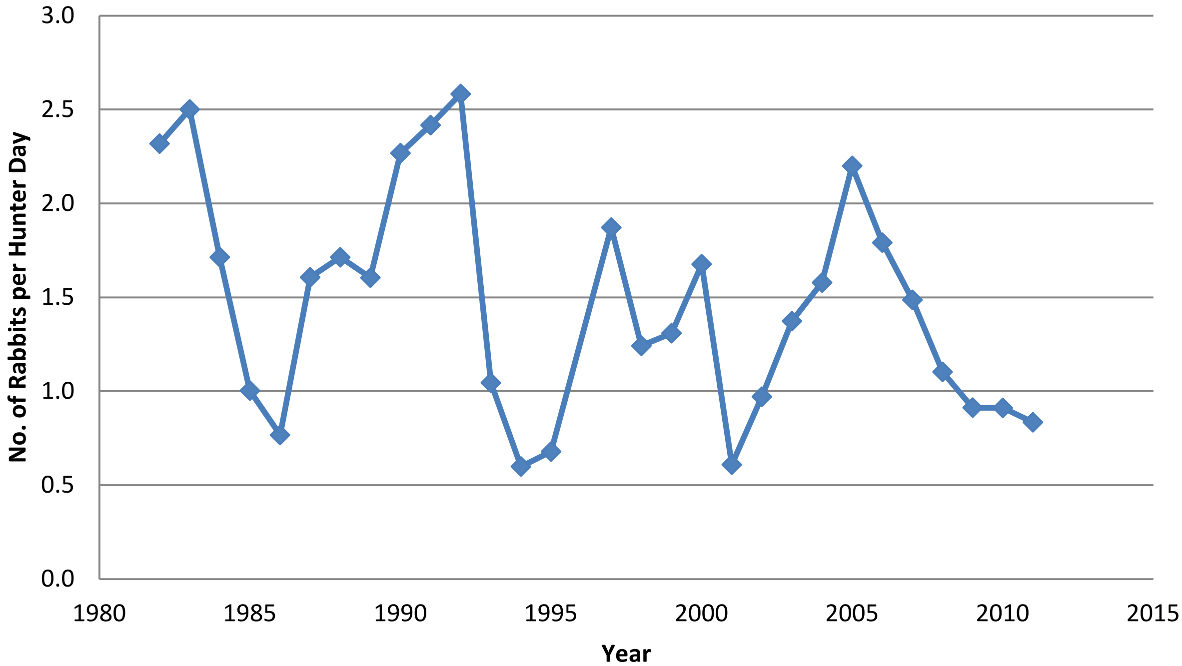

Figure 10. Hunter harvest of cottontail rabbits (*Sylvilagus* spp.) in Management Area 5, southeast Wyoming (High Plains and eastern half of Wyoming Basin Ecoregions).

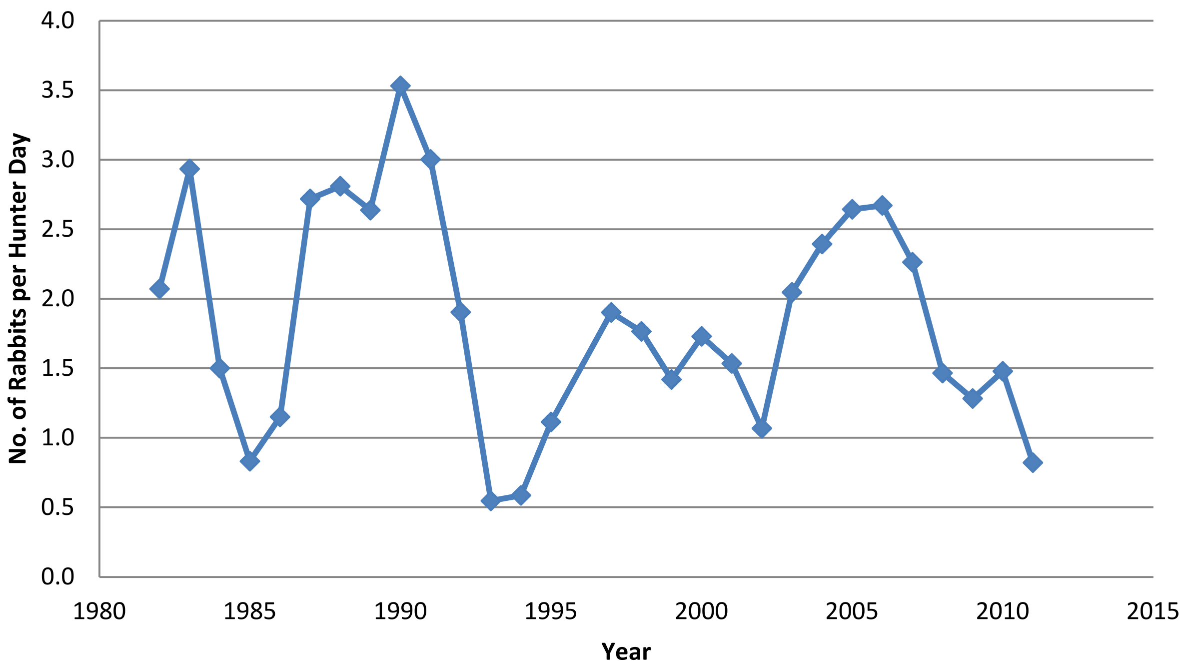

Figure 11. Hunter harvest of cottontail rabbits (*Sylvilagus* spp.) in Management Area 4, southwest Wyoming (Wyoming Basin Ecoregion).

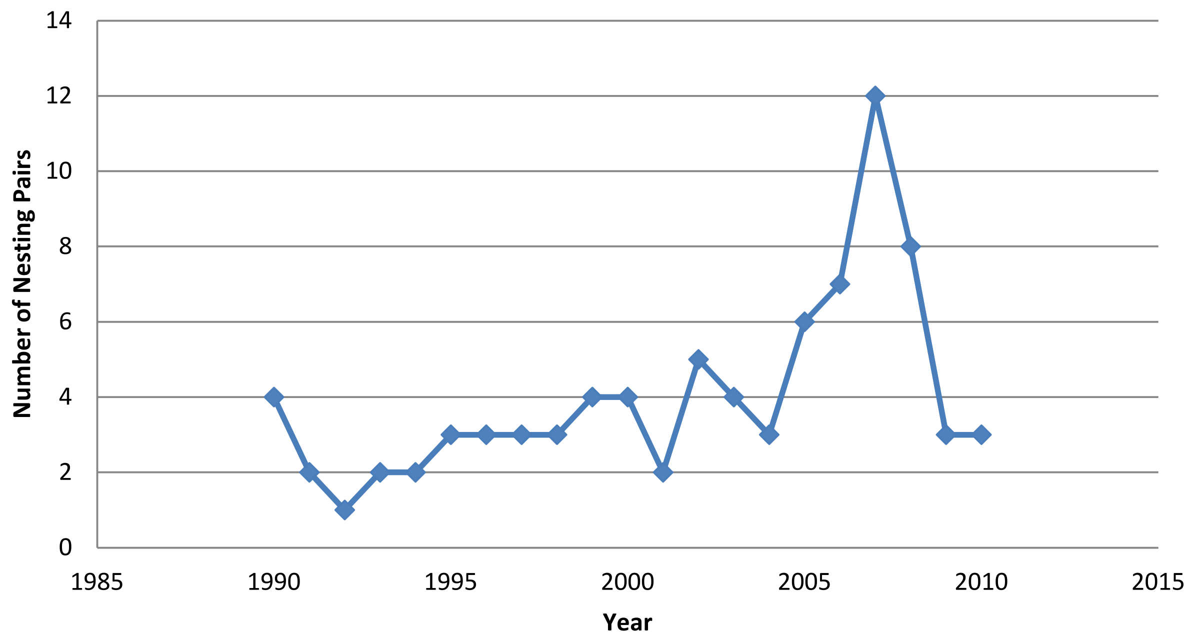

Figure 12. Number of nesting pairs of Ferruginous Hawks (*Buteo regalis)* in the North Antelope Coal Mine Monitoring Area.

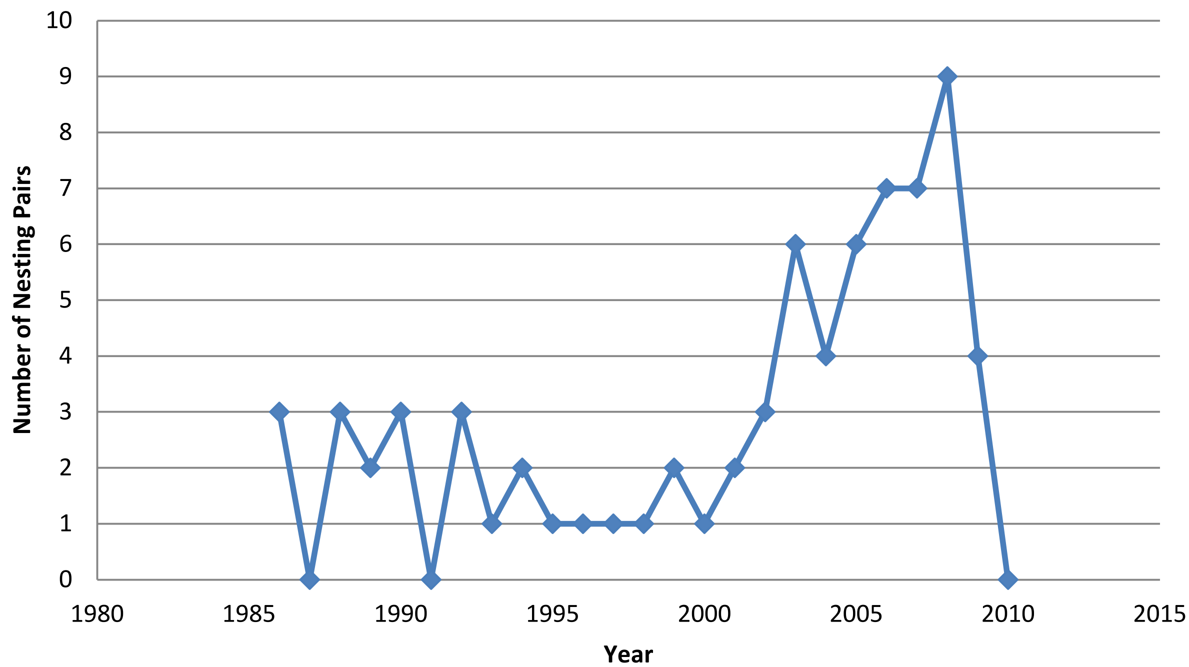

Figure 13. Number of nesting pairs of Ferruginous Hawks (*Buteo regalis)* in the North Rochelle Coal Mine Monitoring Area.

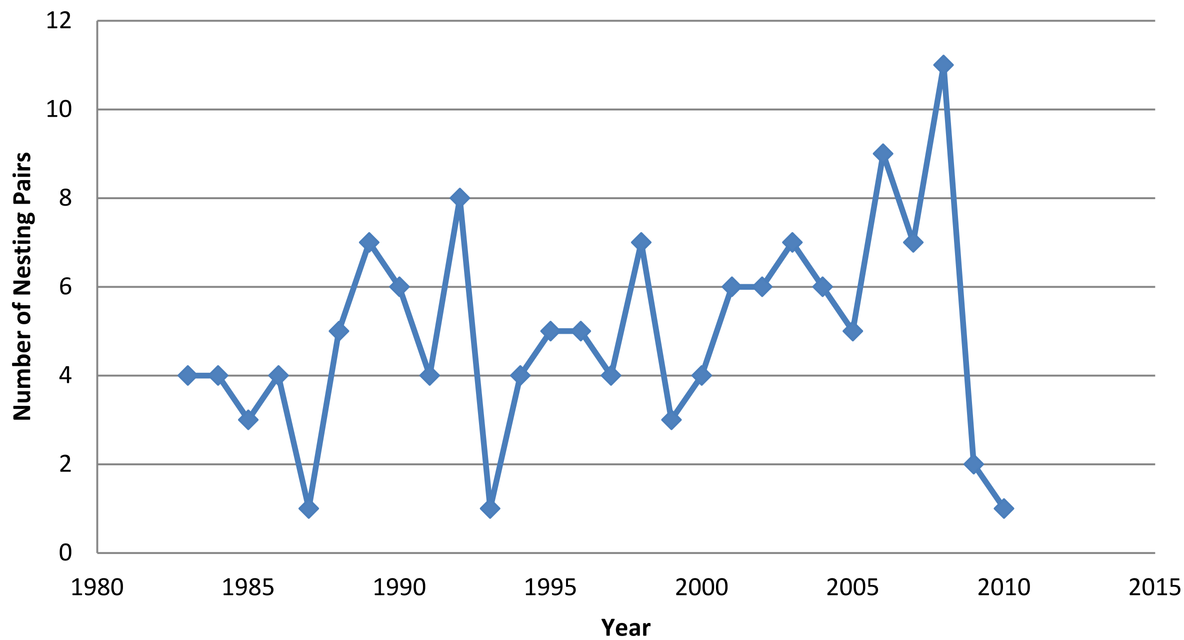

Figure 14. Number of nesting pairs of Ferruginous Hawks (*Buteo regalis)* in the Black Thunder Coal Monitoring Area.

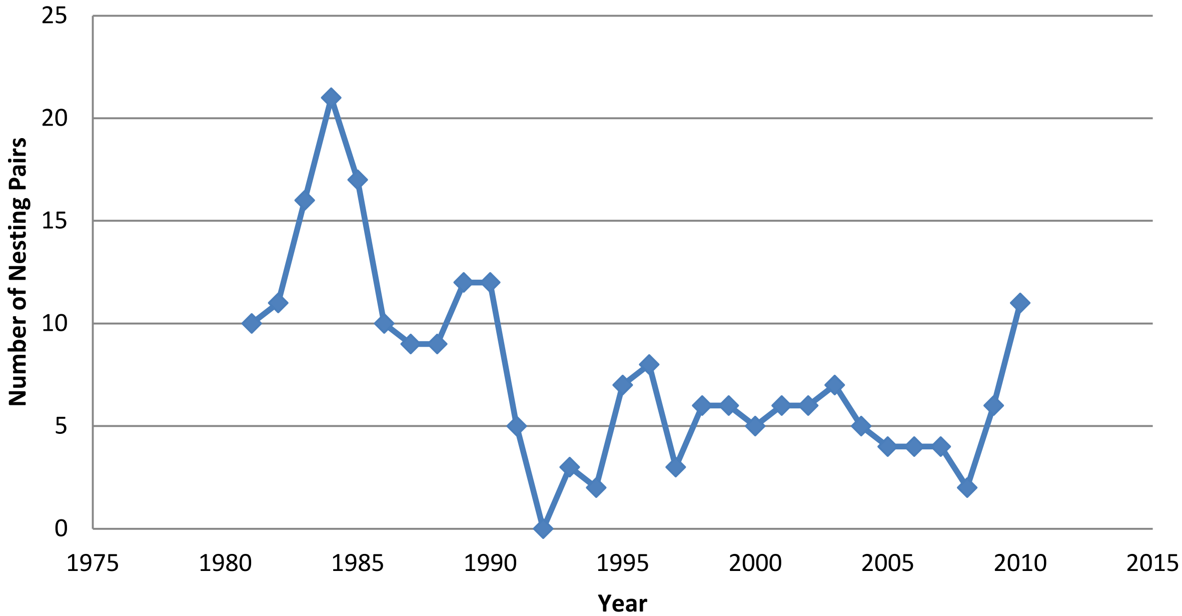

Figure 15. Number of nesting pairs of Ferruginous Hawks (*Buteo regalis)* in the Black Butte Coal Mine Monitoring Area.

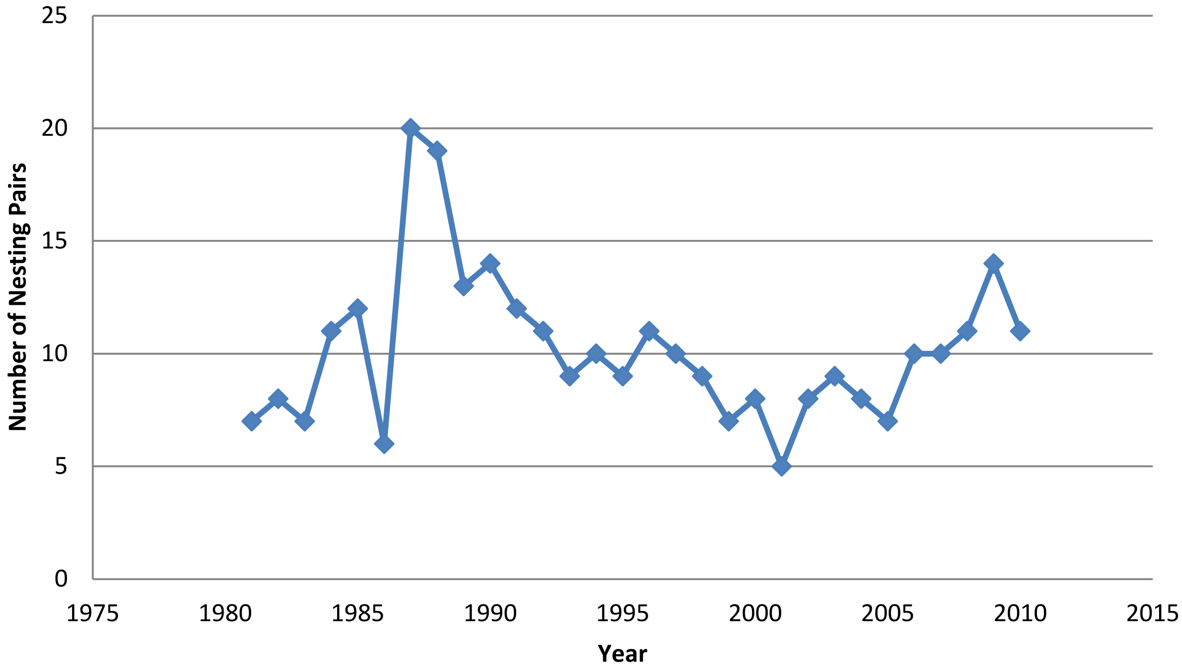

Figure 16. Number of nesting pairs of Ferruginous Hawks (*Buteo regalis)* in the Bridger Coal Mine Monitoring Area.

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

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Peregrine Falcon

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations and United States Fish and Wildlife Service Cooperative Agreement #60181G446

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 30 September 2012

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

ABSTRACT

We continued monitoring of nesting Peregrine Falcons (*Falco peregrinus*; peregrines) in Wyoming since the species was removed from protection under the Federal Endangered Species Act in 1999. In cooperation with the US Fish and Wildlife Service (USFWS), Wyoming participated in the National Monitoring Plan for delisting of the American Peregrine Falcon every 3 years (2003, 2006, 2009, and 2012). We have also monitored nesting performance of peregrines in Wyoming on an annual basis in between these USFWS-sponsored surveys. In 2012, the 15 nesting territories assigned by the USFWS had 14 breeding pairs which fledged 1.1 young per occupied territory. Additional monitoring efforts in 2012 and between years indicated higher productivity, suggesting a sample size issue with only 15 territories that were monitored in Wyoming. The expanded data sets and results are similar to long term averages and remain well above recovery goals, indicating Peregrine Falcons are maintaining stable populations in Wyoming.

INTRODUCTION

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

Peregrine reintroduction and monitoring efforts are detailed in previous Department Nongame Annual Completion Reports and annual reports completed by The Peregrine Fund, Inc. In Wyoming, we released 384 peregrines from 1980-1995, with at least 325 (85%) surviving to dispersal (i.e., 1 month post-release). We have not released peregrines since 1995 because we attained objectives in 1994-1995 and the species was subsequently delisted at the national level in 1999. We do, however, continue monitoring efforts, as populations are relatively limited. In cooperation with the US Fish and Wildlife Service (USFWS), Wyoming also participated in the National Monitoring Plan for delisting of the American Peregrine Falcon every 3 years with supplemental funding from the USFWS (Agreement #60181G446) in 2003, 2006, 2009, and 2012. We have also monitored nesting performance of peregrines in Wyoming on an annual basis in between these USFWS-sponsored surveys. Our objectives in 2012 were to continue annual monitoring at 30 randomly selected nesting sites throughout Wyoming to assess occupancy and productivity.

METHODS

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

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

RESULTS AND DISCUSSION

In 2012, we located four new occupied nesting territories. Three of these cliffs were previously occupied by Prairie Falcons (*Falco mexicanus*) and one was previously occupied by nesting Golden Eagles (*Aquila chrysaetos*). Monitoring of the 15 USFWS selected eyries documented 14 of them as occupied (Table 1). Only seven (50%) were successful and fledged 16 young or 1.1 young per occupied territory. Also in 2012, we surveyed 29 of the 30 randomly selected nesting territories (which included the above data set of the 15 USFWS territories); 23 of these territories were classified as occupied. Occupied territories fledged 37 young, for an average of 1.6 young per occupied territory (Table 2). We also checked an additional 16 nesting territories in 2012, for a statewide total of 45 territories, 38 of which were occupied by breeding adults (Table 3). These 38 pairs fledged 61 young or 1.6 young per occupied territory. When we added survey data from 2012 to cumulative data collected since 1984, we have recorded ≥946 nesting attempts at 93 territories. These attempts have resulted in ≥1,448 young, and a mean of 1.5 young fledged per nesting attempt.

The expanded data sets and results (Tables 2 and 3) are similar to long-term averages and remain well above recovery goals, suggesting Peregrine Falcons are maintaining stable populations in Wyoming. The 15 territories selected by the UFWS (Table 1) appear similar to expanded data sets in 2003 and 2006, but lower in 2009 and 2012. We qualitatively reviewed territory location, longevity, and habitat quality, along with weather patterns. Having only four years and 15 territories of data preclude a quantitative evaluation and suggest sample size issues by focusing on a small sample size in one State. Certainly, a research project could be designed to answer the question as to why these territories produced at lower rates in 2009 and 2012. However, the bottom line will be the National and Regional evaluations that will come from combining data sets from all States.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature though General Fund Appropriations and the US Fish and Wildlife Service through a cooperative assistance agreement, for which the Department is extremely grateful. L. Van Fleet assisted with peregrine surveys during 2012. S. Wolff, A. May, and W. Scherer assisted with surveys in Grand Teton National Park. Peregrine Falcon monitoring in Yellowstone National Park was conducted by L. Baril, J. Dahl, K. Duffie, D. Haines, and A. Metea.

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

Year	No. territories checked	No. territories occupied	No. successful territories (%)	No. young fledged	No. young per occupied territory
2003	15	15	12 (80)	28	1.9
2006	14	14	11 (79)	26	1.9
2009	15	14	7 (54)	14	1.0
2012	15	14	7(50)	16	1.1

Table 2. Number of Peregrine Falcon (*Falco peregrinus*) territories checked, occupied, and successful, and productivity of 30 randomly selected sites in Wyoming, 2005-2011. Percent of successful territories were the number of territories that produced young to fledging divided by the total number of territories checked.

Year	No. territories checked	No. territories occupied	No. successful territories (%)	No. young fledged	No. young per occupied territory
2005	30	30	21 (70)	51	1.7
2006	30	30	22 (73)	49	1.6
2007	30	27	19 (70)	40	1.5
2008	22	22	13 (59)	30	1.4
2009	30	25	15 (60)	36	1.4
2010	28	24	19 (79)	42	1.7
2011	24	21	14 (68)	33	1.6
2012	29	23	15(65)	37	1.6
Mean	27.9	25.3	17.3 (68.0)	39.8	1.6
SD	3.3	3.6	3.6 (7.0)	7.9	0.1

Table 3. Number of Peregrine Falcon (*Falco peregrinus*) territories checked, occupied, and successful, and productivity for all monitored sites in Wyoming, 1998-2011. Percent of successful territories were the number of territories that produced young to fledging divided by the total number of territories checked.

Year	Territories checked (*n*)	Territories occupied (*n*)	Successful territories (%)	Young fledged (*n*)	Young per occupied territory (*n*)
1998	44	44	35 (79)	84	1.9
1999	42	42	25 (59)	57	1.4
2000	46	46	40 (87)	83	1.8
2001	42	42	39 (93)	81	1.9
2002	60	59	49 (83)	97	1.6
2003	58	58	50 (86)	107	1.8
2004	66	65	56 (86)	130	2.0
2005	64	64	45 (70)	99	1.6
2006	61	61	44 (72)	101	1.7
2007	54	51	36 (71)	75	1.5
2008	29	29	19 (65)	45	1.5
2009	46	41	28 (68)	58	1.4
2010	42	36	30 (83)	66	1.8
2011	39	33	26 (79)	50	1.5
2012	45	38	25(66)	61	1.6
Mean	49.2	47.5	36.6 (77.2)	79.6	1.7
SD	10.9	11.8	10.8 (9.8)	24.3	0.20

HABITAT ATTRIBUTES, PERMANENT SURVEY ROUTES, AND SURVEY TECHNIQUES TO MONITOR MOUNTAIN PLOVER (*CHARADRIUS MONTANUS*) POPULATIONS IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need – Mountain Plover

FUNDING SOURCE: Bureau of Land Management Cooperative Agreement #L08AC13184 and Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: 1 May 2012 – 30 June 2012

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Fritz Knopf, Mountain Plover Contract Biologist
Andrea Orabona, Nongame Bird Biologist

ABSTRACT

As part of the Wyoming Partners in Flight monitoring effort and the Wyoming Game and Fish Department Nongame Program's effort to fulfill recommendations for the Mountain Plover as stated in the Wyoming State Wildlife Action Plan (WGFD 2010), we completed project objectives outlined in Request for Proposal number 0260-V. From 21 May-12 June 2012, we visited Mountain Plover (*Charadrius montanus*) breeding sites within the Big Horn Basin, Great Divide Basin, Mexican Flats, Shirley Basin, and Laramie Plains. We also accessed the Foote Creek Rim wind generation area where plovers have nested historically. During these field visits, we discussed on-site criteria for identifying breeding habitats of Mountain Plover and alternative survey methodologies for monitoring annual population numbers at these areas of known breeding concentrations. Based upon the highly dispersed nature of the Mountain Plover population, both locally and statewide, and its overlapping into multiple land-ownership categories, an annual population census would be impossible. Likewise, transect approaches to calculate density estimates would be precluded by the political barrier of driving off-road and would require a major annual time commitment to assure continued access year-to-year. The costs of acquiring density estimates would be significant and would likely assure that the program would be paired back or eliminated after just a few years. Patch occupancy surveys would also be prohibitively costly, in both time and resources, due to the need to mark patches and then visit each patch multiple times to assure which patches are not occupied. We determined that the best approach for statewide monitoring to track Mountain Plover numbers would be a point-transect protocol that is a species-focused variation on the annual Breeding Bird Survey protocol. We offer the rationale for this recommendation and details to be

considered in survey design and execution. Once the survey protocol is finalized, every attempt should be made to resist changes in plot locations and observers.

INTRODUCTION

The Mountain Plover (*Charadrius montanus*; plover) is a species of semi-desert landscapes dominated by short, prostrate shrubs and shrub-like vegetation, such as like sagebrush (*Artemisia* spp.) and cactus (*Opuntia* spp.), with exposed bare ground. Grasses, if present, are shorter bunch grasses. Mountain Plovers often frequent active white-tailed prairie dog (*Cynomys leucurus*) towns, and are actually attracted to herbivores that historically included prairie dogs, bison (*Bison bison*), pronghorn (*Antilocapra americana*), and elk (*Cervus elaphus*). Modern day ecological substitutes include cattle, horses, and, especially, sheep. The herbivore activity stimulates arthropod production while removing grass and forb cover that conceal prey.

In shortgrass prairie locales of more easterly Wyoming, plovers nest where vegetation is sparse or absent—conditions created by drought, fire, or heavy cattle/sheep grazing. Plovers especially favor black-tailed prairie dog (*C. ludovicianus*) towns. Vegetation in shortgrass prairie sites is typically less than 10 cm tall. However, at the actual time of nesting, herbaceous vegetation is often strictly the residual from previous seasons and is often virtually absent due to late season/winter grazing or winter weather. Thus, at the time of nest-site selection, plovers are actually selecting sites without grass cover.

In both xeric shrub and shortgrass prairie landscapes, positive indicators for Mountain Plovers include flat, open terrain; the presence of prairie dogs; bare ground; cactus pads; active livestock grazing (cattle, horses, or sheep); widely spaced plants; and Horned Larks (*Eremophila alpestris*). It would be unusual to find Mountain Plovers on sites characterized by irregular or rolling terrain; dense, matted vegetation; moist soils or sites near water; or sites where either Killdeer (*Charadrius vociferous*) or Lark Buntings (*Calamospiza melnocorys*) are present. Slope at all sites is less than 5%.

Mountain Plovers will also nest in non-native landscapes that have been severely disturbed to the point of having been obliterated. Along these lines, plover nests have been found on bare ground created by oil and gas development activities; dry/low traffic dirt roads and two-track roads; along fence lines and power transmission rights-of-way; on dryland, cultivated agriculture; and sites of heavy-armor military training maneuvers. Plover nesting on agricultural fields that are barren in late April or May has primarily been recorded in Laramie County. However, management of these fields varies from year-to-year and with commodity markets, and makes their availability to plovers unpredictable for inclusion in an annual survey protocol.

Eggs in Mountain Plover nests hatch within a couple of hours of laying, and the precocial chicks leave the nest cup as soon as they are dry. Chicks will often move 1 km or more in the first 48 hrs of life, primarily to distance themselves from the olfactory cues that attract predators to the hatch site. The exception to this rule is that plover chicks that hatch on a black-tailed prairie dog town are often raised on that town.

Brood-rearing habitat for Mountain Plovers includes sites where the vegetation is somewhat taller (but widely scattered). The taller structure could be forbs along two-track roads, scattered bunch grasses up to 40 cm in height, or sage/grass edges where scattered sagebrush shrubs have become established out into the grass. These areas harbor a much richer assemblage of food items for chicks that includes Coleopteran beetles, Hymenopterans, and Arachnids. Open grassy areas are dominated by grasshoppers (Order Orthoptera.), which have often gotten too large for young chicks to handle. Also at this time, plovers either lead or follow their chicks to areas of cattle concentration, such as stock tanks. If the tanks result in moist soil around them, however, plovers tend not to use them and a Killdeer will often be present. The preference for stock tanks is again the presence of a larger invertebrate biomass due to the herbivore activity.

As part of the Wyoming Partners in Flight monitoring effort and the Wyoming Game and Fish Department (Department) Nongame Program's effort to fulfill recommendations for the Mountain Plover as stated in the Wyoming State Wildlife Action Plan (WGFD 2010), we completed project objectives outlined in Request for Proposal number 0260-V. The Mountain Plover is a Species of Greatest Conservation Need due to unknown population status and trends, particularly outside of identified breeding concentration areas; the need for species-specific monitoring due to existing survey and monitoring activities that are not adequate to determine population status and trends; and severe limiting factors (habitat loss and degradation, and disturbance during nesting caused by human activities) that continue to increase in severity.

METHODS

We used the Department's Wildlife Observation System database to map previous plover locations, and contacted the Wyoming Natural Diversity Database and Rawlins Field Office of the US Department of Interior Bureau of Land Management (BLM) to obtain maps of historic Mountain Plover sightings in the targeted survey areas. Once the RFP was granted, we made arrangements for on-site field visits in known Mountain Plover breeding concentration areas and nearby sites with potential plover habitat. The objectives of the site visits were to: 1) view and discuss characteristics of Mountain Plover habitat in known breeding concentration areas, 2) select sites for establishing Mountain Plover survey routes, 3) discuss and determine the best survey methodology to implement for plovers, and 4) use site visit results to develop a long-term population monitoring program for Mountain Plovers in Wyoming. When site visits were completed and test surveys were conducted, we prepared a final report with project findings and recommendations for implementing a long-term Mountain Plover population monitoring program in Wyoming.

RESULTS AND DISCUSSION

Site Visits

On 22 May 2012, we surveyed the Polecat Bench site north of Powell, Wyoming, and the Chapman Bench area north of Cody, Wyoming, both in Park County. We discussed timing of an annual Mountain Plover survey and habitat cues to be used in setting up permanent site locations.

On Polecat Bench, we noted specific sites where plovers had nested in the last 10 years and how those sites varied from the ones just to the north where plovers moved their chicks during the brood-rearing phase. We discussed and recorded specific routes and stops on those routes.

We repeated the above efforts on Chapman Bench. This site was rather different from the former, with habitat patches being more scattered and, unfortunately, not as easily accessed on existing county or two-track roads. We were, however, able to locate an adequate number of sites for survey points, especially if one specific area can be surveyed by driving off-road. That area is currently an open grassland/feathered sagebrush edge on the east side of Wyoming Highway 120 running north from Little Sand Coulee Road.

On 29 May 2012, we toured the Great Divide Basin area south of Jeffrey City, Wyoming in Fremont County. We discussed the overall site and potential route locations, and made some adjustments to consolidate the spatial patterning of the survey and, thus, reduce travel time between points.

On 30 May 2012, we surveyed down the Wamsutter-Dad road southeast of Wamsutter, Wyoming in Sweetwater and Carbon Counties through the extensive oil and gas field being developed therein. We visited sites with historical plover detections as compiled by the BLM Rawlins Field Office. Mapping within this area is relatively worthless for survey design, given the rapid, ongoing road development.

We located some older roads that transected good potential plover habitat northwest of Baggs, Wyoming in Carbon County, and visited historical plover nesting sites in the Mexican Flats area. This area (specifically along Cottonwood Creek along the first few km west from Muddy Creek) held much promise for plovers, and was selected for a survey route.

On 11 June 2012, we visited the Shirley Basin area north of Medicine Bow, Wyoming in Carbon County. We first examined sites where many Mountain Plovers were detected in 2002 on private lands just south of Highway 77. Unfortunately, right-of-way fencing and tame-grass seedings by the Wyoming Department of Transportation precluded using the highway as a survey line. We then progressed to the two-track road along the rim just north of Shirley Basin Reservoir. We had previously scoped this area and concluded it proved ideal for a plover survey route. We then explored areas to the north and west of the rim road and found them unproductive; however we were able to find some good two-track roads running north of and parallel to Highway 77 and south of the Shirley Basin Reservoir that held much promise.

On 12 June 2012, we visited the Foote Creek Rim area north of Arlington, Wyoming in Carbon County. Unfortunately, what had been easy access in the past was convoluted by recent sales of operational functions of the wind energy program at that site, and we were buffeted from entry. Moving from Arlington eastward, we followed the Cooper Cove (S)/Diamond Lake (N) Road exit (No. 279) off Interstate 80. The Diamond Lake Road offered opportunities to put in survey points. As we looped back to Rock River, we progressed back south past Foote Creek Rim operations facilities and were fortunate to make contact that allowed us up on the Rim. We reviewed the Rim layout of roads and where plover nesting has occurred in recent years.

However, due to access issues, we concluded that this site would not be conducive to the plover monitoring program. Moving off the Rim, we traversed back along Cooper Cove Road with no success in finding potential plover habitat, but did locate good habitat in the Highway 130 and Mandel Lane area. We were also impressed with an old railroad right-of-way that traversed the area; however, access opportunities proved to be impossible for a long-term monitoring effort. We discussed combining the Diamond Lake Road and Mandel Lane areas into one route, since there was the ability to place enough count points to adequately survey the Laramie Basin area.

Mountain Plover Survey Techniques

Surveys for Mountain Plovers can be conducted during the period when most plovers are either: 1) tending nests or, 2) raising chicks. Throughout their range, these dates generally occur from May 1st through July 10th. In Wyoming, the best dates for surveying nesting birds are from the last 10 days in May through the first week in June; for birds with chicks, the survey should be conducted from the last 10 days in June through the first week in July. The difference between these survey dates is that the first period would represent a survey of the population trends of breeding plovers; the second period would be a survey of the population trends of plovers that have successfully hatched a clutch of eggs and are raising chicks. Thus, the latter period provides information on the health of the plover population as an index to annual population recruitment.

Mountain Plovers are very 'calm' birds. They tolerate machinery, larger grazers, and vehicles without the slightest concern. The 'flushing' distance from a vehicle (e.g., all-terrain vehicle, pickup truck) is about 1 m from each side of the vehicle as it passes. Thus, line-transect surveys where the observer stays in the vehicle result in very minimal aerial coverage of the landscape. In other words, an observer has to drive many, many kilometers of transects to get adequate detections of plovers to provide a valid index of bird numbers.

Contrarily, Mountain Plovers are extremely wary when it comes to an observer outside or off of a vehicle. If an observer were to walk across the landscape during the nesting phase, many plovers would not be seen in an area of relatively high population density. Plovers leave the nest when an observer is 300-400 m away, and always with the back toward the observer, hunkered low, and disappearing into the landscape. Seen often in winter but only occasionally in summer, foraging plovers (without nests or chicks) will simply sit down to avoid detection when an observer is present (Knopf 1996).

The observer should drive a vehicle between points to be surveyed. These points should be approximately 400 m apart or 200 m from unsuitable habitat. (We based these distances upon the determination that even the most proficient plover observer starts missing birds at >200 m.) The survey need not be continuous, but can be fragmented with points being located in smaller patches of appropriate plover habitat. Plovers will breed in patches of suitable habitat as small as a few hectares that are surrounded by tall, dense shrubs (Knopf 1996).

Upon reaching a point, the observer should walk out 5-6 m and around the vehicle, and then get back inside or on the vehicle. The walking phase will alert plovers to the observer. The plover will stand up and walk a short distance from the nest (late May/early June nesting phase surveys) or it will become agitated if chicks are present (late June/early July brood-rearing surveys). Using binoculars, the observer should search for plovers by scanning in a 360 degree circle around the vehicle for 3 min. The scanning should be done from inside the vehicle during the earlier nesting phase, but may be done from either inside or outside the vehicle during the later brood-rearing phase. The 3-min scanning period per point is designed to be compatible with the Breeding Bird Survey protocol (, and to ensure consistency between observers both within and between survey efforts. Some birds seen during either the earlier or later survey periods may have neither a nest nor chicks. Also, singing birds will only be heard during the earlier survey period when courtship and territory establishment may still be underway.

Weather will interfere with plover detections on cloudy, rainy days during the nesting phase surveys only. Weather will affect both survey periods if it makes roads impassable.

The brood-rearing phase surveys will detect both adult and juvenile plovers. The observer should only record the number of adults seen and indicate the presence of chicks. All chicks will not survive, and information on number of chicks is not interpretable.

Alternate Approaches to Describing Mountain Plover Populations – Census

Quantifying the size of a population has challenged the wildlife professional for a century. Although conducting a complete census (counting every individual) is ideal, such is rarely ecologically possible and economically justifiable. The argument for conducting an actual count is that, rather than acquiring an estimate of the population size, a census provides a 'real' number with total confidence.

Unfortunately the Mountain Plover does not lend itself to a true count at any time in its annual cycle due to its cryptic coloration, observer-avoidance behaviors, widely scattered breeding population, and highly mobile wintering population. The only known situation where a specific population of plovers can be censused would be on black-tailed prairie dog towns in Phillips County, Montana. There, surrounding landscapes are unacceptable to plovers, and the birds are relatively easy to count during the nesting phase on the de-vegetated small towns. We are unaware of any locale or ecological setting in Wyoming that would favor the use of an annual census as a monitoring tool.

Alternate Approaches to Describing Mountain Plover Populations – Density

Population density is, by definition, the number of individuals per unit area. Populations are usually sampled in a portion of the available habitat, and then the calculated density is applied to the larger area of concern to generate an estimated population in that area of interest. Obviously, once a density estimate (with confidence interval) is available, its validity in extrapolation to the larger area to estimate the total population is also dependent upon the precision when defining available habitat within that larger area.

Estimates of population density of birds are mostly generated using transect (line or point) sampling, and yield population density estimates as calculated with program DISTANCE (Buckland et al. 2001). Transect sampling involves recording birds observed along a moving transect or at a series of points along a transect line where the observer stops and scans at a point. The difference between transect surveys and the protocol described for the trend surveys is that the observer records not only the number of birds, but also the distance to each bird where it was first seen. In the case of line transects, the recording is that actual (measured) distance perpendicular to the line. In the case of point surveys, it is the measured distance from the point.

As noted, a moving observer will likely miss most plovers and valid density estimates will require many kilometers of transects to obtain adequate detections (>40 birds) to provide confidence intervals on the estimate. Thus, a line transect should record plover detections from the vehicle, stopping only to record the distance to each bird detected (preferably without leaving the vehicle). This approach has been applied successfully to provide an estimate of plovers in South Park, Colorado, by Wunder et al. (2003).

A point survey, where the observer drives to a specific point, stops, and records distances to birds observed, is preferable for plovers. During a breeding (nesting phase) population survey, the observer needs to exit the vehicle as previously described, and then re-enter the vehicle to conduct the scan. The observer does not need to re-enter the vehicle to conduct the survey during the brood-rearing phase. In addition, a variation on the point survey can include using a second observer during the surveys. The second observer conducts the same survey as the first observer (traveling together), but neither communicates on their observations for each point. Such enables one to replicate a survey and calculate a 'correction' for missed plover detections by the primary observer, and provides an improved precision in the density estimate. This double-observer approach was used to generate the current minimum population estimate for Wyoming by Plumb et al. (2005).

Whereas obtaining density estimates is both more time consuming and costly, such surveys are usually conducted as part of a larger effort within a focused research project. Density estimates are generally time-specific over a 1 to 3-year period and are too costly to be included in a long-term, annual survey protocol. Whereas the major source of error in density calculations comes from observer variability in detecting birds, standardizing surveys by identifying specific points to run the survey and designating the same individual to run the survey each year results in a raw count of birds being perfectly correlated with the calculated density through time.

Alternate Approaches to Describing Mountain Plover Populations – Relative Abundance

Biologists often use some form of comparative population numbers to evaluate habitat quality for a species. Again, such efforts are more common in research projects than in statewide monitoring programs. The comparative abundance of individuals needs to be standardized per unit area and can be done in a number of time- or area-defined approaches. For example, birds per unit time of sampling as compared between hypothetical sites A, B, and C would provide some relative ranking of the quality of those sites as habitats. Likewise, birds per 100-hectare plots at those three sites would also provide a relative valuation among the sites as they provide suitable habitat for the species.

A newer approach to comparing species abundances was recently applied to a real Mountain Plover question by Dreitz et al. (2006). These authors compared the importance of shortgrass prairie, black-tailed prairie dog towns, and agricultural fields to Mountain Plovers in eastern Colorado using a patch-occupancy approach. This approach requires more effort to set up in that patches need to be identified in advance and marked using either existing physical structures or flagging. For plovers, patches should not exceed twice the maximum detection abilities of observers (approximately 400 m) on any side. Each patch is visited multiple (>3) times in a season, with the objective of confirming those patches that definitely do not have plovers.

As pointed out by Dreitz et al. (2006), patch occupancy has much promise but probably only proved cost effective in their study because (besides having research funding) they were working in areas of known-to-be-dense concentrations of plovers. For most of Wyoming, plovers are so widely dispersed as to make this approach cost prohibitive. In addition, the approach allows for the observer to walk the perimeter of the patch, which (as mentioned) greatly reduces the likelihood of detecting plovers during the nesting phase.

The costs of setting up the plots (and assuring standardization among years) plus multiple visits to plots are prohibitive for an annual trend survey of plovers based upon patch-occupancy surveys. This approach has great potential to research inquiries about plover populations and habitats but, unfortunately, is not a good fit for an annual survey that has to be completed in a narrow time window.

Interestingly, patch occupancy is the foundation for quick-clearance of a proposed site disturbance (oil and gas, agricultural, etc.) during the nesting phase of plover biology. A protocol of a few rapid visits to assure plover lack-of-use is precisely what industry is looking for in the real world. Guidelines for site clearances are appended in this report.

Alternate Approaches to Describing Mountain Plover Populations – Trend Survey

The simplest and least expensive approach to monitoring a population is a standardized survey that, over time, provides an index to whether that population is increasing, decreasing, or stable. The most effective approach that has been used for Mountain Plovers is to employ a point-transect methodology as described by Knopf (2008). The approach should definitely include the use of a vehicle, with the observer walking briefly into the habitat at each stop. The advantage of a trend survey over trying for a density estimate is in the time savings in recording distances to individual plovers and in relaxing the number of detections needed to run program DISTANCE. A small survey of (for example) only 40 points that yields 8 plover detections the first year still has value if the survey is repeated multiple years. Using the point-transect protocol also has the advantage over line-transects in that the vehicle does not need to be driven off-road. Off-road driving is ecologically questionable as a standard practice, and can also preclude access to conducting surveys in habitat that laps onto private lands.

Recommendations for Long-term Monitoring of Mountain Plovers in Wyoming

When choosing a time frame (nesting versus brood-rearing phases) for conducting the annual Mountain Plover survey, the later period is strongly encouraged for five reasons: 1) the additional information gained on nesting success; 2) the increased visibility of plovers due to adults with chicks being very active while trying to alert the chicks to the observer's presence and simultaneously preparing to distract the observer as it would a predator; 3) the ability to run more survey points in an allotted amount of time given the increased visibility of the birds; 4) surveys are not weather-dependent, given adult birds' maternal/paternal protective instincts; and 5) surveys can be run all day rather than being restricted to morning or evening hours. This latter point is especially significant in that it enables an observer to run from two to three times as many points during a given day.

From an operational point-of-view, running the surveys in the earlier time frame competes with other responsibilities of a biologist who has to monitor other species during their respective breeding seasons. The down-side of running the annual plover survey in the later time frame, however, is that it becomes susceptible to being aborted in years of competing priorities or funding. Every effort should be made to assure that conservation priority for monitoring the Wyoming Mountain Plover population assures that administrative priority follows.

The objective of Wyoming's annual monitoring program for Mountain Plovers is to provide an index to population numbers through time. Clearly, the most cost effective approach will be a trend survey based upon point-transect protocol that is run annually between 21 June and 7 July 7. This is the same protocol upon which the annual Breeding Bird Survey has been running since 1966, although the survey dates in Wyoming are from 1 June 1 through 7 July. For a plover-specific survey, points should be at least 200 m apart within good potential plover habitat and recorded with Global Positioning System coordinates to standardize annual visits. Again, the points do not have to be located in contiguous habitat, but can be located in disjunctive patches of suitable plover habitat.

Obviously, points located closer together reduce travel time when running the survey and favor scanning more points within the available time frame. The more points in the survey, the greater the habitat coverage.

Given that the points are fixed in location, the greatest potential for introducing variation into the surveys is going to be annual turnover in the observers running each survey. Precision in survey accuracy will be best favored by observer consistency. Reducing observer bias is critical in all forms of population inventory. The Department should easily be able to reduce this source of bias in that surveys will be conducted by permanent FTE personnel (the Nongame Bird Biologist and Regional Wildlife Biologists) among years. Every attempt should be made to minimize personnel turnover once the final plot locations are established.

LITERATURE CITED

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, New York, New York, USA.

Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: an example using Mountain Plovers. Condor 108:700-706.

Knopf, F. L. 1996. Mountain Plover (*Charadrius montanus*). *In* The Birds of North America, Number 211 (A. Poole and F. Gill, Editors). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, D. C., USA.

Knopf, F. L. 2008. Mountain Plover studies: Pawnee National Grassland, 1985-2007. http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/Profiles/Knopf2008PNGPloverStudies.pdf (accessed 28 June 2012).

Plumb, R. E., F. L. Knopf, and S. H. Anderson. 2005. Minimum population size of Mountain Plovers breeding in Wyoming. Wilson Bulletin 117:15-22.

Wunder, M. B., F. L. Knopf, and C. A. Pague. 2003. The high-elevation population of Mountain Plovers in Colorado. Condor 105:654-662.

APPENDIX 1 – MOUNTAIN PLOVER SURVEY GUIDELINES FOR WYOMING

Early guidelines were developed by US Fish and Wildlife Service biologists (USFWS 2002) and Dr. Fritz Knopf, USGS-BRD, and are herein updated and adapted by the Wyoming Game and Fish Department Nongame Program to apply specifically to Wyoming conditions. Contact the Wyoming Game and Fish Department's Nongame Bird Biologist (307-332-2688) with questions or concerns.

INTRODUCTION

The Mountain Plover (*Charadrius montanus*) is a relatively small shorebird [7 inches (17.5 cm)] about the size of a Killdeer (*C. vociferus*). The Mountain Plover has a lighter brown plumage above with a white breast and belly, but lacks the contrasting dark breast-band common to many other plovers. During the breeding season, the Mountain Plover has a white forehead and a dark loral line between the beak and eye, which contrasts with the dark crown.

Across its range, Mountain Plover breeding habitat includes shortgrass prairie and shrub-steppe landscapes; dryland, cultivated farms; prairie dog towns; and sites of local vegetation disturbance. Mountain Plovers usually nest where vegetation is sparse or absent in shortgrass landscapes; conditions created by drought, fire, and herbivores, including domestic livestock and black-tailed prairie dogs (*Cynomys ludovicianus*). Vegetation in shortgrass prairie sites is typically less than 4 inches (10 cm) tall. Slope at all sites is less than 5%. Nest sites within the shrub-steppe landscape are also confined to areas of little to no vegetation, but may be surrounded by areas visually dominated by shrubs. Nest sites within shrub-steppe areas are generally in xeric sites, often with scattered prostrate sagebrush (*Artemisia* spp.), and may also be on active white-tailed prairie dog (*C. leucurus*) towns. In addition to disturbance by prairie dogs or livestock, nests have also been found on bare ground created by oil and gas development activities, and on dryland, cultivated agriculture. Mountain Plovers do not frequent moist soils or sites near water. Positive indicators for Mountain Plovers include flat, open terrain; the presence of prairie dogs; bare ground; cactus (*Opuntia* spp.) pads; livestock grazing (cattle, horses, or, especially, sheep); widely spaced plants; and Horned Larks (*Eremophila alpestris*). It would be unusual to find Mountain Plovers on sites characterized by irregular or rolling terrain; dense, matted vegetation; wet soils; or the presence of Killdeer or Lark Buntings (*Calamospiza melnocorys*).

In Wyoming, the Mountain Plover is an uncommon summer resident, arriving in early April and departing by mid- to late August. In the 2010 State Wildlife Action Plan, the Mountain Plover is classified as a Species of Greatest Conservation Need with an unknown Native Species Status due to population status and trends that are unknown, and the need to implement a species-specific monitoring program to determine this information. The Mountain Plover's range includes Park, Bighorn, Johnson, Campbell, Crook, Sublette, Fremont, Natrona, Converse, Niobrara, Lincoln, Uinta, Sweetwater, Carbon, Albany, Platte, Goshen, and Laramie Counties. Breeding has been confirmed in 17 of the State's 28 latilongs (latitudinal/longitudinal degree blocks), suspected breeding has been documented in 3 latilongs, and observations have been reported in the remaining 8 latilongs. Although plovers are widely dispersed across the State, numbers are not especially abundant at locations where they occur.

GENERAL GUIDELINES FOR SURVEYS

In 1999, the USFWS first proposed listing the Mountain Plover as threatened under the federal Endangered Species Act. Since that time, an inventory of the regional population and analysis of the potential threats to the Mountain Plover have indicated that the species is not in danger of extinction or likely to become endangered within the foreseeable future. However, surveys for Mountain Plovers are recommended to better define nesting and brood-rearing areas, minimize potential negative impacts in areas planned for development, determine occupancy, and monitor population trends. Although these efforts will lessen the chance of direct impacts to, and mortality of, individual Mountain Plovers in a specific area, they do not mitigate indirect effects to plovers, including changes in habitat suitability and habitat loss. Surveys are, however, a necessary starting point. The following survey guidelines were developed to determine plover presence/not detected (possible presence) at specific sites during the nesting season for long-term and short-term projects, or to estimate plover abundance and track population trends over time within breeding concentration areas.

Survey Protocol

Surveys for Mountain Plovers are conducted during the period when most plovers are either: 1) tending nests or, 2) raising chicks. Throughout the plover's geographic breeding range, these dates generally occur from mid-April through July. In Wyoming, the best dates for nesting plovers are from the last 10 days in May through the first week in June, and the best dates for plovers with chicks are from the last 10 days in June through the first week in July. However, seasonal restrictions for ground disturbing activities in suitable Mountain Plover habitats are usually longer than the survey dates. The earlier seasonal restrictions allow for protection of sites during courtship and early nesting. Restrictions are typically not necessary after mid-July since all birds will either be tending the mobile chicks or have left the breeding area. Specific nesting dates across the breeding range of the plover vary according to latitude, elevation, and local weather; thus, the project proponent or land management agency should contact the WGFD to determine what seasonal restrictions apply for specific projects.

Two types of surveys may be conducted: 1) surveys to determine the presence/not detected of breeding plovers (e.g., displaying males or foraging adults), and 2) surveys to estimate plover abundance and population trends. The survey type chosen for a project and the extent of the survey area [i.e., beyond the edge of the construction or operational right-of-way (ROW)] will depend on the type of project activity being analyzed (e.g., construction vs. operation) and the biologist's objective(s).

Techniques Common to Each Survey Method

Conduct surveys during the courtship and nesting phase, or the pre-fledging and brood-rearing phase. In Wyoming, these dates are best from the last 10 days in May through the first week in June for the nesting phase, and from the last 10 days in June through the first week in July for the brood-rearing phase.

- Conduct surveys between local sunrise and 1000 and from 1730 to sunset (periods of horizontal light to facilitate spotting the white breast of adult plovers) during the nesting period. Surveys during the brood-rearing period can be conducted all day, as plovers with chicks are more animated and become easier to detect in this latter period. Keep in mind, however, that the bi-modal approach may still work best for locating plovers due to more conducive lighting and a lack of heat waves during the early morning and evening hours.

- Drive transects within the project area to minimize early flushing. Flushing distances for Mountain Plovers may be within 10 feet (3 m) from vehicles, but plovers on nests often calmly sneak away undetected at distances greater than 650 feet (200 m) when approached by humans on foot. Mountain Plovers cannot be effectively surveyed by a walking observer.

- Use of a vehicle is preferable where allowed. Use of an all-terrain vehicle (ATV) has proven highly successful in observing and recording displaying males. (Always seek guidance from land management agencies regarding use of vehicles on public lands, and always obtain permission of private landowners before entering their lands.)

- During the nesting phase surveys, stop the vehicle, walk out 20 feet (6 m) and around the vehicle, and then get back inside (or on the ATV). The walking phase will alert plovers to the observer and cause them to get off nests (often undetected). Once the observer is back inside the vehicle or on the ATV, plovers will start moving (usually foraging) and will eventually return to their nests. Plovers are not afraid of vehicles (e.g., ATVs, pickup trucks, tractors). Using binoculars, search for plovers by scanning in a 360^{o} circle around the vehicle for 3 minutes, and record those detected.

- Conducting surveys in inclement weather (i.e., high wind, precipitation, etc.) will reduce detection rates—especially from ATVs and during the earlier nesting phase surveys. Such reduced detection is attributed more to the impaired abilities and comfort of biologists to conduct the scanning than to the behavior of the plovers.

- For all birds observed during the nesting phase, conduct additional on-site surveys immediately (<72 hours) prior to construction activities to search for active nest sites.

- If an active nest is located, an appropriate buffer area should be established to prevent direct loss of the nest or indirect impacts from human-related disturbance. The appropriate buffer distance will vary depending on topography, type of activity proposed, and duration of the disturbance. For disturbances including pedestrian foot traffic, a 0.25 mile (0.4 km) buffer is recommended.

- Surveys conducted during the brood-rearing phase will detect both adult and juvenile plovers, as adults with chicks are very active and easily detected, which would indicate successful reproduction. Thus, this is not a breeding population survey, but rather a successfully breeding population survey.

- At each point, stop the vehicle, walk out 20 feet (6 m) and around the vehicle, and then walk back to the vehicle. Plovers with chicks will become agitated during the walking phase. Using binoculars, search for plovers by scanning in a 360^{o} circle around the vehicle for 3 minutes. Scanning may be done from either outside or inside the vehicle.

- Use the standard Mountain Plover data sheet to record the number of adults detected and indicate the presence of chicks. All chicks will not survive, and information on the number of chicks is not interpretable.

SURVEYS TO DETERMINE PRESENCE/NOT DETECTED (POSSIBLE PRESENCE)

Short-term projects

Many projects have minimal impact on Mountain Plover nesting habitat, and these projects may only be present in suitable habitat for a day or less. Therefore, the following guidelines were developed to address concerns from project proponents about delays associated with Mountain Plover surveys for these projects. However, project proponents are encouraged to plan these projects so that all work occurs outside the plover nesting season, approximately August through March.

Short-term projects are defined as projects that are in or move through an area within the course of a few days and result in no permanent habitat vegetation/topographic changes. Short-term projects may include activities such as cattle water tank installation/maintenance, pipeline or fiber optic cable maintenance efforts, and seismic exploration. For these projects, all ROW surveying/staking activities should be completed before April 1 to avoid discouraging plovers from nesting in suitable habitat. If ROW surveying cannot be completed before April 1, surveyors will need to coordinate with the lead wildlife and land management agencies before entering these areas, and a plover survey will be required prior to ROW demarcation if potential habitat is present. For these projects, the presence/not detected guidelines above should adhere to the dates below.

1. Mid April through mid June – a plover survey will need to be completed 1-3 days prior to any activity, including initial brush clearing, to avoid direct take of Mountain Plovers. The survey should include the route and a 0.25 mile (0.4 km) buffer on either side of the project corridor. If there is a break in construction activity in these areas of more than 3 days (e.g., between pipe stringing, trenching, or welding), an additional plover survey is necessary before construction activity can resume after that break in activity. Generally, Mountain Plovers are establishing territories or starting nests in April, and young chicks commonly freeze in place to avoid detection in early/mid-June, which increases their vulnerability to accidental take. After the third week of June, Mountain Plover chicks are sufficiently mobile to reduce the risk of direct take.

2. If an active nest is found in the survey area, the planned activity should be delayed 37 days, or 7 days if small chicks are found.

Larger scale/longer term projects

These surveys are designed to monitor Mountain Plover population trends over time. The counts should be conducted at precisely the same point and, ideally, by the same personnel annually. Every attempt should be made to minimize personnel turnover among years.

1. Conduct surveys between the last 10 days in May through the first week in June.

2. All plovers located should be observed long enough to determine if a nest is present. These observations should be made from within a stationary vehicle, as plovers are not wary of vehicles. Once spotted from a vehicle, a plover that is nesting will likely forage, generally moving laterally back and forth. If it moves directly away from the vehicle (the observer sees mostly the back), the probability of a nest is much reduced. If the plover occasionally 'rocks' the body (often called a 'head bob') then the probability is very high that a nest is in the vicinity. This behavior also exists for about a week after the eggs hatch; at that time the plover will also give a soft vocalization that phonetically sounds like "whirt!". This vocalization is telling the chicks to stay hidden. Once it has been seen, backing the vehicle up about 325 feet (100 m) encourages a plover to go back to the nest/chicks sooner and expedites the survey.

3. Using the UTM coordinates of adult Mountain Plovers detected, plot sightings on a minimum of 1:24,000 scale map and on a ROW diagram or site grid. The ROW diagram should depict the location of breeding birds (and possible nest sites) relative to the ROW centerline, construction boundary, and applicable access roads.

4. Because this survey is used to determine presence/not detected only, and not to calculate density, there is no recommended distance interval for stopping the vehicle to scan for birds. Obviously, numerous stops will be required to conduct a thorough survey, but the number of stops should be determined on a project- and site-specific basis. Within landscapes suitable for plovers, stops should not exceed 0.25 mile (400 m) apart.

5. A site must be surveyed 3 times during the survey window, with each survey preferably separated by 5-7 days. The need for 3 surveys is to capture the entire nesting period, with the intent of reducing the risk of concluding that the site is not plover nesting habitat by a lack of nesting birds during a single survey.

6. Initiation of the project should occur as near to completion of the survey as possible. For example, seismic exploration should begin within 3 days of survey completion.

7. If an active plover nest is found in the survey area, the planned activity should be delayed 37 days, or 7 days post-hatching. If a brood of very small ("bumble bee" looking) chicks is observed, activities should be delayed at least 7 days. If the adult is seen with chicks actively moving, no delay is necessary, as the adult will move the chicks away from any disturbance.

ESTIMATING DENSITY OF MOUNTAIN PLOVERS

Intensive studies, such as those to obtain a regional or statewide population estimate or to evaluate proposed project impacts upon Mountain Plover populations, often benefit from some estimate of the actual number of birds that are occupying a specific area. Whereas obtaining density estimates is both more time consuming and costly, such surveys are usually conducted as part of a larger effort within a focused research project. Density estimates are generally time-specific over a 1-3 year period and are too costly to be included in a long-term, annual survey protocol.

Approaches and procedures to improve precision in population density estimates have been an active area of statistical and mathematical research for over 20 years. Technical volumes have been written, and the refinement of procedures and their abilities to estimate densities will be continuing after publication of these Guidelines.

Population density is, by definition, the number of individuals per unit area. Populations are usually sampled in a portion of the available habitat and then the calculated density is applied to the larger area of concern to generate an estimated population in that area of interest. Obviously, once a density estimate (with confidence interval) is available, its validity in extrapolation to the larger area to estimate the total population is also dependent upon the precision when defining available habitat within that larger area.

There are two general approaches to quantifying density. First, is to conduct a series of surveys that record the distance to each bird detected, and then calculate the effective area surveyed. Second, is to establish a series of plots in the habitat area and determine how many of those plots are occupied. The former are generally referred to as transect (line or point) sampling and yield true population density estimates as calculated using program DISTANCE (Buckland et al. 2001). The second approach does not calculate an actual density, but uses patch-occupancy sampling to provide a relative density ("abundance") comparison between or among study areas. Both have been used in Mountain Plover studies.

TRANSECT SAMPLING FOR DENSITY ESTIMATES

Transect sampling involves recording birds observed along a moving transect or at a series of points along a transect line where the observer stops and scans at a point. The difference between transect surveys and the protocol described for the trend surveys is that the observer records not only the number of birds, but also the distance to each bird where it was first seen. In the case of line transects, the recording is that actual (measured) distance perpendicular to the line. In the case of point surveys, it is the measured distance from the point.

A moving observer will likely miss most plovers and valid density estimates will require many miles of transects to obtain adequate detections (>40 birds) to provide confidence intervals on the estimate. Thus, a line transect should record plover detections from the vehicle, stopping only to record the distance to each bird detected (preferably without leaving the vehicle). This approach has been applied successfully to provide an estimate of plovers in South Park, Colorado (Wunder et al. 2003).

A point survey, where the observer drives to a specific point, stops, and records distances to birds observed, is preferable for plovers. However, the observer needs to exit the vehicle as previously described for surveys, and then return and conduct the scan. In addition, a variation on the point survey can include using a second observer during the surveys. The second observer conducts the same survey as the first observer (traveling together) but neither communicates on their observations for each point. Such enables one to replicate a survey and improve precision in the density estimate. This double-observer approach was used to generate the current minimum population estimate for Wyoming (Plumb et al. 2005).

Establishing Transects

1. Identify appropriate plover habitat within the geographic areas of interest.

2. Upon arriving in appropriate habitat, drive to a previously determined random starting point.
3. For subsequent points, drive a previously determined distance of 0.2-0.5 miles (0.3-0.8 km). Either a 0.25 mile (0.4 km) or 0.5 mile (0.8 km) distance between points is recommended to standardize with the Breeding Bird Survey protocol.

Conducting the Point Counts

1. Conduct counts during the nesting phase (May 22-June 7) to survey the breeding population, or the brood-rearing phase (June 21-July 7) to survey the successful breeding population.

2. Use either 1 or 2 observers as per published examples above.

3. Scan from the vehicle for the breeding population survey, and from either inside/on or close to the vehicle for the successful breeding population survey.

4. Conduct counts for as long as necessary to assure observer that a plover has not been missed within 650 feet (200 m).

5. Measure the distance (in meters) to all Mountain Plovers detected. The method used should be noted (e.g., laser rangefinder, paced, measured with a tape measure).

6. If a Mountain Plover is disturbed while approaching the point, measure the distance from the point center to the spot from which the bird was flushed.

7. Use the standard Mountain Plover data sheet to record information. Record fly-overs as “FO” in the distance column. Weather information will provide little useful insight.

Recording Data

Record the following information on the top of the data sheet:

- Survey route name and unique code (e.g., Shirley Basin = SB)
- Survey date
- Data sheet page number (e.g., page 1 of 2)
- Detailed route location description (e.g., road number, distance to important intersections, County)
- Observer's name, e-mail address, and phone number (or other contact information)

Record the following information at every point on each route:

- Unique point code (e.g., SB1, SB2, SB3)
- UTM coordinates in NAD 83
- Start time
- Number of Mountain Plovers detected, distance in meters to each, and distance aide used
- Mountain Plover juveniles detected
- Habitat and land use information
- Comments and other species of interest detected

PATCH OCCUPANCY SAMPLING TO ESTIMATE RELATIVE ABUNDANCES

The second approach to providing an area-based estimate of plover numbers is to determine the plover use of randomly selected patches of landscape. This approach is also likely too expensive in time and costs to employ as a simple trend survey technique. Rather, it has applications in research contexts where an observer wants to evaluate the comparative value/use of different sites by plovers, and it provides a comparative feel for the magnitude of differences between/among sites as those sites provide habitat for a plover population. The approach has been applied to a real plover question by Dreitz et al. (2006), who compared the importance of shortgrass prairie, prairie dog towns, and agricultural fields to Mountain Plovers in eastern Colorado. As those authors pointed out, patch occupancy has much promise but probably only proved to be cost effective in their study because they were working in areas of known-to-be-dense concentrations of plovers. For most of Wyoming, plovers are so widely dispersed as to make this approach cost prohibitive as a valid survey strategy to monitor trends across time.

Establishing Plots

1. Identify appropriate plover habitat within the geographic area of interest.

2. Predetermine plot boundaries using natural features or by flagging/marking corners of plots. Plots can vary in size, but should not exceed 650 feet (200 m) on any one side, as observers will miss some birds at greater distances.

Conducting the Plot Surveys

1. Surveys can be done from a vehicle or by walking the perimeter of the plot. The observer should not enter the plot. (This option of walking the plot boundaries is generally problematic with plover surveys in that plovers may respond to the observer and move outside the plot before detection.)

2. Plots should be surveyed multiple times, but at least more than 3 times. The purpose of multiple surveys is to confirm which plots do not have plovers.

3. Record standard information on dates, locations, plot numbers, and number of plovers detected. Weather information will provide little useful insight.

4. Reference the Dreitz et al. (2006) study for modeling procedures.

Recording Data

Record the following information on the top of the data sheet:

- Route name and unique code (e.g., Shirley Basin = SB)
- Survey date
- Data sheet page number (e.g., page 1 of 2)
- Detailed route location description (e.g., road number, distance to important intersections, County)
- Observer's name, e-mail address, and phone number (or other contact information)

Record the following information at every point on each route:

- Unique point code (e.g., SB1, SB2, SB3)
- UTM coordinates in NAD 83
- Start time
- Number of Mountain Plovers detected
- Comments and other species of interest detected

LITERATURE CITED

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, New York, New York, USA.

Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: an example using Mountain Plovers. Condor 108:700-706.

Plumb, R. E., F. L. Knopf, and S. H. Anderson. 2005. Minimum population size of Mountain Plovers breeding in Wyoming. Wilson Bulletin 117:15-22.

United States Fish and Wildlife Service [USFWS]. 2002. Mountain Plover Survey Guidelines, March 2002. Unpublished report.

Wunder, M. B., F. L. Knopf, and C. A. Pague. 2003. The high-elevation population of Mountain Plovers in Colorado. Condor 105:654-662.

MOUNTAIN PLOVER SURVEY DATA SHEET

Survey Route Name and Code:________________ **Survey Date:**____________ **Page**____**of**____

Route Location Description:________________________

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

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

Habitat/Land Use: BG=bunchgrass, SG=shortgrass, SS=scattered shrubs, ST=shrub stringer, OS=*Opuntia spp.*, PD=prairie dogs, BA=bare ground, FA=fallow ground, PF=plowed field, BR=on bench/rim, TA=stock tank, OT=other.
Distance Aide: 1=laser rangefinder, 2=paced, 3=tape measure, 4=estimated.

Notes:________________________

WGFD WOS Database:______

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

STATE OF WYOMING

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

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

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

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

ABSTRACT

Long-billed Curlew (*Numenius americanus*) populations declined in Wyoming in the late 19th and early 20th centuries due to uncontrolled hunting, habitat conversion, and pesticides, all of which have contributed to their classification as a Species of Greatest Conservation Need by the Wyoming Game and Fish Department. To monitor curlew populations, the Wyoming Game and Fish Department initiated annual roadside surveys in 1991 in western Wyoming during the breeding season. In 2012, we detected 61 unique individuals on 4 pre-determined survey routes in addition to 9 individuals recorded by Breeding Bird Survey participants on 4 separate routes. In general, curlew numbers have remained relatively stable among survey years, particularly from the mid- to late 1990s until the present, although the relatively poor fit of trendlines and high variability among years suggests these results should be interpreted cautiously. We are currently revising protocols that would include measures of detection probability in order to increase precision of trend estimates, estimate abundance, and allow for inclusion of site and survey specific variables that may be influencing trends of curlews.

INTRODUCTION

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

Our objective for surveys of curlews in 2012 was to continue to accumulate annual count data for curlews along four of the five established survey routes in western Wyoming where breeding populations are known to occur (the National Elk Refuge route was not conducted in 2012 due to the initiation of an irrigation project on the refuge). We then added these data to data collected since 1991 to further evaluate trends over time and investigate any changes in curlew populations.

METHODS

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

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

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

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

RESULTS

We surveyed all four of the Long-billed Curlew routes conducted in 2012 twice during the breeding season (Table 1). All curlew survey data (number of curlews seen, heard, as well as comments made during each survey) are located in the Nongame Bird Biologist's files at the Department's Lander Regional Office.

Slight declines in the number of curlews detected occurred on three of the four routes. Horse Creek demonstrated a decline of 0.43 individual curlews per km per 3-year interval (R^2=0.60; Fig. 1), Chapman Bench showed a decline of 0.17 individuals per km per 3-year interval (R^2=0.28; Fig. 2), and GTNP Hayfields had a decline of 0.04 individuals per km per 3-year interval (R^2=0.17; Fig. 3). New Fork curlew populations appear to be stable, with a slight increase of 0.06 individuals per km per 3-year interval (R^2=0.02; Fig. 4).

Participants detected curlews on 27 BBS routes since initiation of the BBS in Wyoming in 1968. Observers surveyed 15 (55.6%) of these routes in 2011 and detected 9 curlews on 4 routes. Of the remaining 12 routes, an observer is needed on 7 routes (25.9%), 4 routes (14.8%) are assigned but were not conducted, and 1 route (3.7%) has been discontinued due to dangerous and noisy conditions. Counts in previous years have fluctuated from a low of 1 curlew detected on 1 of 15 routes surveyed in 1998 to a high of 19 curlews detected on 8 of 16 routes surveyed in 1999. Overall, BBS routes have shown a slight increase of 0.02 individuals per route per year (R^2=0.12; Fig. 5) since 1991.

DISCUSSION

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

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

Although the trendline fit well for the Horse Creek route, with year explaining 60.5% of the variation in curlew numbers, the trendline did not fit the other survey routes as well. The New Fork and Chapman Bench routes in particular appear to be heavily influenced by 1 or 2 years of data. We recorded 10.6 individuals per km in 1997 on the New Fork route, which greatly increased our estimate as well as our variance for 1997-1999. Removing this point increases both our trend estimate and precision to an increase of 0.15 individuals per km per year ($R^2 = 0.28$). Chapman Bench is more problematic, with 3.6 and 1.9 individuals detected per km in 1992 and 1993, respectively (Fig. 2). These numbers are significantly higher than any surveys since. Removing these two years changes the direction of our trend estimate from a decreasing population to slight increases of 0.02 individuals per km per year ($R^2 = 0.20$). This drastic drop in detections between 1993 and 1994 along the Chapman Bench route may indicate a decrease in availability or suitability of nesting habitat, but the subsequent increases in curlew detections may be promising, although the low R^2 value still suggests this trend should be interpreted with caution.

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

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would like to acknowledge the following Wyoming Game and Fish Department personnel for their valuable contributions to the 2012 curlew monitoring effort: D. Brimeyer, D. Clause, J. Randall, and D. McWhirter.

LITERATURE CITED

Cochrane, J. F. 1983. Long-billed Curlew habitat and land-use relationships in western Wyoming. Thesis. University of Wyoming, Laramie, USA.

Cochrane, J. F., and S. H. Anderson. 1987. Comparison of habitat attributes at sites of stable and declining Long-billed Curlew populations. Great Basin Naturalist 47:459-466.

Cochrane, J. F., and B. Oakleaf. 1982. Long-billed Curlew survey evaluations with notes on distribution, abundance, and habitat use in Wyoming. Wyoming Game and Fish Department Special Projects Report, Cheyenne, USA.

Fellows, S. D., and S. L. Jones. 2009. Status assessment and conservation action plan for the Long-billed Curlew (*Numenius americanus*). United States Department of Interior, Fish and Wildlife Service, Biological Technical Publication, FWS/BTP-R6012-2009, Washington, D.C., USA.

Jones, S. L., T. R. Stanley, S. K. Skagen, and R. L. Redmond. 2003. Long-billed Curlew (*Numenius americanus*) rangewide survey and monitoring guidelines. United States Fish and Wildlife Service, Washington, D.C., USA.

Nicholoff, S. H. 2003. Wyoming bird conservation plan. Version 2.0. Wyoming Partners in Flight. Wyoming Game and Fish Department, Lander, USA.

Pampush, G. J., and R. G. Anthony. 1993. Nest success, habitat utilization and nest-site selection of Long-billed Curlews in the Columbia Basin, Oregon. The Condor 95:957-967.

Robbins, C. S., and W. T. VanVelzen. 1967. The breeding bird survey, 1966. United States Department of Interior Bureau of Sport Fisheries and Wildlife Special Scientific Report on Wildlife 102.

Stanley, T. R., and S. K. Skagen. 2007. Estimating the breeding population of Long-billed Curlews in the Unites States. Journal of Wildlife Management 71:2556-2564.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Survey information from four routes surveyed for Long-billed Curlews (*Numenius americanus*) in western Wyoming, 2012, including route name, length, number of stops, survey dates, and total number of curlews (LBCU) detected along each route. GTNP represents Grand Teton National Park. The National Elk Refuge route was not conducted in 2012.

Route	Length (km)	Survey stops (*n*)	First survey		Second survey	
			Date	LBCU detected (*n*)	Date	LBCU detected (*n*)
Horse Creek	12.8	17	7 May	34	16 May	28
New Fork	6.4	9	7 May	18	14 May	18
Chapman Bench	12.8	17	13 May	3	17 May	7
GTNP Hayfields	15.2	20	29 May	0	30 May	2

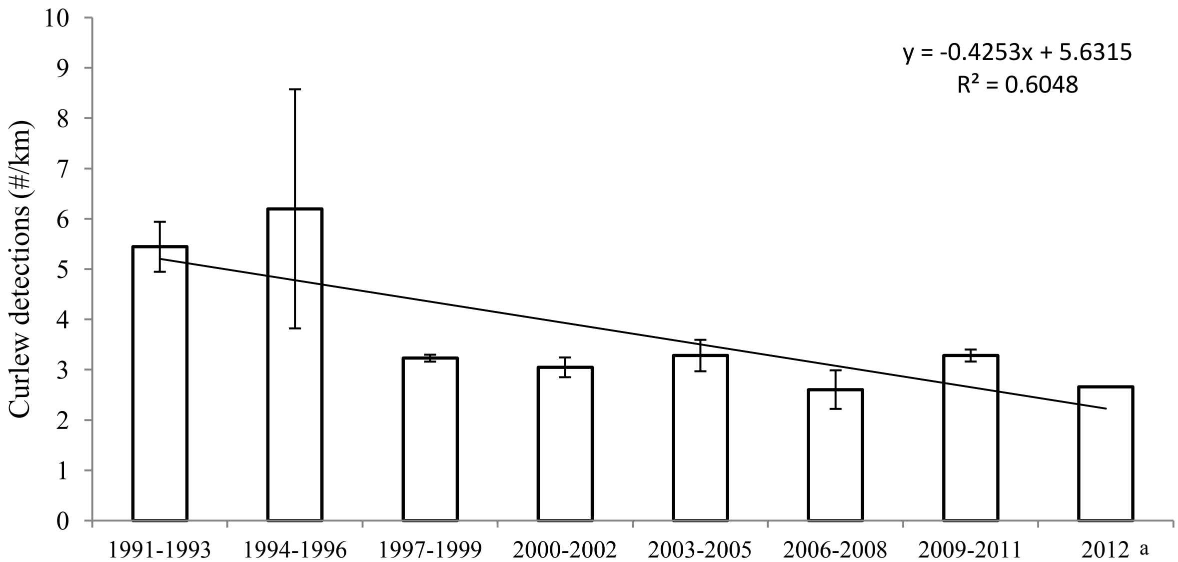

Figure 1. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Horse Creek survey route (12.8 km) in western Wyoming, 1991-2012. [a] Indicates data from a single year. The trendline is shown for reference.

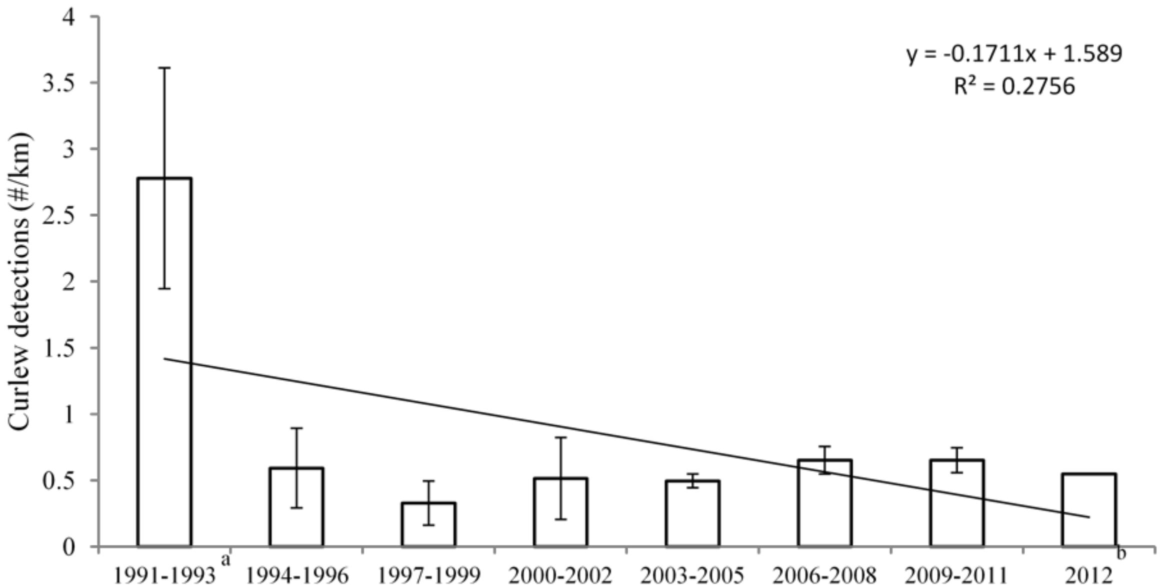

Figure 2. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Chapman Bench survey route (12.8 km) in western Wyoming, 1991-2012. [a] Indicates an average over only 2 years. [b] Indicates data from a single year. The trendline is shown for reference.

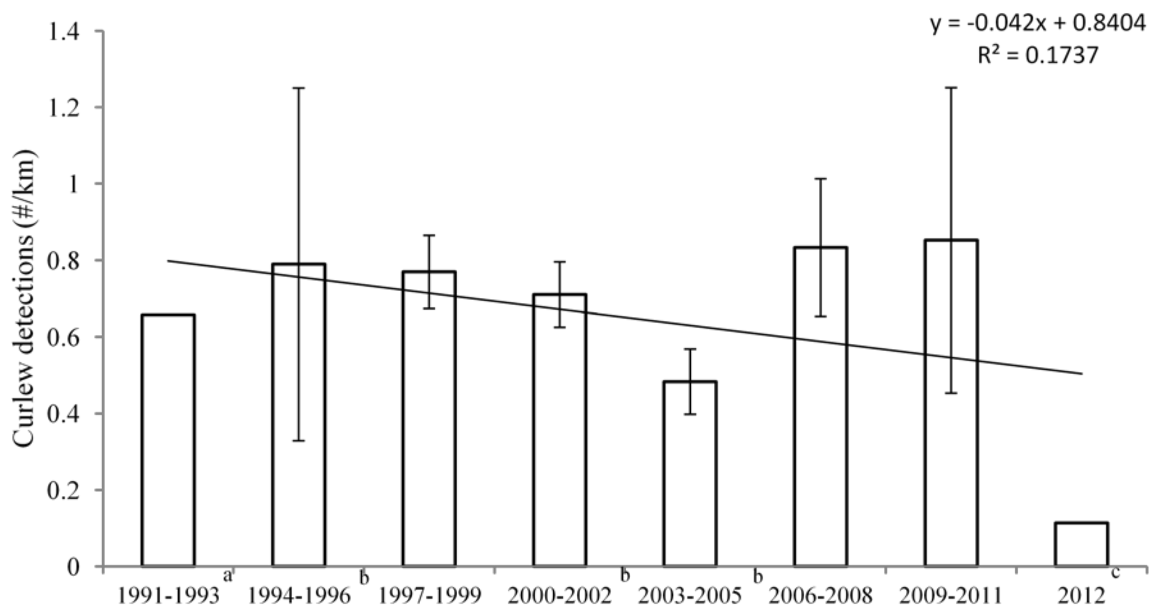

Figure 3. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the Grand Teton National Park (GTNP) Hayfields survey route (15.2 km) in western Wyoming, 1991-2012. [a] Indicates only one survey in the 3-year span. [b] Indicates an average over only 2 years. [c] Indicates data from a single year. The trendline is shown for reference.

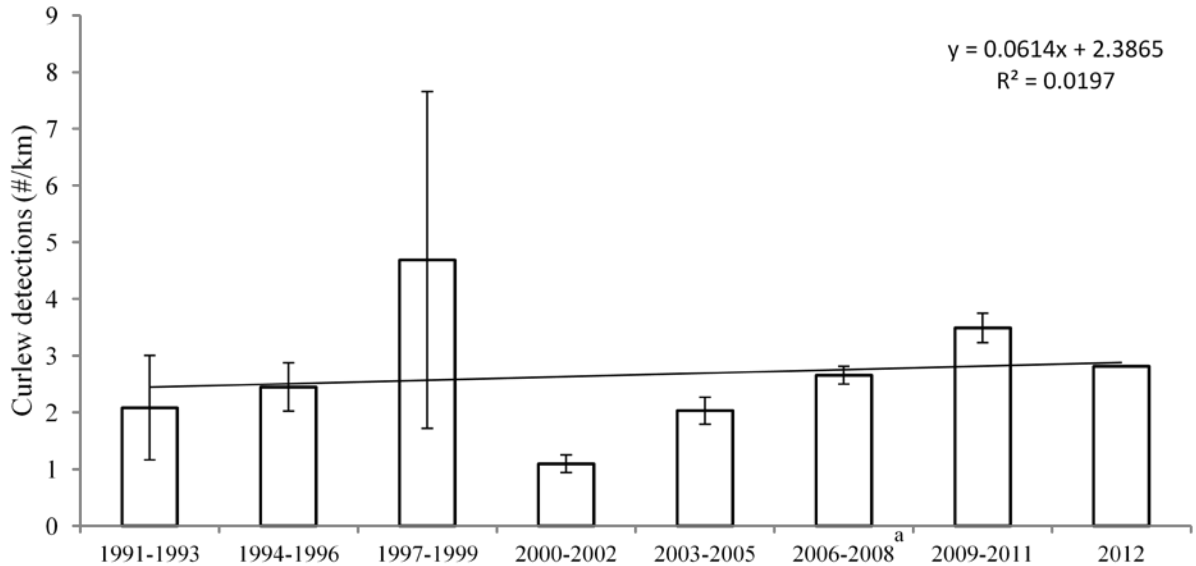

Figure 4. Three-year average (±SE) of number of Long-billed Curlews (*Numenius americanus*) detected per km along the New Fork survey route (6.4 km) in western Wyoming, 1991-2012. [a] Indicates an average over only 2 years. [b] Indicates data from a single year. The trendline is shown for reference.

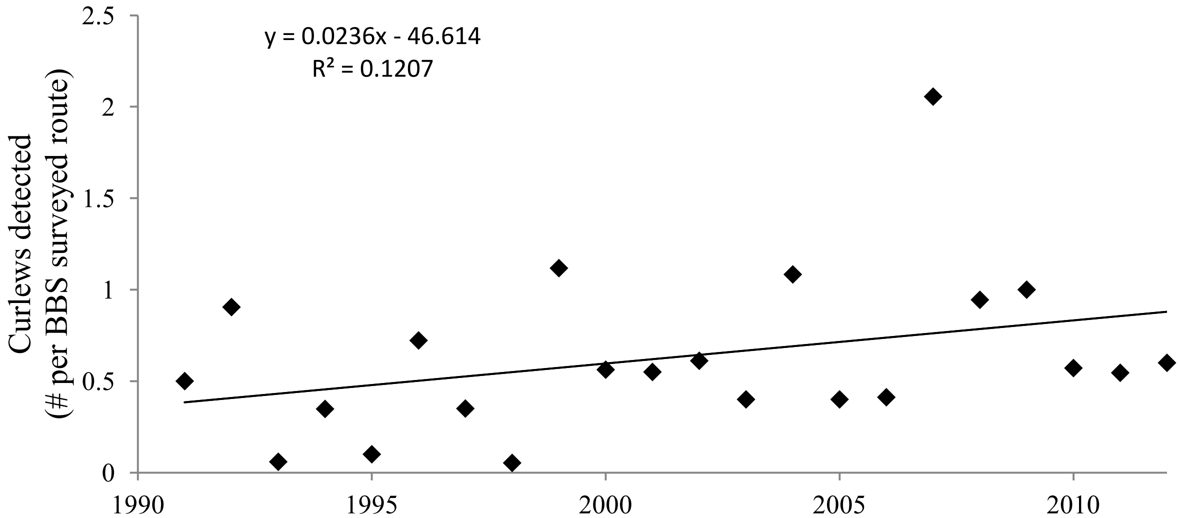

Figure 5. Average number of Long-billed Curlews (*Numenius americanus*) detected per Breeding Bird Survey (BBS) route in Wyoming, 1991-2012. Only routes that have resulted in a curlew detection since surveys were initiated in Wyoming in 1968 were included. The trendline is shown for reference.

MECHANISTIC STUDY OF ENERGY DEVELOPMENT IMPACTS TO SONGBIRDS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need / Sagebrush Obligate Songbirds – Brewer's Sparrow, Sage Sparrow, Sage Thrasher

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations and Wyoming Game and Fish Department

PERIOD COVERED: 1 September 2011 – 31 August 2012

PREPARED BY: Matthew G. Hethcoat, Wyoming Cooperative Fish and Wildlife Research Unit
Anna D. Chalfoun, Wyoming Cooperative Fish and Wildlife Research Unit

SUMMARY

This period, we met with colleagues and collaborators to incorporate comments and suggestions into the 2012 methods. We presented our preliminary results and obtained valuable feedback via oral presentations at the 2011 Wyoming Chapter meeting of The Wildlife Society and 2012 Wyoming Landscape Conservation Initiative Science Workshop. In addition, we purchased and assembled necessary field equipment and hired field technicians who assisted with the data collection for the second of two field seasons.

The 2012 field season began 30 April and was completed on 10 August. We monitored over 400 nests, 381 of which belonged to our focal species [234 Brewer's Sparrow (*Spizella breweri*), 61 Sage Sparrow (*Artemisiospiza belli*), and 86 Sage Thrasher (*Oreoscoptes montanus*)]. We deployed 83 nest cameras during the 2012 field season. The majority of confirmed nest predators (~70%) were members of *Rodentia*, although other mammalian and avian predators were confirmed. We conducted nearly 400 avian predator point count surveys, 80 diurnal predator surveys, and maintained 150 scent stations for meso-predators. Habitat metrics were measured at nest sites and at a paired random site within each territory in order to address questions relating to nest site selection preferences. In the coming months we will present our preliminary analyses in a poster presentation at the 2012 international meeting of the North American Ornithological Conference in Vancouver, British Columbia and the 2012 national meeting of The Wildlife Society in Portland, Oregon.

SPECIES OF GREATEST CONSERVATION NEED – *MAMMALS*

INVENTORY OF BATS IN CLIFFS AND CANYONS OF WESTERN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

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

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Becky Abel, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Eighteen species of bats occur in Wyoming and 11 of those species are recognized as Species of Greatest Conservation Need by the Wyoming Game and Fish Department. We now have a greater understanding of the distribution and diversity of forest-dwelling bats in Wyoming since the Department completed the forest bat inventory during 2008-2011. However, still lacking are observations of bats that are associated with arid habitats with barren features such as cliffs, canyons, caves, and rock outcrops (cliffs and canyons). In 2012, we conducted an inventory of bats that are associated with cliffs and canyons of western Wyoming. We used mist nets and acoustic detectors to document distribution, relative abundance, reproductive status, and diversity of bat species. We captured 346 individuals, representing 10 resident species, at 26 grids we surveyed. Males and females were represented equally among captures, while 11% of captures were juvenile bats. The most common species captured in mist nets were the little brown myotis (*Myotis lucifugus*), western small-footed myotis (*M. ciliolabrum*), silver-haired bat (*Lasionycteris noctivagans*), and long-legged myotis (*M. volans*). We recorded 40,062 files that contained bat call sequences, including 5,605 call sequences of good quality. Call sequences that were classified represented 11 resident species and 1 peripheral species at 30 grids we surveyed. The most common species we detected during acoustic surveys differed from capture surveys with the western small-footed myotis, big brown bat (*Eptesicus fuscus*), little brown myotis, silver-haired bat, and long-eared myotis (*M. evotis*) being most common. We notably also observed Townsend's big-eared bat (*Corynorhinus townsendii*), pallid bat (*Antrozous pallidus*), spotted bat (*Euderma maculatum*), and Yuma myotis (*M. yumanensis*). Improving our understanding of distribution and abundance of bats associated with cliffs and canyons of Wyoming is essential for conservation planning, species status review, facilitating management responses to white-nose syndrome in Wyoming, and minimizing potential impacts to bats from large-scale habitat changes.

INTRODUCTION

Bats (Order: Chiroptera) comprise nearly 20% of mammalian species worldwide. Indeed, there are an estimated 1,232 species of bats occupying a variety of ecological niches (Kunz et al. 2011). There are at least 45 species of bats that occur in North America, and 18 insectivorous species have been documented in Wyoming (O'Shea and Bogan 2003, Hester and Grenier 2005). Survival of bats depends in large part on the availability of suitable roosting sites and adequate foraging sites. In the US, 21 species of bats either exclusively or opportunistically roost in caves and mines at least part of the year, while other species roost in forests (Kunz and Lumsden 2003, Barclay and Kurta 2007, Brigham 2007). In Wyoming, features such as cliffs, caves, canyons, and rock outcrops provide important roosting habitat for at least 13 species (BCI 2011).

Declines in many bat populations at both continental and local levels have led to concern about the future of migratory and resident bats in Wyoming (Ellison et al. 2003). Insectivorous bats are difficult to study because of their small size and nocturnal, volant behavior, thus making conservation and management of insectivorous bats more challenging than other mammals (Kunz and Racey 1998). Additionally, bats are vulnerable to rapid declines in abundance because of their low reproductive rates and specialized behaviors (O'Shea and Bogan 2003). Reasons for declines are many: habitat loss, modification, and fragmentation; roost site disturbances; collisions with wind turbines; pesticides; and emerging pathogens have all been implicated (Kunz et al. 2007, Baerwald et al. 2008, Abel and Grenier 2011). Declines in abundance of bats could have far-reaching consequences, as bats are essential to maintaining functional ecosystems (Kunz et al. 2011).

The most recent threat to the survival of species of bats in North America is white-nose syndrome (WNS), which is causing major declines in abundance of bats that hibernate in caves and abandoned mines in the eastern United States and Canadian provinces. WNS is caused by a conspicuous white fungus, *Geomyces destructans,* which invades and erodes the skin, causing hibernating bats to arouse more frequently and prematurely deplete fat stores (Cryan et al. 2010). WNS and *G. destructans* has been confirmed in 19 states and 4 Canadian provinces, and may continue spreading west in the near future. The Wyoming Game and Fish Department (Department) Nongame Program developed a strategic plan for WNS in Wyoming to facilitate management responses, increase public and agency awareness, and attempt to minimize the risk of spreading *G. destructans* via human activities to bats and their habitats in Wyoming (Abel and Grenier 2011).

Capturing bats with devices such as mist-nets and harp traps is useful for documenting presence and gathering data on morphometry and demography. Conversely, acoustic bat detectors are useful tools for gathering information on activity of bats when physical capture is impractical, unlikely, or unnecessary. Investigators can record, view, and quantify search-phase calls of bats. In many cases, the recorded calls may be identified to species, and data can be used to determine presence and develop an index of activity for each location or survey period (O'Farrell et al. 1999). Acoustic detection can be especially useful for detecting some species in Wyoming that are difficult to capture, for example the Yuma myotis (*Myotis yumanensis*), western small-footed myotis (*M. ciliolabrum*), Townsend's big-eared bat (*Corynorhinus* *townsendii*), and spotted bat (*Euderma maculatum*; O'Farrell and Gannon 1999). Some species of bats have similar acoustic signals, and these similarities and presence of background noise can contribute to errors in differentiation of calls to species. Species identification may be further confounded by differences in detectability and call structure in cluttered versus open habitats (Schnitzler and Kalko 1998). Despite these limitations, acoustic surveys provide an efficient method to obtain basic information on presence and activity levels of bats, especially when used in conjunction with capture surveys.

Of the 18 species of bats in Wyoming, 12 are considered residents for at least part of the year (Hester and Grenier 2005; Table 1). Ten resident species and one peripheral species have been designated as Species of Greatest Conservation Need (SGCN) by the Department (WGFD 2010; Table 1). Prior to 2008, inventories for bats in Wyoming were lacking. However, we conducted inventories for forest-dwelling bats across the State from 2008-2011, greatly increasing our knowledge of the distribution, diversity, and relative abundance of bats in forested habitats (Filipi et al. 2009, Abel and Grenier 2012*b*). Despite this effort, we still have an incomplete understanding of bats that rely on arid habitats with abundant rocky features. Having incomplete knowledge on the entire suite of species found in Wyoming constrains our ability to effectively manage all bats classified as SGCN and the habitats upon which they depend (Hester and Grenier 2005).

Our objectives in 2012 were to collect data on distribution, relative abundance, reproductive status, and diversity of bat species that occur in cliff, cave, canyon, and rock outcrop (cliff and canyon) environments in western Wyoming. This included collecting data on demography such as reproductive status, sex ratios, and age structure, as well as morphometry measurements of individuals, and was accomplished using mist nets concurrently with acoustic detectors. This is the first year of a 2-year project focused on inventory of bats associated with cliffs and canyons of western Wyoming.

METHODS

We used GIS (ArcGIS v10.1, Environmental Systems Research Institute, Redlands, CA, USA) and the Bat Grid system (BG; P. Ormsbee, pers. comm.) to identify potential survey grids in western Wyoming. We selected cliff and canyon land cover types from NatureServe and The Nature Conservancy land cover models. We overlaid the BG onto these layers and an additional layer that depicted areas where slopes were ≥30 percent. We used all BGs that intersected at least two of the three layers (e.g., two land cover models and slope greater than 30 percent) and randomly selected approximately 40 survey grids of 100 km^2. While in the field, we identified specific survey locations within each grid based on: 1) habitat features that encouraged concentration of bats such as water sources, flyways, and roosting areas; 2) accessibility to site by personnel; 3) the ability to effectively capture bats with mist nets at the site; and 4) the ability to effectively use detectors to record bats at the site while minimizing the presence of background noise in call files (Abel and Grenier in press). If accessible and effective survey locations were not available in a pre-selected grid, we selected a suitable replacement site in an adjacent grid.

We worked in crews of two using mist nets (Avinet, Inc., Dryden, NY) to capture bats and Song Meter SM2BAT detectors (Wildlife Acoustics, Inc., Concord, MA) to record call sequences of bats from May to early September 2012. We recorded additional information at each site, such as the location and conditions present during each nightly survey. We recorded our location and elevation with a GPS unit (GPSMap 62S, Garmin International, Inc., Olathe, KS, USA) in datum NAD 83. We recorded other data, including diagrams of net configurations and detector locations; surrounding vegetation species and description; and weather conditions including temperature, wind speed, and cloud cover at the start and end of each survey. If precipitation, lightning, or wind ≥7 mph occurred, we closed nets and ended the survey. We adapted the above methods from those outlined by Abel and Grenier (in press). We adhered to all WNS decontamination protocols outlined in Abel and Grenier (2011).

Capture Surveys

We used various configurations to position mist nets depending on the type, size, and configuration of targeted habitat and the surrounding landscape. Mist nets were set roughly 0.5 m above ground level, and varied in length from 2.6-18 m. We used a combination of single, 2.6 m tall nets and triple-high nets that were 7.8 m tall to optimize our potential to capture bats. We opened nets ≤30 min after civil sunset and kept them open 2.5-3 hrs after sunset.

We promptly removed all captured bats from nets and processed individuals at the site. We recorded species, sex, age, and reproductive status for all captured bats. We classified bats as adult or juvenile based on the ossification of epiphyseal plates in phalanges (Brunet-Rossinni and Wilkinson 2009). To determine reproductive status of female bats, we gently palpated the abdomen to verify pregnancy and examined nipples and mammary glands to confirm lactation or post-lactation. We examined testes to determine reproductive status in male bats. We collected additional measurements on forearm length, ear length, and weight. Finally, we examined wing membranes for signs of WNS-related damage (Reichard and Kunz 2009). We released bats at the netting site immediately after recording data, ≤30 min from time of capture.

Acoustic Surveys

Within grids where we captured bats, we positioned one detector near the netting site, and 1-2 detectors ≥100 m from the site. We set detectors approximately 2 m above ground level, and oriented microphones upward at 45 degrees. We programmed detectors to power on ≤30 min after civil sunset and left them running until 2.5-3 hrs after sunset.

We used Sonobat 3.02 (J. Sweczak, Arcata, CA, USA) to analyze call sequences of bats we recorded. Before classifying call sequences, we ran raw acoustic files through the Sonobat Batch Scrubber 3.vi utility to remove files that did not contain bat call sequences. We then used Sonobat Sonobatch classifier to assist in classifying call sequences to species. Calls of good quality usually resulted in classification from Sonobatch with discriminant probability >0.90. We manually verified any calls that had a discriminant probability ≤0.90 and ≥0.80. Because there remained a small percentage of noise files among files with call sequences after using the Sonobat Scrubber utility, we used the number of classified calls (i.e., calls of good quality) per hr as an index of activity.

RESULTS

During May-September 2012, we surveyed 30 grids in cliff and canyon habitats of western Wyoming, including Department regions of Cody, Jackson, Lander, and Green River. We conducted the majority of surveys in "barren-special features" habitat types consisting of caves, cliffs, and rock outcrops (WGFD 2010). Less frequently, we conducted surveys in "basin-prairie shrub-shrub steppe" and "mountain foothills shrub-shrub steppe" habitat types as well as other xeric habitats consisting of juniper (*Juniperus* spp.). Less frequently, we surveyed cliffs and canyons within lower montane forests. Locations we surveyed had a mean (± SE) elevation of 1,808 m (± 71 m).

The data we collected during surveys resulted in several updates to the Department's Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012). We updated reproductive status in some latilongs for pallid bats (*Antrozous pallidus*), Townsend's big-eared bats, big brown bats (*Eptesicus fuscus*), hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans)*, western small-footed myotis, long-eared myotis (*Myotis evotis*), and long-legged myotis (*M. volans*). Additionally, we recorded new acoustic occurrences in other latilong degree blocks with no previous records for pallid bats, Yuma myotis, silver-haired bats, and spotted bats (Table 2). Maps of individual species' distributions are shown in Figures 5-16.

Capture Surveys

We surveyed 26 grids with mist nets in western Wyoming (Fig. 1). We suspended nets in multiple configurations over a variety of ephemeral and permanent water bodies, including artificial and natural ponds, creeks and rivers, and irrigation ditches. We used an average of 37.0 m (± 3.5 m) of mist nets for 2.9 hrs (± 0.1 hrs) per survey to capture bats.

We captured 346 bats representing 10 species in 23 of the 26 grids (Table 1). On average, we captured 12.8 (SE: 2.4; Range: 0-49) bats during each survey. Of the 346 bats, 6 individuals escaped the net or the handler before they could be positively identified to species. The most common species we captured were the little brown myotis (*Myotis lucifugus*; 33.8%), western small-footed myotis (12.1%), silver-haired bat (11.8%), and long-legged myotis (10.6%). We captured all other species and undetermined species at rates <10% (Table 1). We captured males and females nearly equally (Table 3). More than half of the bats were reproductive adults (52%). Females comprised 67% of those reproductive bats, while males comprised 33%. Juveniles represented 11% of captures (Table 3). We did not document bats with any wing damage consistent with WNS. It was common to capture bats with small holes or tears in the wing membrane; however, the damage appeared to be caused by normal activity and roost substrates rather than the necrotic tissue usually associated with WNS. Means of standard morphometric measurements, including forearm length, ear length, and weight, are reported for each species in Table 4.

Bat captures were well-distributed throughout western Wyoming. Activity of bats, as measured by the mean number of captures per effort, was highest in the Jackson region followed by the Cody Region, the Lander region, and the Green River region (Table 5). The diversity of bats captured per survey was the highest in the Jackson region and the lowest in the Lander region (Table 5). However, over the course of the season, we documented the most diverse suite of bats in the Cody region (10 species), followed by the Green River (7 species), Jackson (6 species), and Lander region (5 species). We present activity of bats in Figure 3 and diversity in Figure 4 associated with each survey grid.

Acoustic Surveys

We surveyed 30 grids with acoustic detectors in western Wyoming (Fig. 1). We placed 1-2 acoustic detectors within each grid for a total of 43 survey nights. We deployed bat detectors at a variety of features that we expected bats to use, such as cliffs, caves, mines, and ephemeral and permanent water bodies, including artificial and natural ponds, creeks and rivers, and irrigation ditches. We used bat detectors for an average of 4.8 hrs (± 0.4 hrs) per survey night.

We recorded 40,062 files, including bat call sequences and environmental noise, during acoustic surveys in 2012. Of those, we classified 5,605 good-quality acoustic files to 11 resident and 1 peripheral species in 29 of 30 grids. In addition, we detected 14 passes by spotted bats during surveys, for a total of 5,619 bat detections in 2012 (Table 1). The most common species detected were the western small-footed myotis (42.8%), big brown bat (14.5%), little brown myotis (14.0%), silver-haired bat (13.3%), and long-eared myotis (10.8%). All other bats comprised <10% of our detections (Table 1). We also had a small number of detections of the peripheral Yuma myotis.

Detections of bats were well-distributed throughout western Wyoming. Activity of bats, as measured by the mean number of classified calls per hr, was highest in the Cody region and the Jackson region followed by the Green River and Lander regions (Table 6). We detected the highest number of species at sites in the Jackson region and the lowest at sites in the Lander region (Table 6). Activity and diversity of bats in each survey grid is illustrated in Figures 3 and 4, respectively.

DISCUSSION

This project greatly improves our understanding of distributions for many species of bats and has already resulted in important updates to the Department's Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming (Orabona et al. 2012). With a better understanding of the distribution, relative abundance, and diversity of bat species associated with cliffs and canyons in Wyoming, we can begin to investigate further how bats may respond to loss of habitat, disease, climate change, and energy production in Wyoming (Hester and Grenier 2005). Most notably, these results will improve our ability to comment on and make recommendations for future management and status of bats potentially affected by WNS in Wyoming.

Most species we observed are known to roost in crevices and cavities such as those in cliffs, caves, canyons, and rock outcrops (O'Shea and Bogan 2003). The only resident bat species we did not capture or detect acoustically in 2012 was the northern myotis (*Myotis* *septentrionalis*). The northern myotis occurs only in extreme northeastern Wyoming so was not expected to occur in the study area (Hester and Grenier 2005).

We captured a different assemblage of species in cliffs and canyons of western Wyoming than those reported during the forest bat inventory (Abel and Grenier 2012*a*). However, similar to results of the forest bat inventory, our most commonly captured species was the little brown myotis. This species is known to be extremely versatile in its ecology, occupying many different habitats and elevations, so it was not surprising we captured the little brown myotis so frequently in this habitat (Adams 2003, Hester and Grenier 2005). We commonly captured tree-roosting species, including the silver-haired bat and hoary bat, during surveys at cliffs or canyons that were within forested habitats. However, we were surprised to capture tree-roosting species during surveys in arid environments with only small patches of plains cottonwood (*Populus deltoides*) or quaking aspen (*P. tremuloides*). Even though actual roost locations are unknown, it is possible these species use even small patches of forest or individual trees for roosting when conditions are appropriate.

Sexual segregation of bats is common during the reproductive season. Females are highly selective; they use warmer roosts with stable temperatures, and often roost in groups during energetically costly gestation and lactation periods. Males are more opportunistic; they roost singly and utilize periods of torpor to conserve energy (O'shea and Bogan 2003, Speakman and Thomas 2003). Because we targeted habitats found in lower elevations, our data had a higher proportion of females in this survey and, accordingly, a higher proportion of reproductive females than during previous inventory efforts. Even so, the proportion of juveniles captured in mist nets remained low during this survey. Late in the season, it becomes increasingly difficult to determine the age of individuals as the epiphyses in phalanges continue to ossify. It is possible we misclassified juveniles as adults that we captured in late August and early September.

Generally, acoustical detections of species matched the assemblage of species that were captured. However, we also detected Yuma myotis and spotted bats even though we failed to capture either species. Additionally, we recorded proportionately many more call sequences of western small-footed myotis than we captured, similar to previous inventories. Both western small-footed and Yuma myotis are known to be difficult to capture as both are highly maneuverable species and can easily avoid an obstacle such as a mist net (Aldridge 1986, Holloway and Barclay 2001). Spotted bats forage and commute at high altitudes, often making it difficult to capture them (Adams 2003). Furthermore, detections of the spotted bat usually occurred late, after we closed mist nets. In future surveys that are within the range of spotted bats, we recommend leaving mist nets open for an extended period and using triple-high nets to increase the likelihood of capturing this species. Using acoustic bat detectors in conjunction with mist nets during this inventory increased the likelihood of detecting all species present at a location, especially those that are difficult to capture.

When comparing results between years and among sites, we cannot rule out the influence of annual variation in weather patterns and prey availability on activity and reproduction of bats. Variations in weather conditions, intra-seasonal behavior, prey availability, and netting locations may also cause noticeable differences on success of captures for each survey night (Hester and

Grenier 2005). We attempted to distribute surveys throughout the study area over the course of the summer; however, this inventory encompassed a large geographic area in a relatively short time period, which should be considered when interpreting results. It is difficult to assess the exact distribution, relative abundance, and diversity of bat species in western Wyoming since replication of surveys at a single survey area was not usually feasible. Nevertheless, this updated information is significant and beneficial to increasing our current understanding of management and inventory needs.

ACKNOWLEDGEMENTS

Funding for this project was provided by the USFWS through State Wildlife Grants and the Wyoming State Legislature General Fund Appropriations, for which we are extremely grateful. We thank the USFS, BLM, and private landowners for providing access for this project. We also extend a special thanks to Department personnel L. Van Fleet, K. Romano, and A. Trost, and volunteer M. Abel for their assistance in the field. B. Webber and E. Furtaw provided GIS support for the project.

LITERATURE CITED

Abel, B. L., and M. B. Grenier. 2011. A strategic plan for white-nose syndrome in Wyoming. Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. In Press. Nongame mammals: Bats. Pages 20.2-1–20.2-42 *in* Handbook of biological techniques, fourth edition (S. Tessmann, Editor). Wyoming Game and Fish Department, Cheyenne, USA.

Abel, B. L., and M. B. Grenier. 2012*a*. Inventories of forest bats in southeastern Wyoming: mist netting. Pages 125-154 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Abel, B .L., and M. B. Grenier. 2012*b*. Inventories of forest bats in southeastern Wyoming: acoustic surveys. Pages 125-154 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Adams, R. A. 2003. Bats of the Rocky Mountain West: Natural history, ecology, and conservation. University Press of Colorado, Boulder, USA.

Aldridge, H. 1986. Manoeuvrability and ecological segregation in the little brown (*Myotis lucifugus*) and Yuma (*M. yumanensis*) bats (Chiroptera: Vespertilionidae). Canadian Journal of Zoology 64:1878-1882.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18:R695-R696.

Barclay, R. M. R., and A. Kurta. 2007. Ecology and behavior of bats roosting in tree cavities and under bark. Pages 17-59 *in* Bats in forests: conservation and management (M. J. Lacki, J. P. Hayes, and A. Kurta, Editors). Johns Hopkins University Press, Baltimore, Maryland, USA.

Bat Conservation International [BCI]. 2011. Roosting patterns of US and Canadian bat species. Pages 17-18 *in* Bat Conservation and Management Workshop course booklet. Bat Conservation International, Austin, Texas, USA.

Brigham, R. M. 2007. Bats in forests: what we know and what we need to learn. Pages 1-15 *in* Bats in forests: conservation and management (M. J. Lacki, J. P. Hayes, and A. Kurta, Editors). Johns Hopkins University Press, Baltimore, Maryland, USA.

Brunet-Rossinni, A. K., and G. S. Wilkinson. 2009. Methods for age estimation and the study of senescence in bats. Pages 315-325 *in* Ecological and behavioral methods for the study of bats, second edition (T. H. Kunz and S. Parsons, Editors). Johns Hopkins University Press, Baltimore, Maryland, USA.

Cryan, P. M., C. U. Meteyer, J. G. Boyles, and D. S. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135.

Ellison, L. E., T. J. O’Shea, M. A. Bogan, A. L. Everette, and D. M. Schneider. 2003. Existing data on colonies of bats in the United States: summary and analysis of the US Geological Survey’s bat population database. Pages 127-171 *in* Monitoring trends in bat populations of the United States and territories (T. J. O’Shea and M. A. Bogan, Editors). US Geological Survey, Biological Resources Division, Information and Technology Report, USGS/BRD/ITR 2003-0003.

Filipi, T., M. Grenier, S. Chrisman, and E. Hannelly. 2009. Forest bat inventories completion report. Pages 123-135 *in* Threatened, endangered, and nongame bird and mammal investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Hester, S. G., and M. B. Grenier. 2005. A conservation plan for bats in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Holloway, G. L., and R. M. R. Barclay. 2001. *Myotis ciliolabrum*. Mammalian Species 670:1-5.

Kunz, T. H., and L. F. Lumsden. 2003. Ecology of cavity and foliage roosting bats. Pages 3-89 *in* Bat ecology (T. H. Kunz and M. B. Fenton, Editors). University of Chicago Press, Chicago, Illinois, USA.

Kunz, T. H., and P. A. Racey. 1998. Bat biology and conservation. Smithsonian Institution Press, Washington, D.C., USA.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71: 2449-2486.

Kunz, T. H., E. Braun de Torrez, D. Bauer, T. Lobova, and T. H. Fleming. 2011. Ecosystem services provided by bats. Annals of the New York Academy of Sciences 1223:1-38.

O'Farrell, M. J., and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy 80:24-30.

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammalogy 80:11-23.

Orabona, A., C. Rudd, M. Grenier, Z. Walker, S. Patla, and B. Oakleaf. 2012. Atlas of birds, mammals, amphibians, and reptiles in Wyoming. Wyoming Game and Fish Department Nongame Program, Lander, USA.

O'Shea, T. J., and M. A. Bogan. 2003. Introduction. Pages 1-7 *in* Monitoring trends in bat populations of the United States and territories: problems and prospects (T. J. O'Shea and M. A. Bogan, Editors). US Geological Survey, Biological Resources Division. Information and Technology Report, USGS/BRD/ITR 2003-0003.

Reichard, J. D., and T. H. Kunz. 2009 White-nose syndrome inflicts lasting injuries to the wings of little brown Myotis (*Myotis lucifugus*). Acta Chiropterologica 11:457-464.

Speakman, J. R., and D. W. Thomas. 2003. Physiological ecology and energetic of bats. Pages 430-490 *in* Bat Ecology (T. H. Kunz and M. B. Fenton, Editors). University of Chicago Press, Chicago, Illinois, USA.

Schnitzler, H. U., and E. K. V. Kalko. 1998. How echolocating bats search and find food. Pages 183-196 *in* Bat Biology and Conservation (T. H. Kunz and P. A. Racey, Editors). Smithsonian Institution Press, Washington, D.C., USA.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Species of bats that are known to occur in Wyoming, with number captured during the 2012 survey. Status of residency for bats are represented with the following abbreviations, R=resident (year-round or seasonal); P=peripheral; A=accidental occurrence, as identified by Hester and Grenier (2005). Native Species Status (NSS) of Species of Greatest Conservation Need for bats are 2, 3, 4, or U, as identified in the species accounts of the Wyoming State Wildlife Action Plan (WGFD 2010).

Scientific name	Common name	Resident status	Native Species Status (NSS)	Captures in 2012	Detections in 2012
Antrozous pallidus	Pallid bat	R	NSS3	32	89
Corynorhinus townsendii	Townsend's big-eared bat	R	NSS2	2	6
Eptesicus fuscus	Big brown bat	R	NSS4	28	816
Euderma maculatum	Spotted bat	R	NSS3	0	16*
Lasionycteris noctivagans	Silver-haired bat	R	-	40	749
Lasiurus cinereus	Hoary bat	R	-	12	78
Myotis ciliolabrum	Western small-footed myotis	R	NSS4	41	2,403
Myotis evotis	Long-eared myotis	R	NSS3	33	607
Myotis lucifugus	Little brown myotis	R	NSS4	115	788
Myotis septentrionalis	Northern myotis	R	NSS3	0	0
Myotis thysanodes	Fringed myotis	R	NSS3	1	1
Myotis volans	Long-legged myotis	R	NSS3	36	53
Lasiurus borealis	Eastern red bat	P	NSSU	0	0
Myotis californicus	California myotis	P	-	0	0
Myotis yumanensis	Yuma myotis	P	-	0	13
Tadarida brasiliensis	Brazilian free-tailed bat	P	-	0	0
Nyctinomops macrotis	Big free-tailed bat	A	-	0	0
Pipistrellus subflavus	Eastern pipistrelle	A	-	0	0

*Indicates the species was detected through its audible call in addition to the acoustic bat detector.

Table 2. Updates provided to the Atlas of Birds, Mammals, Amphibians, and Reptiles in Wyoming (Orabona et al. 2012) from surveys in western Wyoming, May-September 2012. Updates are presented by latilong, based on individuals captured and summarized by species. B=Breeding, including dependent young, juvenile animals, lactating or post-lactating females, or males in breeding condition observed; O=Observed but due to mobility of the species and lack of factors listed under "B", breeding cannot be assumed; b=Animals were observed and, due to limited mobility, breeding is assumed; a=The species was detected with acoustic equipment and additional verification is warranted; __=No verified records.

Species	Latilong Degree Block	Current Status	Updated Status
Antrozous pallidus	10	O	B
	2, 8, 15	__	a
Corynorhinus townsendii	4	O	B
Eptesicus fuscus	15	O	B
Euderma maculatum	24	__	a
Lasionycteris noctivagans	3	O	B
	24	__	a
Lasiurus cinereus	15	O	B
	18	a	B
Myotis ciliolabrum	3	b	B
Myotis ciliolabrum	4, 24	O	B
Myotis evotis	4, 8, 10, 18, 24	O	B
Myotis lucifugus	24	__	a
Myotis volans	10, 24	O	B
Myotis yumanensis	8, 18, 24	__	a

Table 3. Population parameters for bats we captured in western Wyoming, May-September 2012. Data are summarized by species. Unknown species are bats that were not identified because the individual escaped before it could be processed. Undetermined (Und.) age, sex, and reproductive status indicate that the individual was released early or escaped the handler before measurements could be taken. Reproductive status is represented by the following abbreviations: N=Non-reproductive; R=Reproductive.

Species	Sex ratio			Age			Reproductive status		
	F	M	Und.	A	J	Und.	N	R	Und.
Antrozous pallidus	28	4		19	13		15	17	
Corynorhinus townsendii	2			2			1	1	
Eptesicus fuscus	8	19	1	26	1	1	11	16	1
Lasiurus cinereus	3	8	1	11		1	6	3	3
Lasionycteris noctivagans	13	24	3	36		4	16	20	4
Myotis ciliolabrum	18	23		36	5		24	17	
Myotis evotis	20	12	1	30	2	1	11	21	1
Myotis lucifugus	57	58		102	9	4	52	52	11
Myotis thysanodes	1			1			1		
Myotis volans	14	21	1	34	1	1	13	21	2
Unknown species			6			6			6
Total	164	169	13	297	31	18	150	168	28

Table 4. Mean and standard error (SE) of measurements taken from individual bats we captured in western Wyoming, May-September 2012. Data are summarized by species.

Species	Forearm length (mm)			Ear length (mm)			Weight (g)		
	Mean	SE	*n*	Mean	SE	*n*	Mean	SE	*n*
Antrozous pallidus	56.6	0.3	32	27.6	0.2	32	21.7	0.5	32
Corynorhinus townsendii	44.6	0.6	2	32.5	1.5	2	11.0	0.0	2
Eptesicus fuscus	46.3	0.3	25	13.7	0.2	25	16.6	0.5	26
Lasiurus cinereus	53.5	0.7	9	14.3	0.4	9	26.2	2.8	6
Lasionycteris noctivagans	41.2	0.3	25	12.8	0.2	25	11.9	0.2	32
Myotis ciliolabrum	32.5	0.2	32	12.0	0.2	32	4.8	0.2	35
Myotis evotis	38.2	0.3	21	18.9	0.3	23	6.0	0.3	23
Myotis lucifugus	37.2	0.1	73	11.9	0.1	63	7.4	0.2	69
Myotis thysanodes	40.2	n/a	1	18.0	n/a	1	8.0	n/a	1
Myotis volans	39.3	0.2	29	11.5	0.1	29	8.2	0.2	34

Table 5. Capture results of mist-net surveys in western Wyoming, May-September, 2012, organized by Wyoming Game and Fish Department Region. Net meter hrs is meters of net × hrs of survey per grid. Captures per effort is an index of activity based on the number of captures and the net meter hrs per grid. The grids in each region include: grids 1744-2425: Cody Region; grids 260-444: Green River Region; grids 1491-1664: Jackson Region; grids 1108-1218: Lander Region.

Capture data	Cody Region (*n*=12)		Green River Region (*n*=6)		Jackson Region (*n*=5)		Lander Region (*n*=3)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total Captures	10.8	2.8	12.7	6.0	20.4	8.2	12.7	4.7
Net meter hrs	98.3	17.9	108.5	24.2	117.0	24.0	108.0	23.8
Captures per effort	14.1	5.3	11.6	5.2	20.4	7.8	14.0	5.8
Species captured	3.3	0.5	3.2	0.9	3.8	0.9	2.3	0.3

Table 6. Results of acoustic surveys in western Wyoming, May-September, 2012, organized by Wyoming Game and Fish Department Region. Total files recorded is the number of files recorded at each survey grid after removing noise files by using the Sonobat Batch Scrubber utility; however a small percentage of noise files remained. Classified files is the number of files with call sequences of good quality that were classified using the Sonobat Sonobatch classification utility. Classified per hr is an index of activity based on good quality calls recorded during surveys. Calls of good quality resulted in classification from Sonobatch with discriminant probability >0.90. Calls that were classified by Sonobatch but had a discriminant probability <0.90 were secondarily classified by personnel. The number of species detected at a site is based upon classifications made by Sonobat and Department personnel. The grids in each region include the Cody region: grids 1857-2425; Green River region: grids 318-444; Jackson region: grids 1491-1664; Lander region: grids 1049-1280.

Acoustic data	Cody Region (*n*=19)		Green River Region (*n*=7)		Jackson Region (*n*=9)		Lander Region (*n*=8)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total files recorded	1,068.7	190.3	619.0	260.8	960.0	238.3	704.1	278.3
Classified files	159.6	39.5	73.7	34.4	137.7	32.5	70.9	21.6
Survey hrs	4.3	1.0	4.3	1.3	4.0	0.0	7.5	1.3
Classified per hr	42.2	11.2	22.2	9.6	34.1	8.1	9.6	2.2
Species detected	5.7	0.4	5.0	1.3	6.4	0.5	4.8	0.6

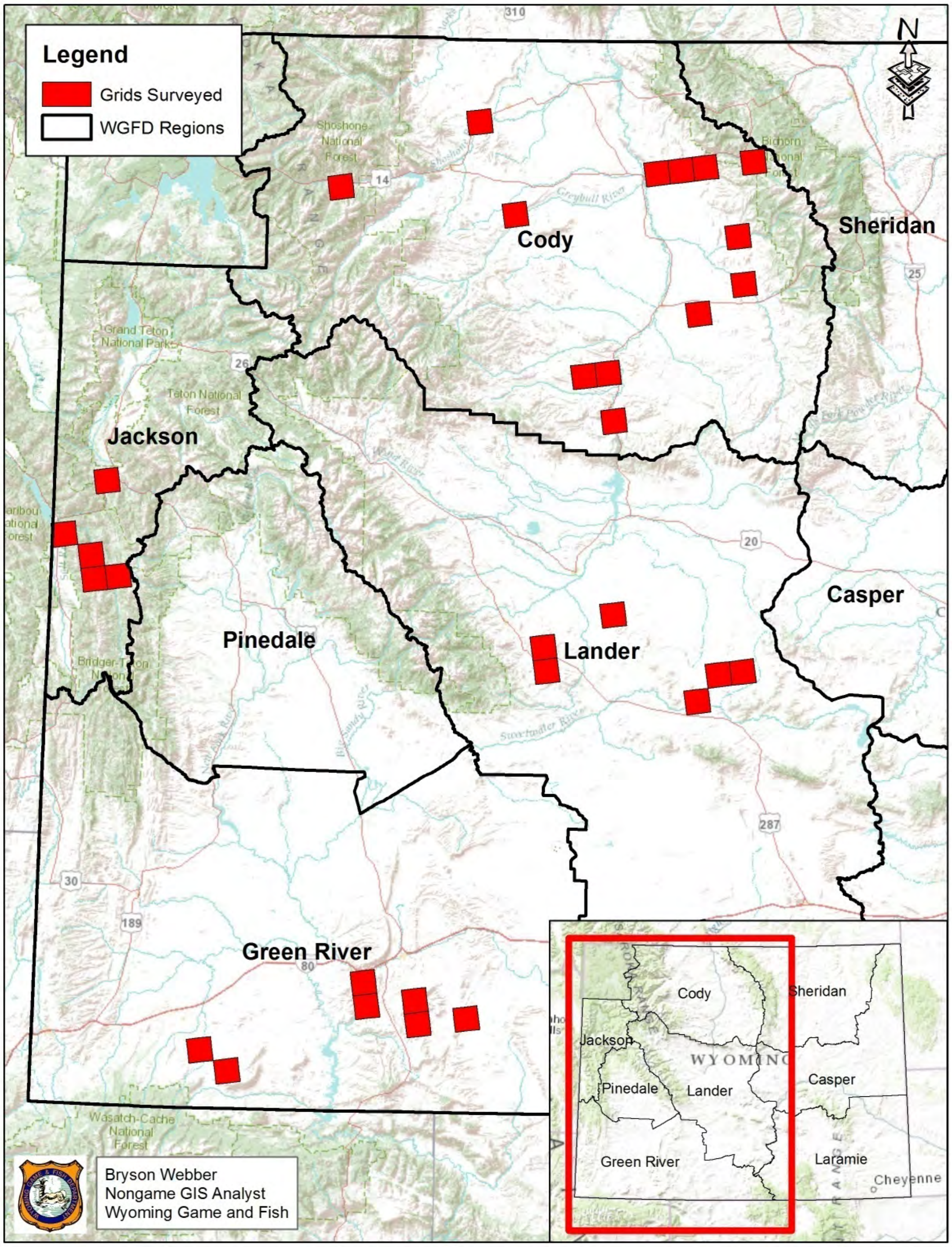

Figure 1. Study area and location of grids we surveyed for bats associated with cliff and canyon habitats in western Wyoming, May-September, 2012.

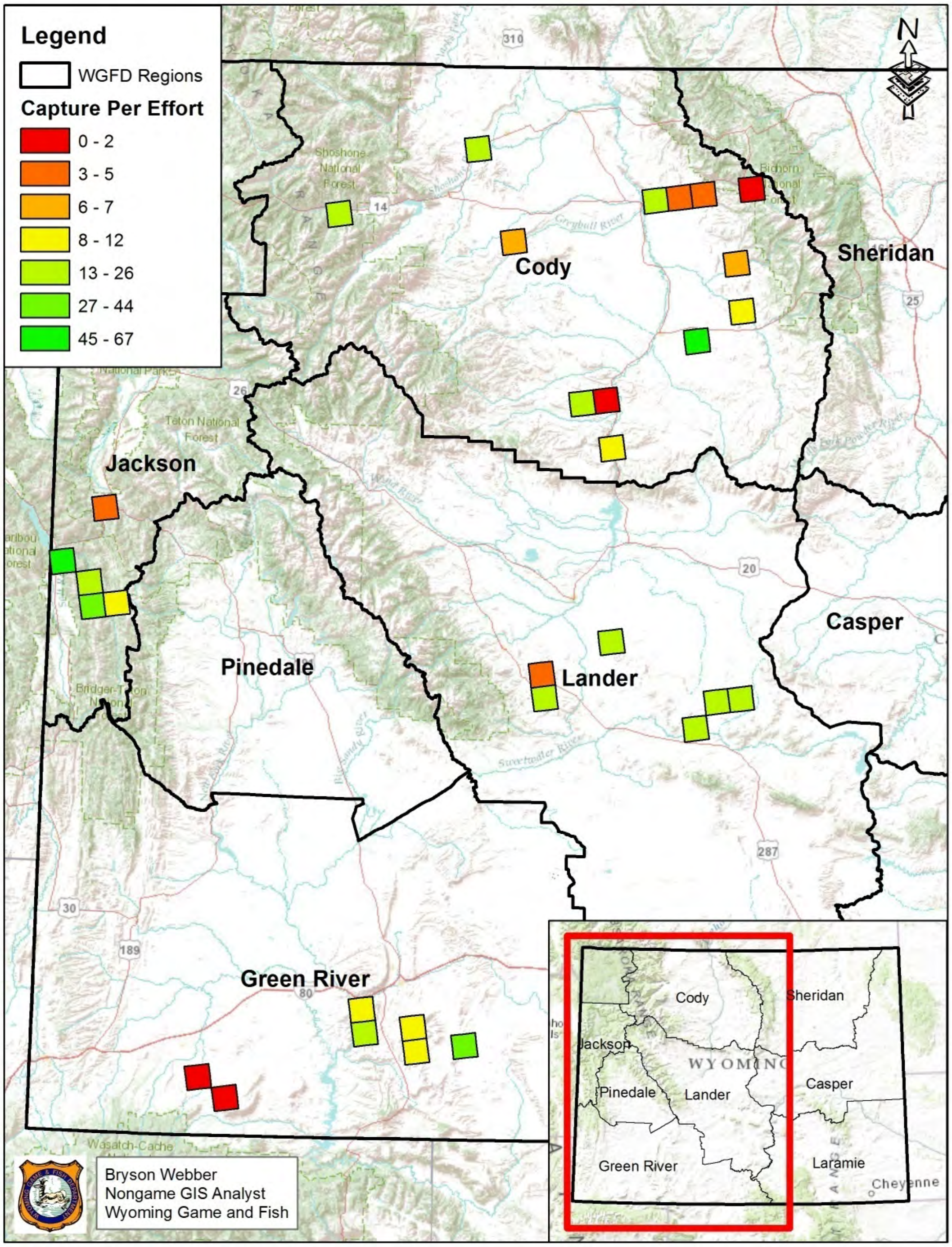

Figure 2. Number of individual bats we captured per unit effort in western Wyoming, May–September, 2012. Captures per unit effort is the number of captures per net meter hr. Net meter hrs is meters of net × hrs of survey per grid.

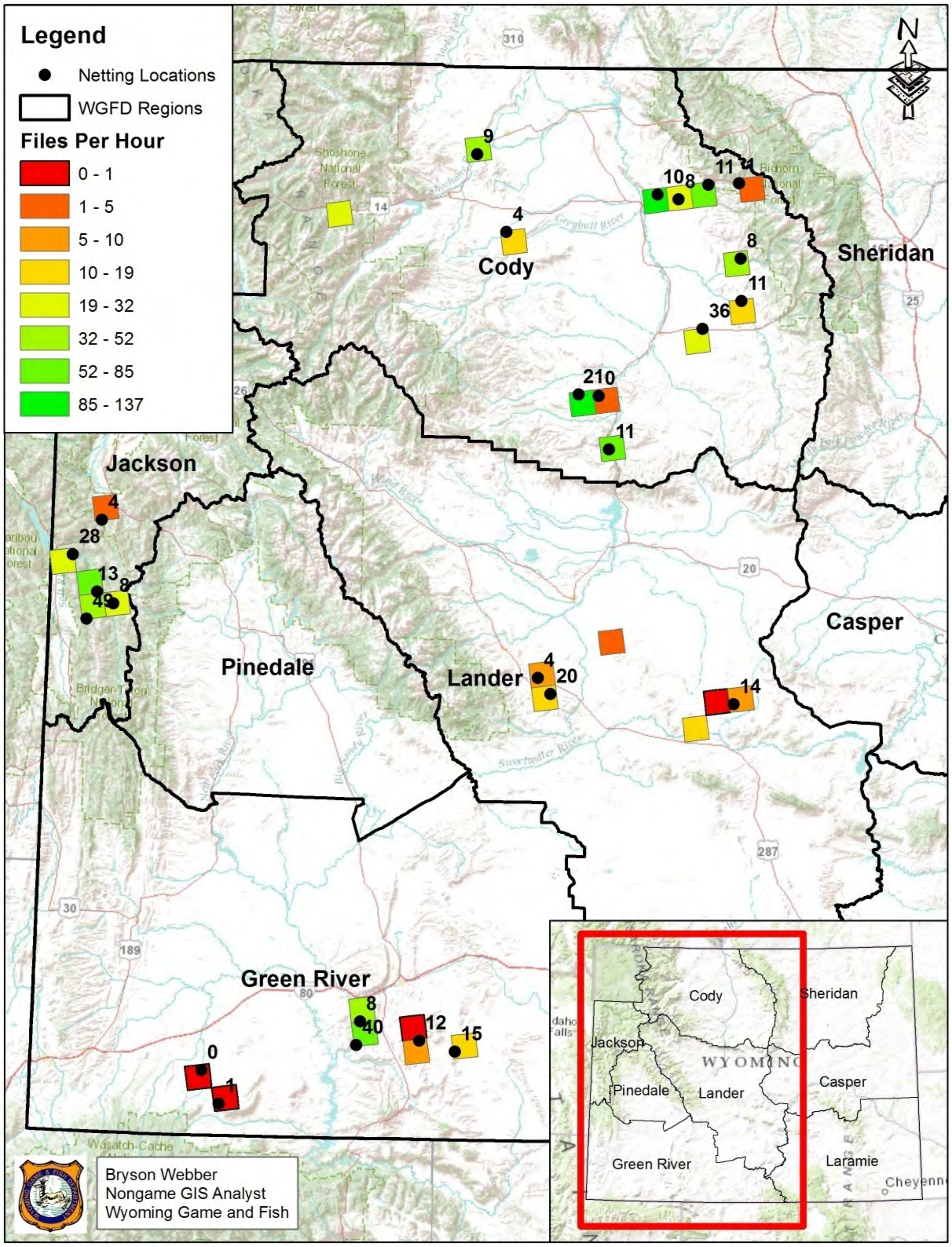

Figure 3. Number of classified files for bats we recorded per survey hr in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files) per hr. Points within each grid represent locations where we captured bats with labels corresponding to the number of individuals captured.

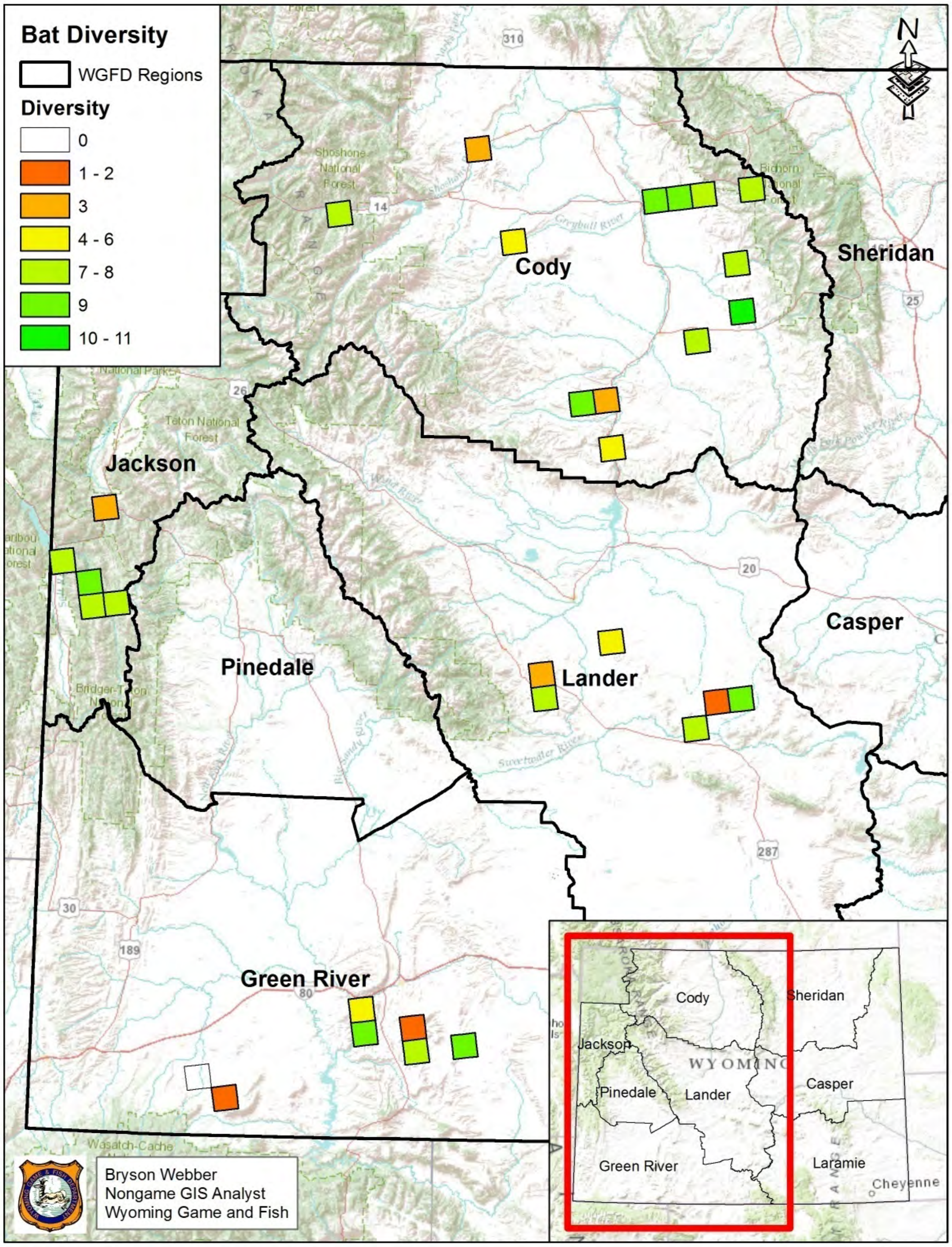

Figure 4. Number of different bat species we detected within each grid surveyed in western Wyoming, May-September, 2012.

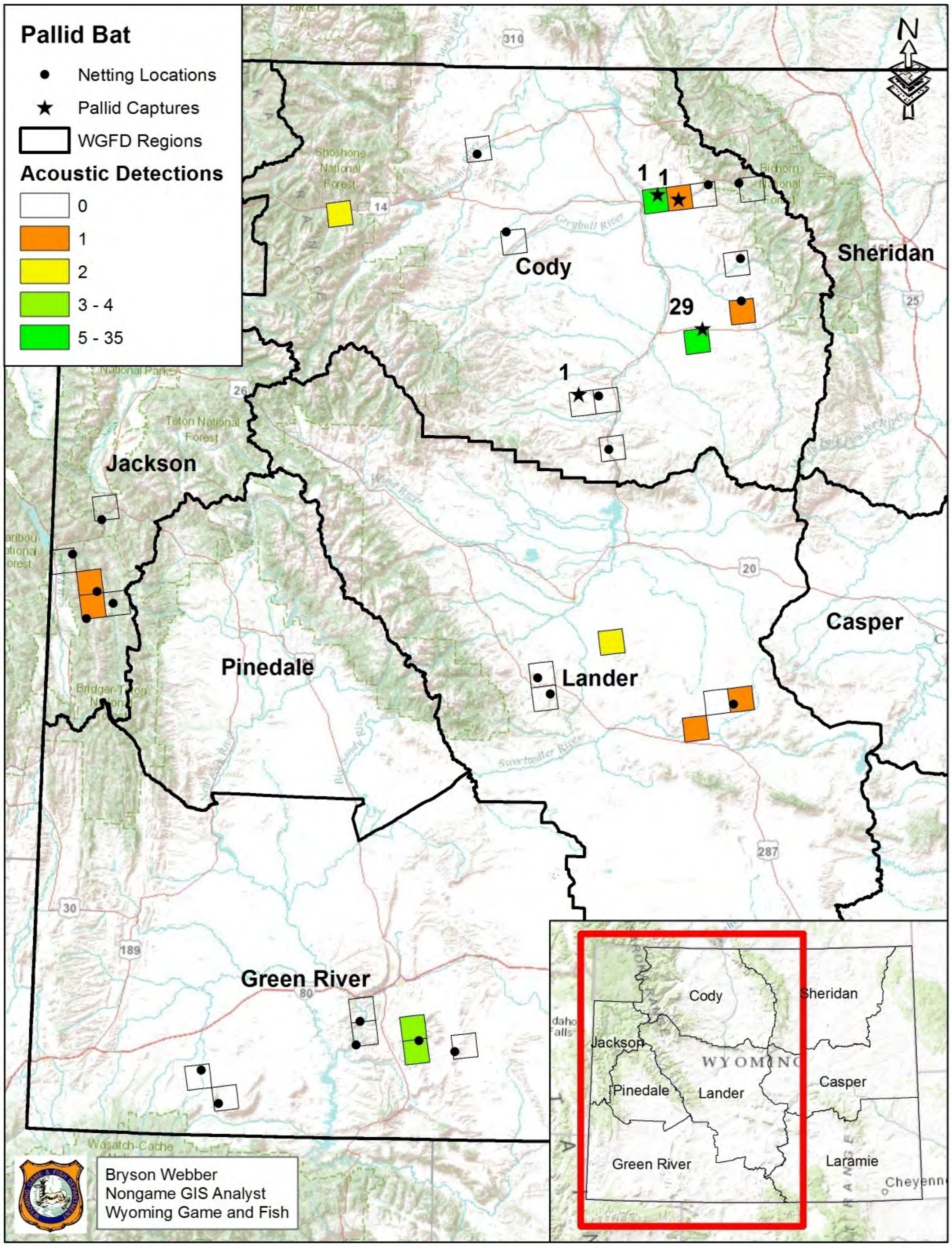

Figure 5. Locations where we captured pallid bats (*Antrozous pallidus*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points within each grid represent locations where we conducted surveys with labels corresponding to the number of individuals we captured for this species.

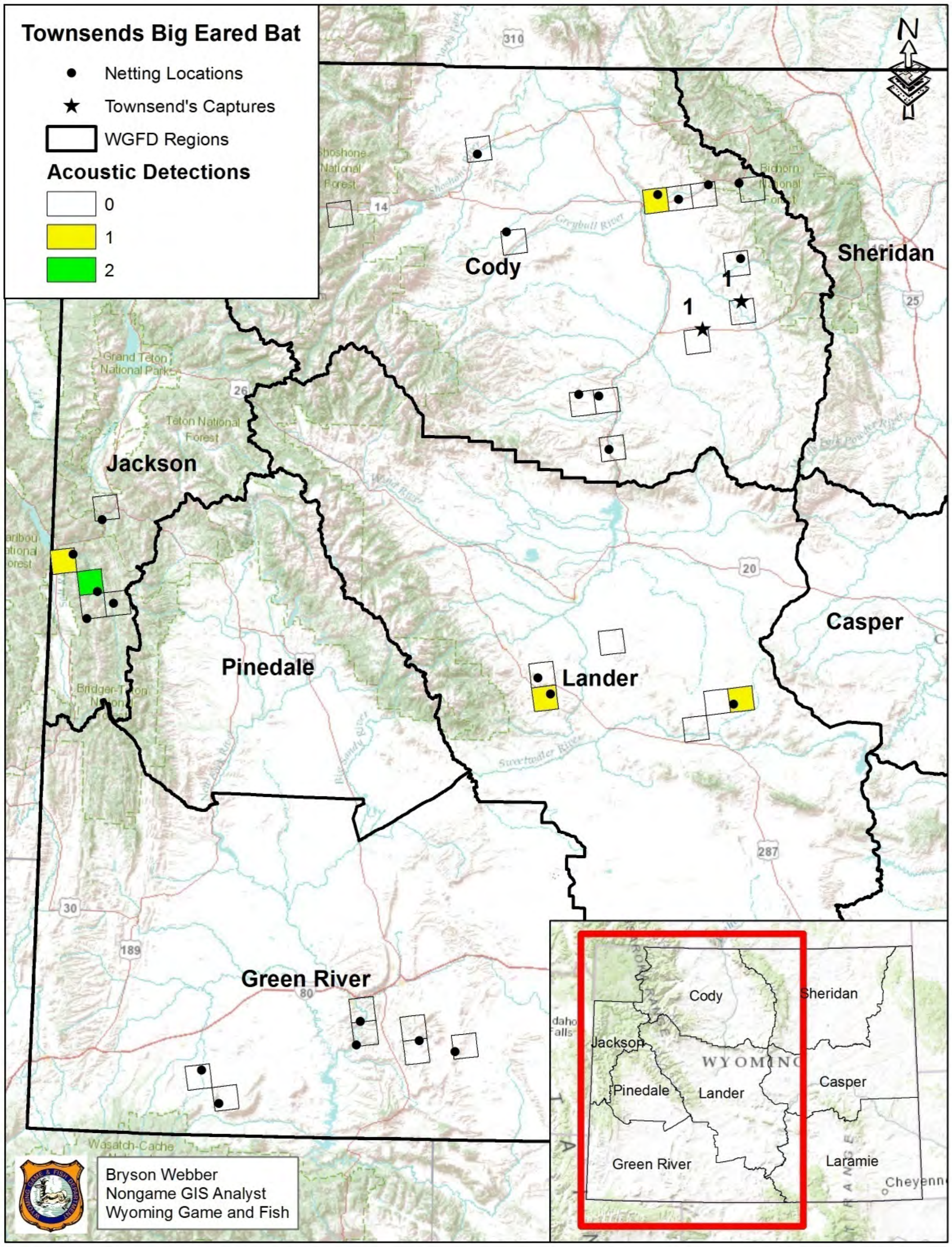

Figure 6. Locations where we captured Townsend's big-eared bats (*Corynorhinus townsendii* observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points within each grid represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

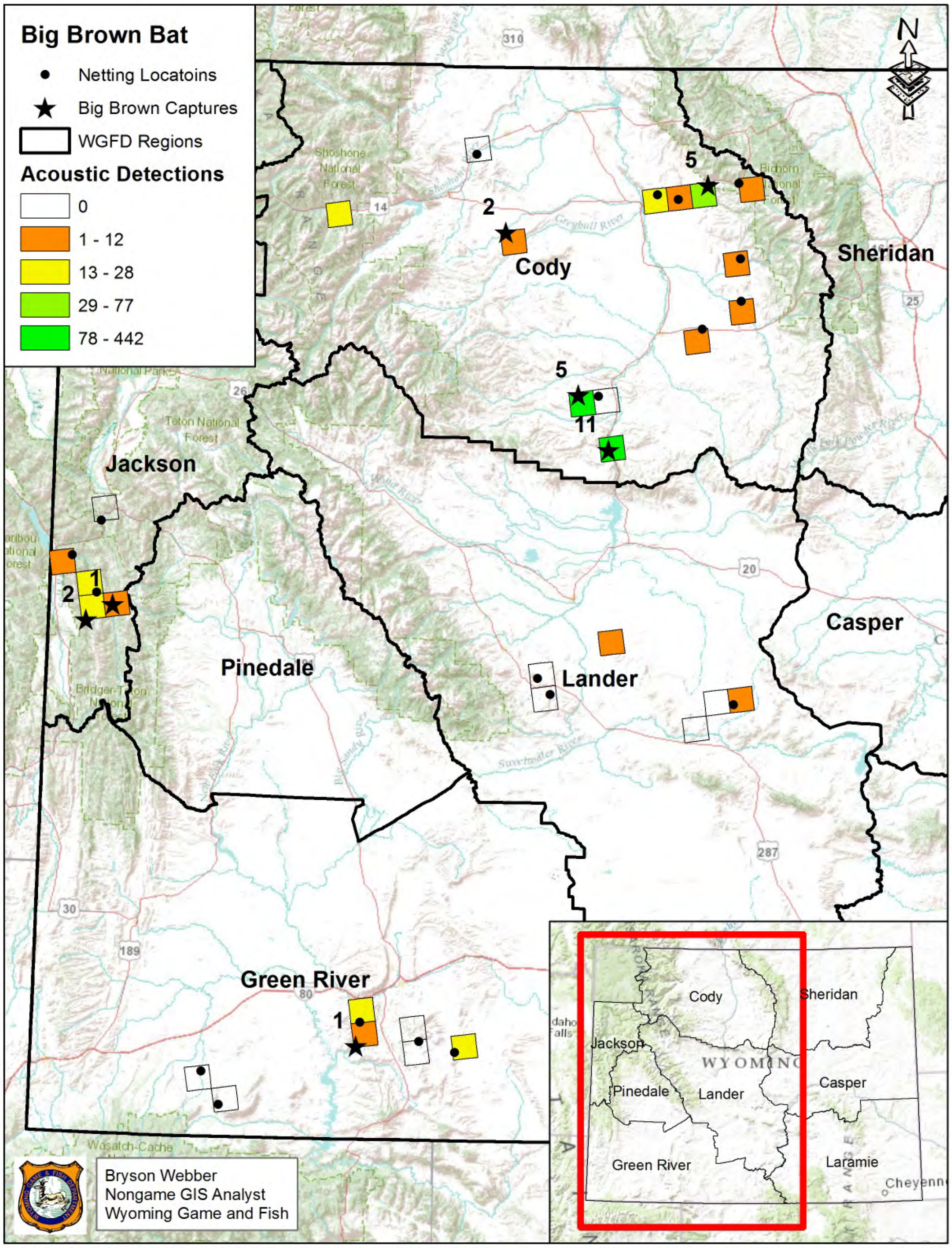

Figure 7. Locations where we captured big brown bats (*Eptesicus fuscus*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

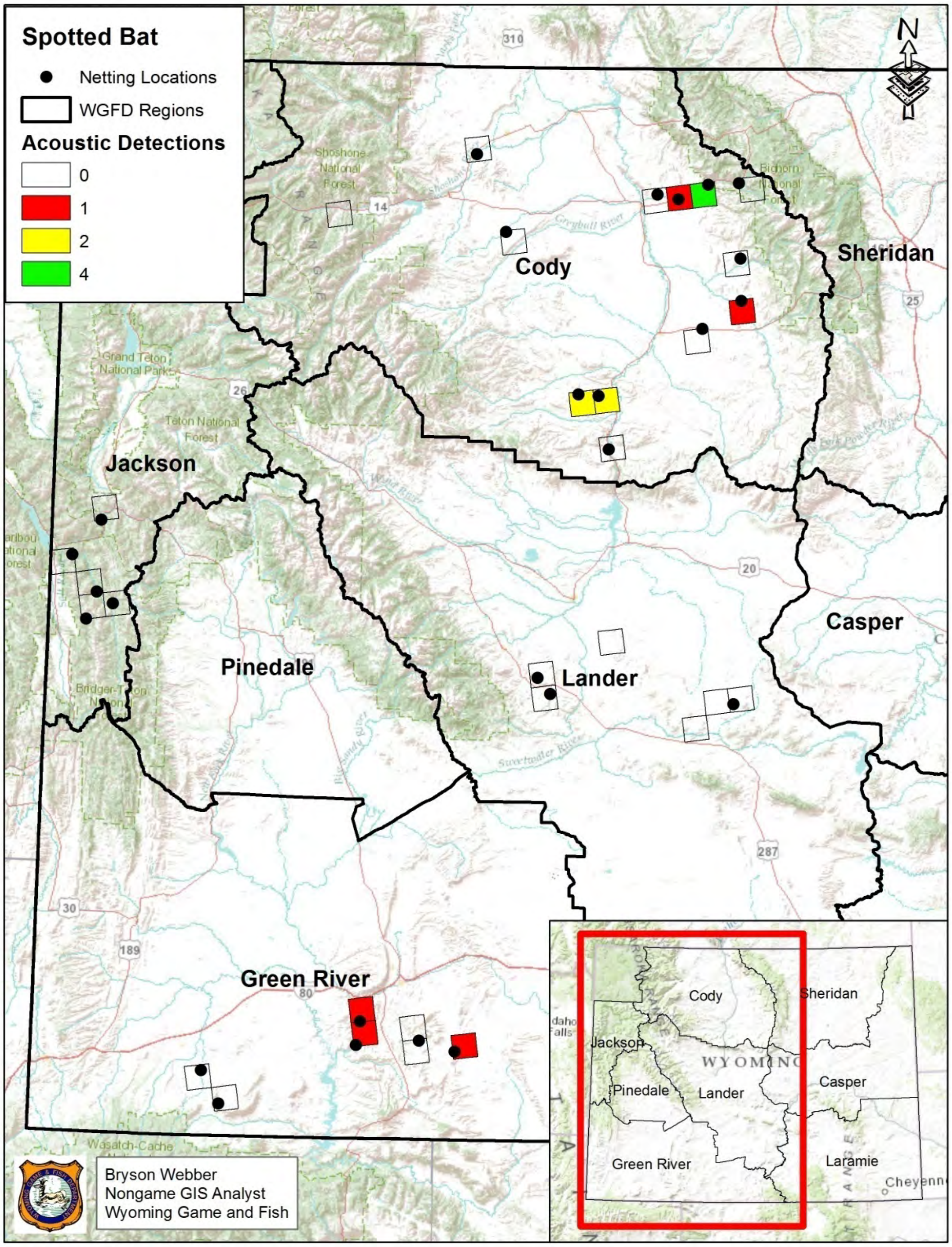

Figure 8. Locations where we captured spotted bats (*Euderma maculatum*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

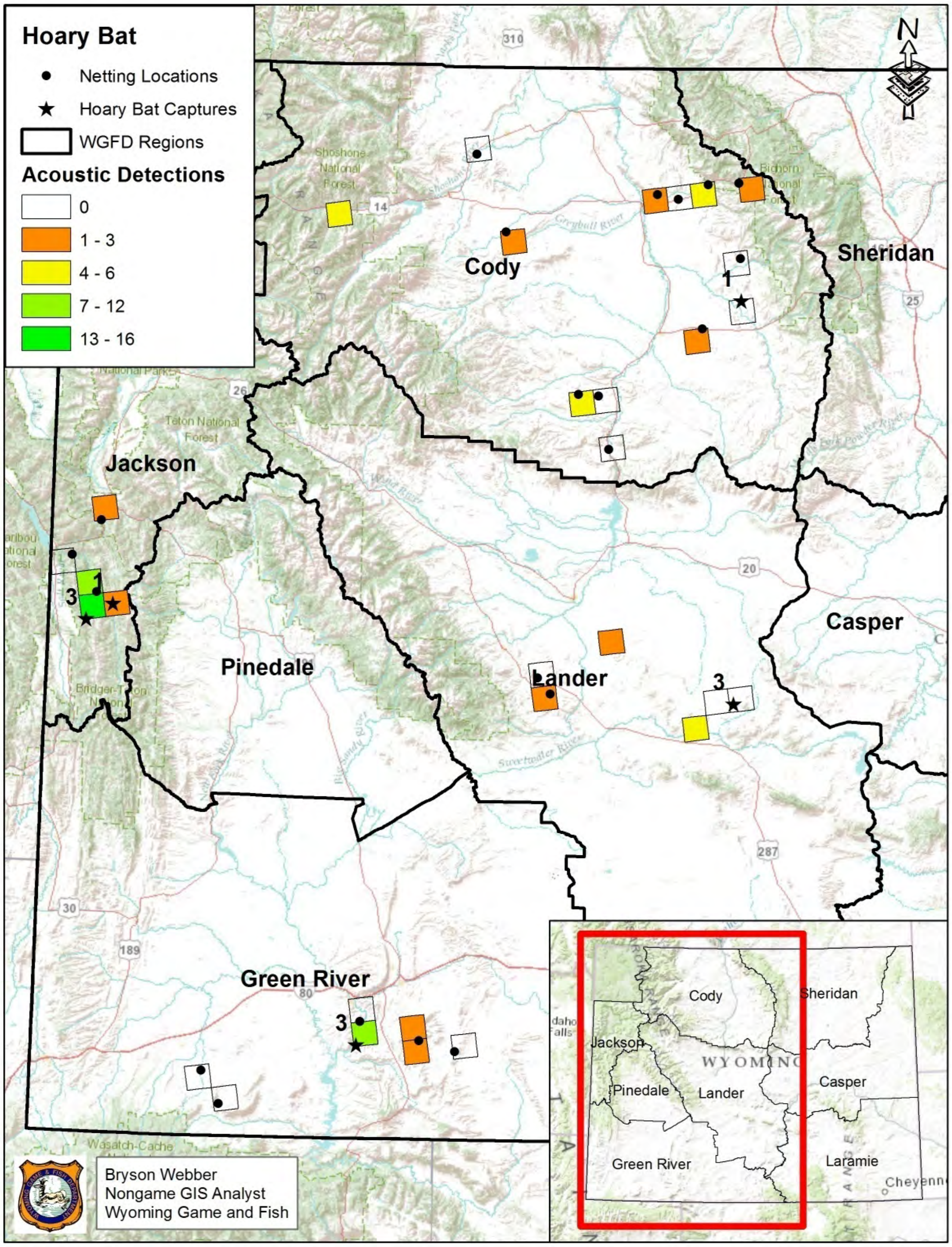

Figure 9. Locations where we captured hoary bats (*Lasiurus cinereus*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

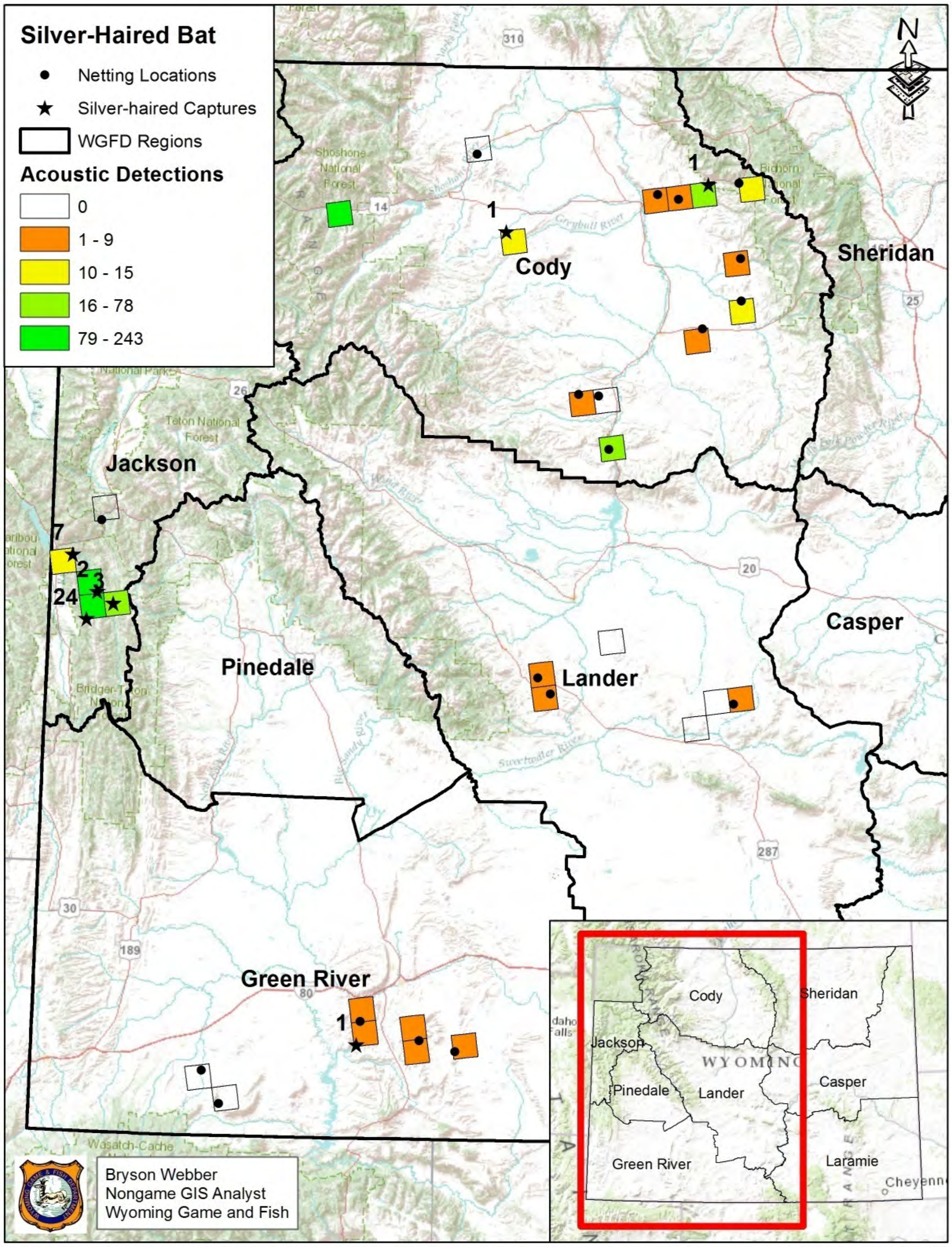

Figure 10. Locations where we captured silver-haired bats (*Lasionycteris noctivagans*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

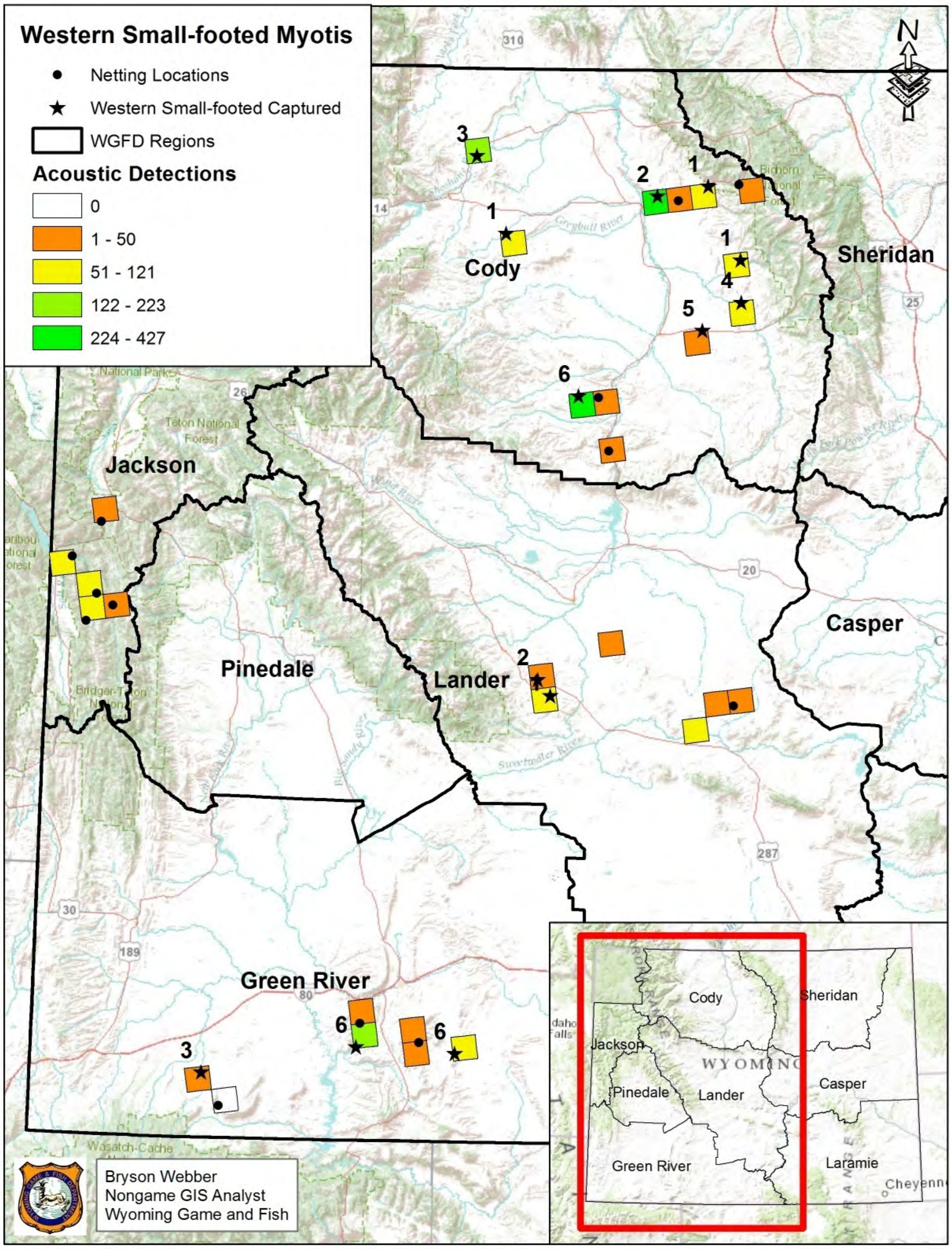

Figure 11. Locations where we captured western small-footed myotis (*Myotis ciliolabrum*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

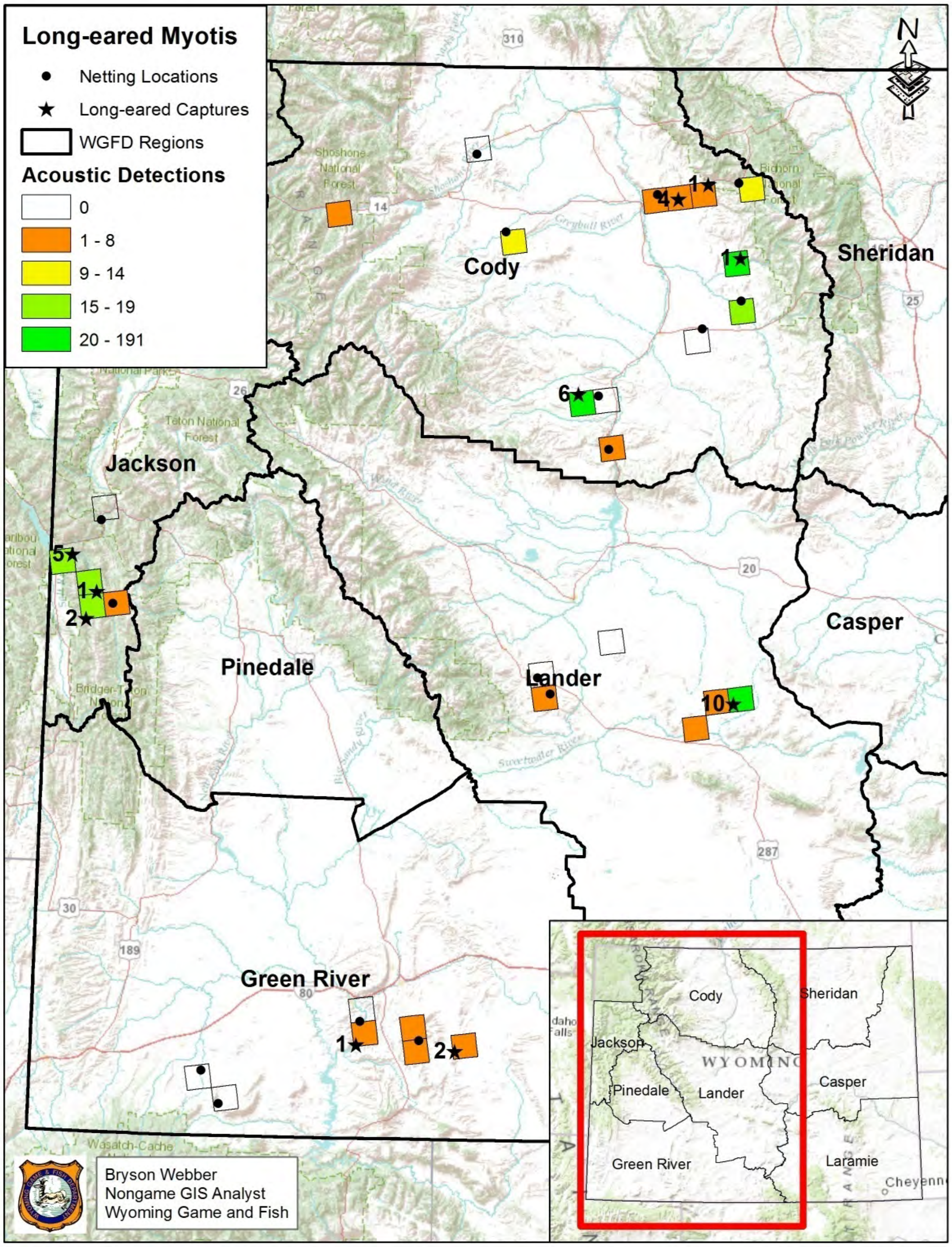

Figure 12. Locations where we captured long-eared myotis (*Myotis evotis*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

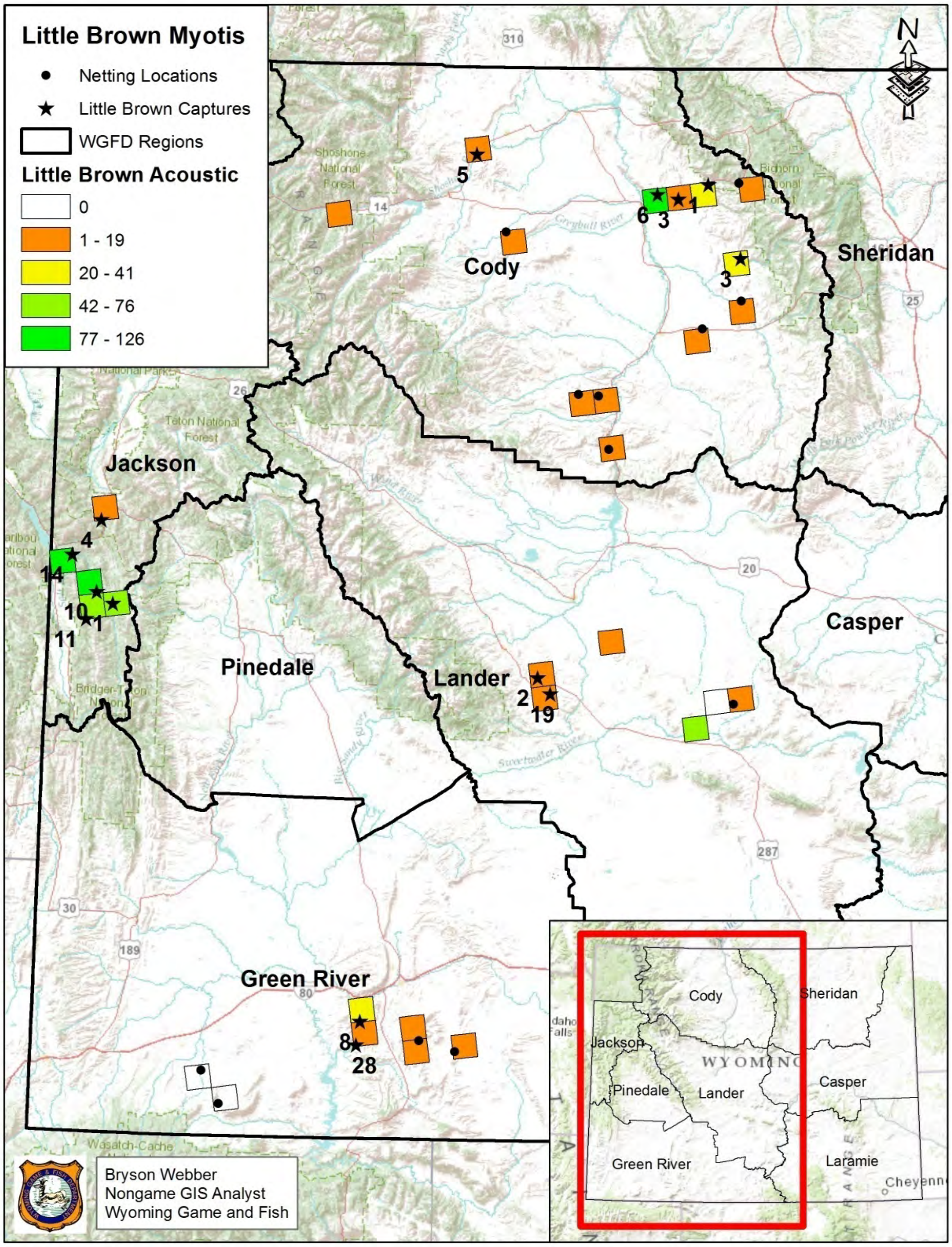

Figure 13. Locations where we captured little brown myotis (*Myotis lucifugus*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

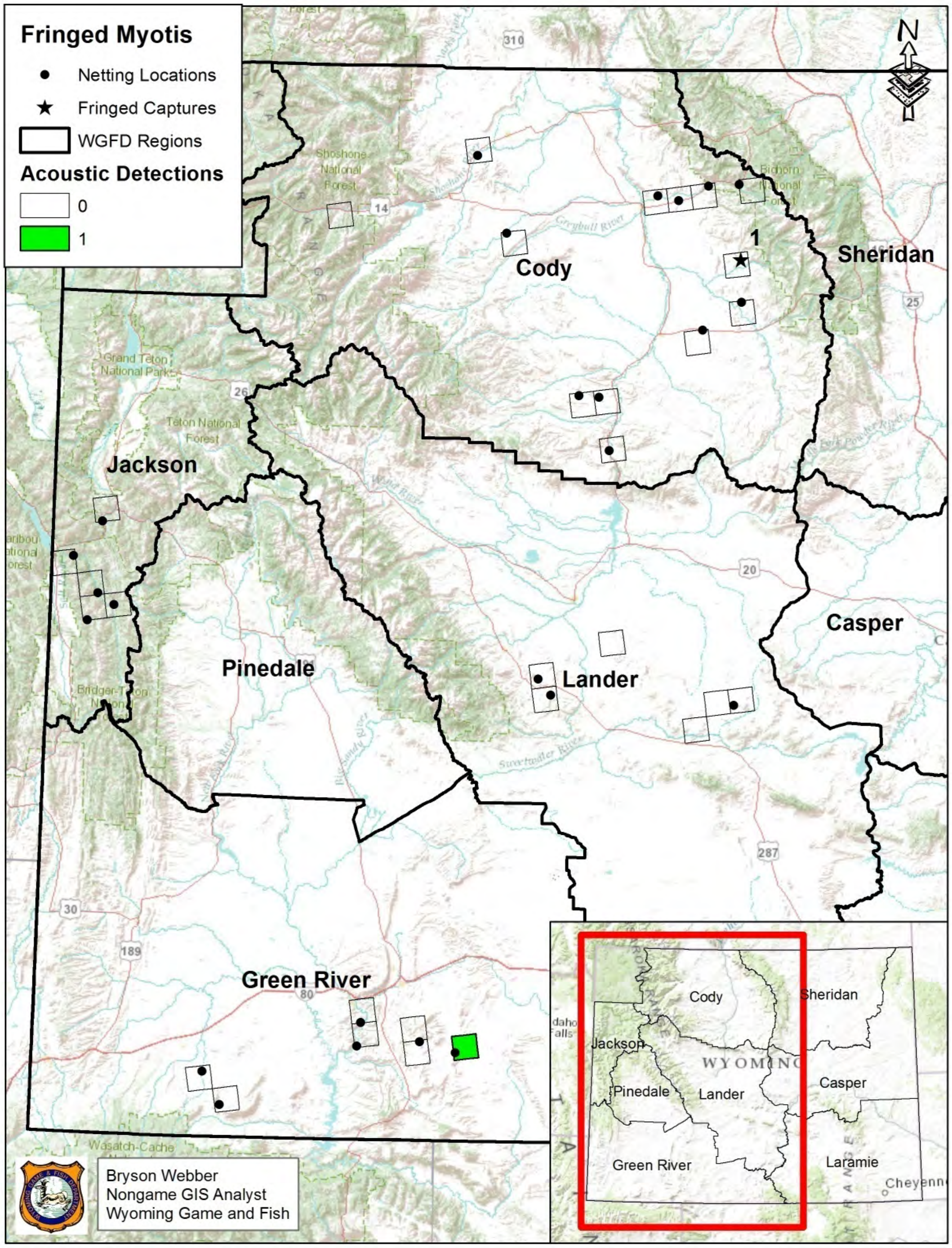

Figure 14. Locations where we captured fringed myotis (*Myotis thysanodes*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

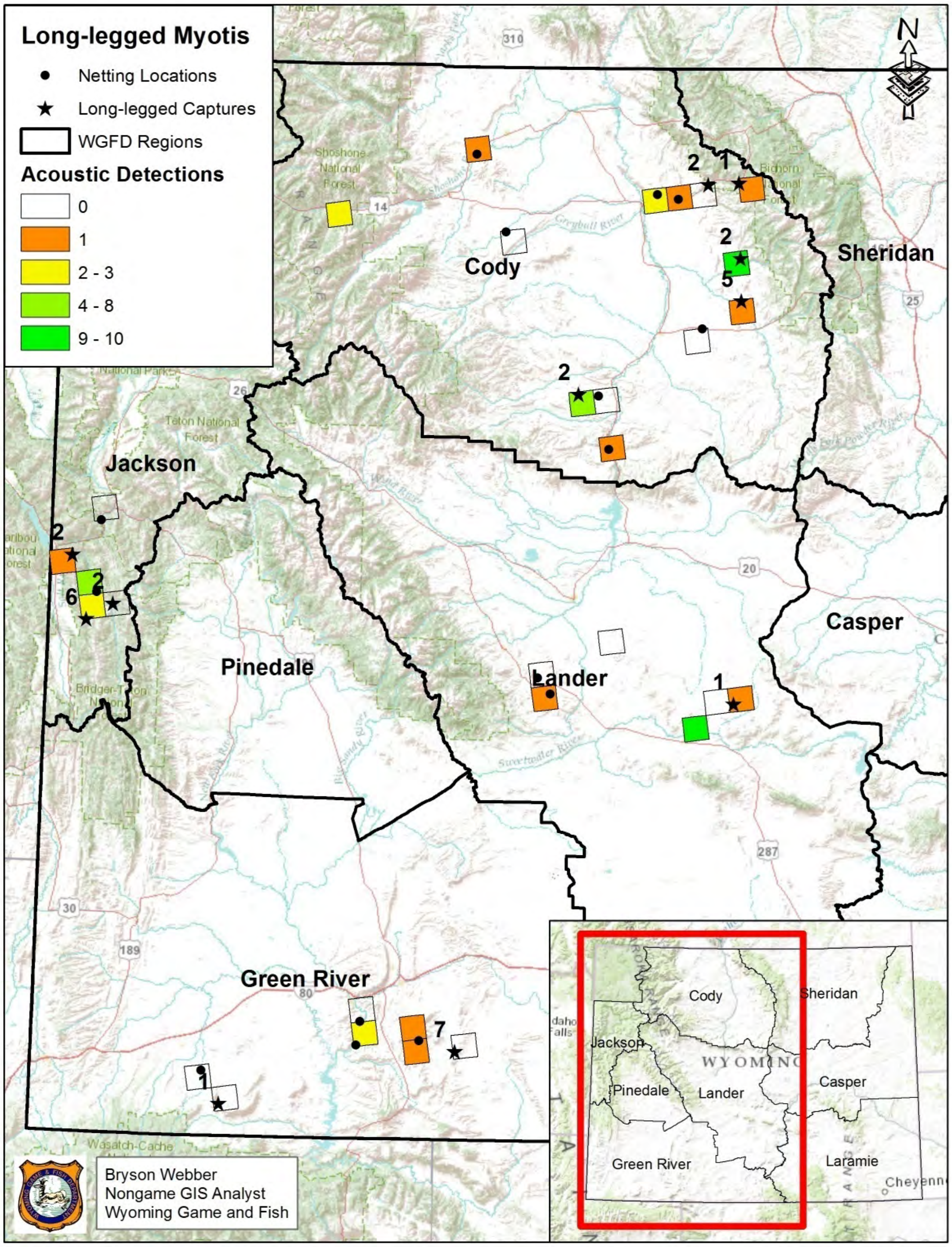

Figure 15. Locations where we captured long-legged myotis (*Myotis volans*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

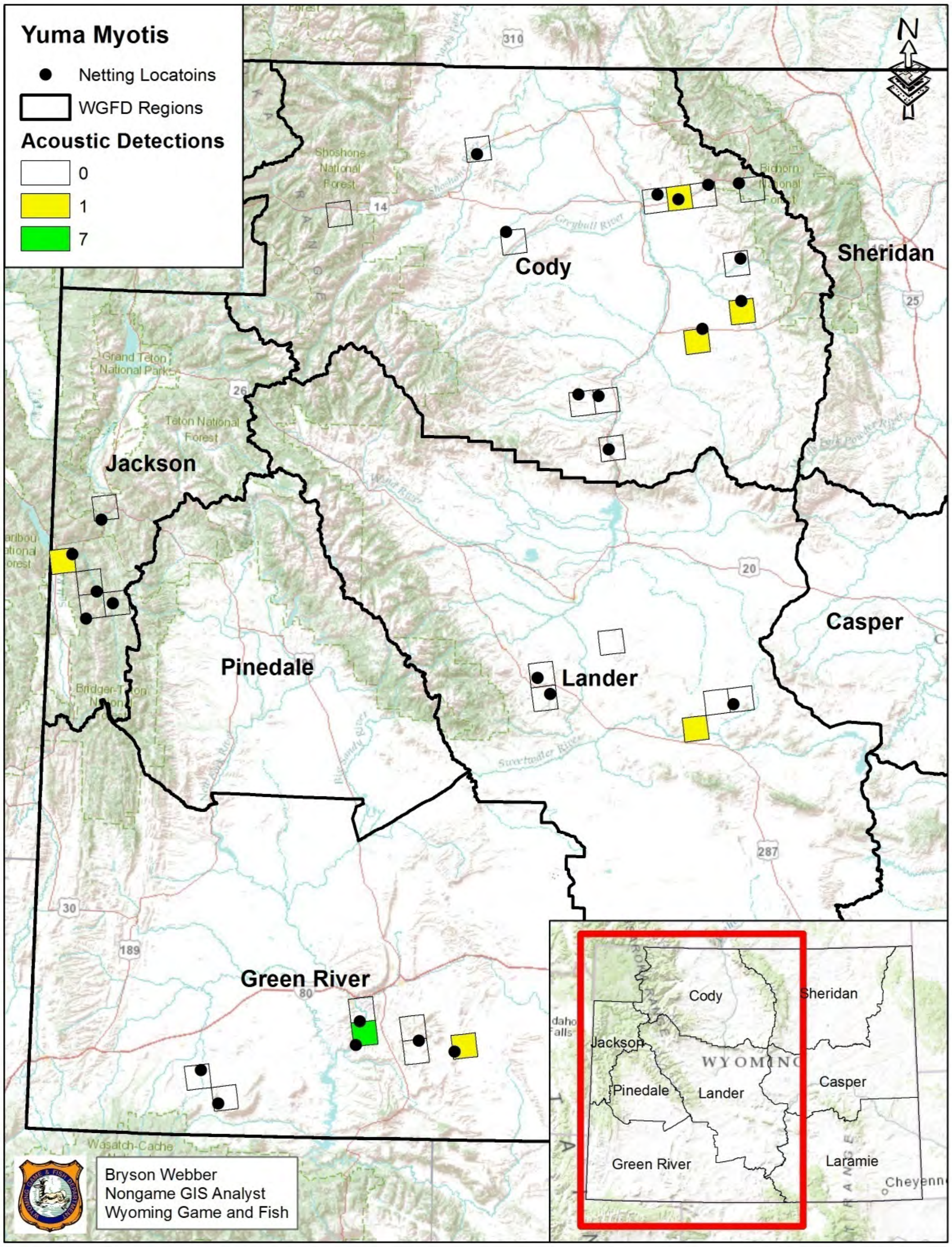

Figure 16. Locations where we captured Yuma myotis (*Myotis yumanensis*) observed within each survey grid in western Wyoming, May-September, 2012. Color of grid corresponds with the number of acoustic detections (i.e., classified call files). Points represent locations where we captured bats with labels corresponding to the number of individuals we captured for this species.

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

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Bats

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

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2012 – 15 April 2013

PREPARED BY: Becky Abel, Nongame Biologist
Martin Grenier, Nongame Mammal Biologist

ABSTRACT

Species of cave- and abandoned mine-hibernating bats in Wyoming are at risk of contracting white-nose syndrome if the causative fungus *Geomyces destructans* continues spreading west. Three species of bats that are found in Wyoming are known to be particularly vulnerable to white-nose syndrome in their eastern range, including the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), and eastern pipistrelle (*Pipistrellus subflavus*). Populations of bats in caves and abandoned mines of Wyoming are orders of magnitude smaller than those in eastern North America, making it difficult to determine if white-nose syndrome will affect populations at the same magnitude should it be introduced in the west. Conditions for optimal growth of *G. destructans* are specific and environmental conditions of caves and abandoned mines in Wyoming are thought to be different from those in eastern North America. Data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming are limited. Our objective in 2012 was to install data loggers that record temperature and humidity inside caves and abandoned mines in Wyoming where the risk of *G. destructans* being introduced and becoming established is high. Our other objective was to census hibernating bats present at each site. We visited 10 sites in 2012, and installed 59 data loggers in 7 of those sites. At 6 sites we observed hibernating bats, including Townsend's big-eared bats (*Corynorhinus townsendii*), big brown bats (*Eptesicus fuscus*), western small-footed myotis (*M. ciliolabrum*), little brown myotis, and long-eared myotis (*M. evotis*). We will revisit sites with data loggers in 2013 to replace devices and download temperature and humidity data.

INTRODUCTION

Bats that hibernate in caves and abandoned mines in North America are at risk of contracting a fungus that is causing major declines in bat populations in the eastern United States and Canadian provinces, namely, white-nose syndrome (WNS). WNS is named after a conspicuous white fungus, *Geomyces destructans,* that invades and erodes the skin of hibernating bats, causing bats to arouse more frequently and prematurely deplete fat stores (Cryan et al. 2010). *G. destructans* growth causes a loss of dermal integrity and disrupts the skin's regulatory properties for fluid balance during hibernation. While the ultimate cause of death is *G. destructans* infection, proximal causes of death as a result of infection include starvation, dehydration, and exposure to cold temperatures. WNS and *G. destructans* has been confirmed in 21 states and 5 Canadian provinces, and may continue spreading west in the near future. In order to address this concern, the Wyoming Game and Fish Department (Department) Nongame Program developed a strategic plan for WNS in Wyoming. The plan outlines actions to facilitate management responses, increase public and agency awareness, and attempt to minimize the risk of spreading *G. destructans* via human activities to bats and their habitats in Wyoming (Abel and Grenier 2012*a*).

Research and reported mortalities suggest that little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*) and eastern pipistrelle (*Pipistrellus subflavus*) are particularly vulnerable to WNS (Cryan et al. 2010). Although northern long-eared myotis and eastern pipistrelle are thought to be rare in Wyoming, little brown myotis is widespread and is the most commonly captured and reported bat species in the state (Abel and Grenier 2012*a*, 2012*b*, 2012*c*). There are 88 known little brown myotis roosts in Wyoming; however, survey data suggest the majority support <50 individuals. Since roosts in Wyoming commonly support populations of bats that are orders of magnitude smaller than populations found in roosts of eastern North America, it is unknown whether WNS will similarly impact populations of bats in Wyoming should it spread west.

Conditions for optimal growth of *G. destructans* include cool temperatures (12.5-15.8^{o} C) and high humidity (Flory et al. 2012, Verant et al. 2012). If the fungus is introduced in Wyoming, habitats in caves and abandoned mines must provide suitable conditions that would support and promote the growth of *G. destructans* in order for it to become established. However, it is unclear whether suitable conditions for *G. destructans* exist within caves and abandoned mines in Wyoming (Truex, pers. comm). Further, less is known about how WNS will potentially affect populations of bats in the west. There is limited data quantifying interior temperatures and humidity of caves and abandoned mines in Wyoming. Some data are available; however, these data are primarily from single surveys. Thus, our understanding of how these parameters vary inter- and intra-seasonally is limited. It has been hypothesized that temperature and humidity of caves and abandoned mines in Wyoming may differ from those in eastern North America and may not be favorable for optimal growth of *G. destructans* (Abel and Grenier 2012*a*, Truex pers. comm).

Our primary objective in 2012 was to deploy data loggers inside caves and abandoned mines in Wyoming to record temperature and humidity. We selected sites where the risk of *G.*

destructans being introduced and becoming established was highest. Our other objective was to census hibernating bats present at each site.

METHODS

We chose to survey roosts that had not been surveyed in the last 3 or more years in an attempt to minimize disturbance to bats and their environment. Within each site, we deployed iButton devices (DS1923-F5, Maxim Integrated, San Jose, CA; data loggers). Each data logger was placed in an iButton key ring (DS9093A+, Maxim Integrated, San Jose, CA) before being deployed. We selected sites that we considered were at risk for contracting WNS fungus. In selecting sites, we considered historical use by hibernating bats, recreational pressure, and whether the roost was gated (Truex pers. comm). We numbered each data logger uniquely with a three digit numerical code (ID no.). We programmed the data loggers to record temperature and humidity data once every 3 hrs.

While at the roost, we worked in crews of two or three to independently search for hibernating bats. We counted individuals and attempted to identify each bat to species, after which we convened and compared data to ensure species counts and identifications were accurate. We deployed data loggers at specific locations within chambers or passages where bats were concentrated. We also placed data loggers inside the entrance and in one to two locations exterior to the site. We placed data loggers in locations that would not be obvious to recreational users, but would facilitate retrieval in the future. When we deployed a data logger, we recorded the ID no., description of location, name of the chamber or passage, and the method we used to attach data logger. Additionally, we measured the temperature and humidity at each location using a pocket weather station (Kestrel 3500, Kestrel Meters, Birmingham, MI). Lastly, we photographed each data logger once it was deployed. We adhered to all WNS survey and decontamination protocols outlined in Abel and Grenier (2012*a*).

RESULTS AND DISCUSSION

We surveyed 10 sites in 2012. We installed 59 data loggers at seven sites (Table 1). We observed hibernating bats at six sites; however, two sites were surveyed in late summer when hibernating bats were not present. Hibernating bats we observed included 47 Townsend's big-eared bats (*Corynorhinus townsendii*), 6 big brown bats (*Eptesicus fuscus*), 37 western small-footed myotis (*Myotis ciliolabrum*), 32 little brown myotis, and 33 long-eared myotis (*M. evotis*; Table 1). We will revisit sites in 2013 to replace data loggers and download temperature and humidity data.

ACKNOWLEDGEMENTS

Funding for this project was provided by the US Fish and Wildlife Service (USFWS) through State Wildlife Grants and Wyoming State Legislature General Fund Appropriations, for which we are grateful. The Bureau of Land Management, US Forest Service, and USFWS all provided data loggers for this project. We thank private landowners for granting access to several sites for this project. We also extend a special thanks to Department personnel L. Van Fleet, N. Cudworth, and J. Julien for their assistance in the field, and B. Webber and S. Cornell for their assistance with GIS.

LITERATURE CITED

Abel, B. L., and M. B. Grenier. 2012*a*. A strategic plan for white-nose syndrome in Wyoming version 1.1. Wyoming Game and Fish Department Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2012*b*. Inventories of forest bats in southeastern Wyoming: mist netting. Pages 125-154 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Abel, B. L., and M. B. Grenier. 2012*c*. Inventories of forest bats in southeastern Wyoming: acoustic surveys. Pages 125-154 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, B. Abel, and N. Cudworth, Editors). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Cryan, P. M., C. U. Meteyer, J. G. Boyles, and D. S. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135.

Flory, A. R., S. Kumar, T. J. Stohlgren, and P. M. Cryan. 2012. Environmental conditions associated with bat white-nose syndrome mortality in the north-eastern United States. Journal of Applied Ecology 49:680-689.

Verant, M. L., J. G. Boyles, W. Waldrep, Jr., G. Wibbelt, and D. S. Blehert. 2012. Temperature-dependent growth of (*Geomyces destructans*), the fungus that caused bat white-nose syndrome. PLoS ONE 7:346280.

Table 1. Sites we visited in Wyoming in 2012 with species of bats observed and number of iButton data loggers deployed. ID number is a unique number designated by the Wyoming Game and Fish Department Nongame Program for each site in the Caves and Abandoned Mines database. Species observed includes Townsend's big-eared bat (*Corynorhinus townsendii*; COTO), western small-footed myotis (*Myotis ciliolabrum*; MYCI), little brown myotis (*M. lucifugus*; MYLU), big brown bat (*Eptesicus fuscus*; EPFU), and long-eared myotis (*M. evotis*; MYEV).

ID	Date	Species observed	No. iButtons
554	2/21/2012	-	0
122	2/22/2012	COTO (24), MYCI (13), EPFU (3)	0
494	2/22/2012	COTO (2), MYCI (2)	0
61	3/13/2012	COTO (6), MYCI (4)	0
71	3/27/2012	COTO (11), MYCI (6), MYLU (28), MYEV (33)	8
143	4/10/2012	-	10
133	4/11/2012	COTO (3), MYCI (8), MYLU (4), EPFU (3)	9
392	4/12/2012	COTO (1), MYCI (4)	6
91	4/25/2012	-	9
121	9/13/2012	-	9
40	9/14/2012	-	8

HABITAT CHARACTERISTICS INFLUENCING SWIFT FOX (*VULPES VELOX*) OCCUPANCY IN EASTERN WYOMING

STATE OF WYOMING

NONGAME MAMMALS: Species of Greatest Conservation Need – Swift Fox

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

PROJECT DURATION: 1 July 2009 – 30 June 2011

PERIOD COVERED: 15 April 2011 – 14 April 2012

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

ABSTRACT

Swift fox (*Vulpes velox*) abundance and distribution declined greatly in the late 19th and 20th centuries due to loss of native prairie habitat and widespread predator control. The Wyoming Game and Fish Department classifies the swift fox as a Species of Greatest Conservation Need because statewide population trends are unknown and the species is at risk from habitat loss and secondary poisoning. In 2010, we used remote infrared cameras to document occupancy of swift fox and update distribution in Wyoming. During surveys, we detected swift fox on five survey grids classified predominately as sagebrush (*Artemisia* spp.), three of which were outside the predicted distribution developed for the State Wildlife Action Plan. Accordingly, we returned to this subset of grids in 2011 to quantify vegetative characteristics. Grids where we detected swift fox tended to have shorter shrubs on average and a different species composition of shrubs compared to grids that occurred in sagebrush habitats where we did not detect swift fox. These results suggest swift fox are likely expanding their distribution westward into sagebrush shrublands and may be utilizing areas previously believed to be unsuitable. Incorporating habitat data during future surveys will help elucidate vegetative characteristics important to swift fox occupancy and may help improve the current distribution and range models for this and other Species of Greatest Conservation Need.

INTRODUCTION

The swift fox (*Vulpes velox*) is a small canid that historically occupied the short- and mixed-grass prairies from northern Texas to southern Canada. Swift fox are highly dependent upon underground dens for pup-rearing (Egoscue 1979). Consequently, suitable habitat for denning may be a key factor in determining presence. Historically, swift fox range covered 12 states, including areas east of the Continental Divide in Wyoming. However, swift fox abundance and distribution declined greatly in the late 19th and 20th centuries due to loss of native prairie habitat and increased predator control (Scott-Brown et al. 1987). The swift fox was petitioned for listing as endangered under the Endangered Species Act (ESA) in 1992, and the US Fish and Wildlife Service issued a "warranted but precluded" finding in 1995. Due in large part to conservation efforts by the Swift Fox Conservation Team and the collection of new data, the swift fox was removed from the ESA Candidate List in 2002. Currently, the swift fox is classified as a Tier 2 Species of Greatest Conservation Need (SGCN) with a Native Species Status of 4 (NSS4) by the Wyoming Game and Fish Department (Department). Although distribution of swift fox is secure and the species is widely distributed, data on population status for the majority of the state are lacking (WGFD 2010).

In 2010, we used remote infrared cameras on 95 survey grids to document occupancy and update the current distribution of swift fox in eastern Wyoming (Cudworth et al. 2011). We recorded 106 unique observations on 25 grids. However, nine of these detections occurred on five grids predominately classified as sagebrush (*Artemisia* spp.). Although swift fox are known to use areas scattered with short, sparse sagebrush plants, these areas are generally not considered to provide habitat for swift fox (Kilgore 1969, Egoscue 1979, Olson and Lindzey 2002, Finley et al. 2005). Accordingly, we returned to these grids in 2011 to quantify vegetative characteristics with the objective to determine what factors influence swift fox occupancy in areas traditionally considered to be marginal habitat.

METHODS

In 2010, we divided the eastern 2/3rd of Wyoming into grids of 31 km^2 and randomly selected 100 grids from all available grids on which to deploy remote infrared cameras (Cudworth et al. 2011). We returned to a subset of these grids from May-September 2011 to conduct vegetative surveys. We used a paired design to record vegetative characteristics at all occupied grids classified as ≥50% sagebrush (n = 5) and the nearest unoccupied grid classified as ≥50% sagebrush (n = 5; Fig. 1). We generated five random locations per grid to serve as center points for vegetative measurements.

We based our vegetative measurements on methods described by Olson (2000). For each random location, we used two perpendicular transects, each 50 m in length, to record vegetative characteristics. We recorded the total amount of each 50-m transect intersected by vertical projections of the canopy to determine canopy cover (Canfield 1941). This method is most appropriate for shrub communities because it provides a high level of accuracy and precision of canopy cover by recording actual values instead of estimates (Higgins et al. 1996). We also recorded species and maximum heights of all shrubs along each transect to determine species composition and maximum shrub height (Olson 2000). We used a modified cover board with alternating bands of 10 cm to record minimum height at which <50% of a band was obscured by vegetation to estimate visual obstruction (Nudds 1977, Olson 2000, Uresk et al. 2003). We took four measurements of visual obstruction per transect at 15 and 25 m from the center of the perpendicular transects. We recorded all visual obstruction measurements from a height of 30 cm (swift fox eye level; Olson 2000). At the end of each transect and at the center point of the perpendicular transects, we used Daubenmire (1959) plots of 0.1 m^2 (20 × 50 cm) to record visual estimates of percent ground cover for bare soil, rock, grass, forbs, lichen, cacti, litter, and shrubs.

We converted the amount of each transect intersected by the canopy to a percentage to determine canopy cover, and averaged the maximum height of all shrubs encountered along transects to provide a mean (±SE) for shrub height. We averaged values (i.e., canopy cover, visual obstruction, and maximum shrub height) from each random point within a grid to provide grid-wide estimates. Finally, we calculated the total number of shrubs and Shannon-Weiner diversity for each grid. We conducted all habitat analyses in SigmaPlot (Systat Software Inc., Chicago, Illinois.). We used paired *t*-tests to compare values from occupied and unoccupied grids to determine what factors influence occupancy of swift fox in sagebrush habitat. We used chi-squared tests to compare ground cover and species composition. We only used shrubs for which we recorded ≥100 individuals from all grids combined to evaluate species composition.

RESULTS

We detected no difference in canopy cover (t_4 = 1.20, P = 0.30), visual obstruction at either 15 m (t_4 = 1.49, P = 0.21) or 25 m (t_4 = 1.50, P = 0.21), number of shrubs (t_4 = -0.27, P = 0.80), or diversity (t_4 = 0.61, P = 0.58) between occupied and unoccupied grids. Only shrub height tended to be important, with shrubs on grids containing swift fox averaging 9.27 cm (±3.59 cm) shorter than shrubs on grids where we did not detect swift fox (t_4 = 2.59, P = 0.061; Table 1). We detected no difference in ground cover between occupied and unoccupied grids (χ^2_8 = 11.61, P = 0.17).

We recorded 2,334 shrubs representing 14 species when all grids were combined. However, we recorded a combined total of ≥100 shrubs for only 5 of these species, which represented 93.7% (n = 2,188) of all recorded shrubs. Shrub composition was distributed non-randomly between occupied and unoccupied grids (χ^2_4 = 151.76, P < 0.001). Grids containing swift fox had 1.8× more black sagebrush (*Artemisia nova*), 1.6× more green rabbitbrush (*Chrysothamnus viscidiflorous*), 1.4× more birdfoot sagebrush (*A. pedatifida*), 3.8× fewer fringed sagebrush (*A. frigida*), and 1.5× fewer Wyoming big sagebrush (*Artemisia tridentata* w*yomingensis*) than grids without swift fox (Table 2).

DISCUSSION

Swift fox are most often associated with flat landscapes dominated by short-grass prairie; sagebrush habitats are typically not considered to provide habitat for swift fox (Kilgore 1969, Egoscue 1979, Finley et al. 2005, but see Olson and Lindzey 2002). However, during an occupancy survey in 2010, we detected swift fox on multiple grids where the majority of the habitat was classified as sagebrush. When comparing vegetative characteristics from these occupied grids to nearby, unoccupied grids, only shrub height was selected by swift fox: shrubs tended to be shorter on occupied grids. This pattern has also been observed at the grassland-sagebrush interface in Shirley Basin in southeastern Wyoming, where swift fox had similar survival and larger litter sizes in these areas sparsely interspersed with sagebrush <1 m tall compared to other portions of their range (Olson and Lindzey 2002). However, sagebrush areas also had the greatest mortality from predation compared to other vegetation types (Olson 2000). Coyotes are known predators of swift fox and can be major causes of mortality (Sovada et al. 1998, Kitchen et al. 1999, Olson and Lindzey 2002); shorter vegetative structure may be essential in allowing swift fox to detect these predators (Kamler et al. 2003). Maximum shrub heights in this study averaged 20.3 cm (±3.3 cm), nearly 10 cm shorter than the average eye level of swift fox (30 cm; Olson 2000). Because of the potentially major threat of predation by other canids, swift fox likely selected areas with shorter shrub heights in an effort to maximize detection of predators.

Composition of shrub species also differed between occupied and unoccupied grids, likely due to a combination of shrub height in order to maximize detection of predators, and soil type in order to maximize suitable structures for denning. Occupied sites tended to have more black sagebrush, green rabbitbrush, and birdfoot sagebrush than unoccupied sites. Both black and birdfoot sagebrush are low-growing shrubs, with black sagebrush reaching 10-30 cm and birdfoot sagebrush reaching 5-15 cm (Taylor 2006, Fryer 2009). Additionally, black sagebrush is associated with a variety of loamy soil types that can be deep in areas where it is associated with Wyoming big sagebrush, as in our study area (Fryer 2009). Because dens of swift fox are most often associated with areas of loamy soil (Kilgore 1969, Jackson and Choate 2000, Olson 2000), black sagebrush may be indicative of areas suitable for swift fox dens. Although green rabbitbrush can reach between 0.3 and 1.1 cm, it is also typically associated with dry, well-drained soils, often in disturbed areas (Tirmenstein 1999). Alternatively, occupied sites tended to have fewer fringed sagebrush and Wyoming big sagebrush than unoccupied sites. Fringed sagebrush is both low-growing, reaching only 10-35 cm, and grows best in a variety of loamy soils (McWilliams 2003), so fewer fringed sagebrush on occupied grids is interesting. However, fringed sagebrush only accounted for 5.1% of all plants recorded on our grids and may simply not have been common enough to influence swift fox habitat selection. Big sagebrush, however, was very common and can grow from 0.6 to 4.0 m, although the Wyoming big sagebrush subspecies typically ranges from 60 to 90 cm (Winward 2004). Although typically associated with deep soils, these soils are usually composed of a high percentage of silt or clay (Howard 1999), which are unsuitable for swift fox dens.

Although we recorded data on a number of vegetative characteristics that have been shown to be important to swift fox in other studies (e.g., Olson 2000, Uresk et al. 2003), only shrub height and species composition tended to differ between occupied and unoccupied grids. Given a sample size of only five paired grids, it is not surprising that more variables were not significantly different. Additionally, because we wanted to compare areas where we knew swift fox were present to areas where they were not detected, we compared occupied to unoccupied grids. However, all these grids met the minimum criteria we originally set when determining potential habitat. Consequently, we would expect occupied grids to be more similar to unoccupied grids in terms of vegetative and physical characteristics than grids that were selected completely at random. Additional collection of habitat characteristics in subsequent surveys will help tease out these potential explanations and improve our understanding of specific vegetative characteristics important to occupancy.

Swift fox appear to select for specific vegetative and physical characteristics within areas classified as sagebrush. A number of SGCN are recognized by the Department as sagebrush-obligate species or species that use sagebrush shrublands opportunistically (WGFD 2010). However, the vegetation layer used to develop the habitat model for Wyoming only has a single designation for sagebrush and does not differentiate among the extreme variation in canopy densities and heights of sagebrush plants. Consequently, we are likely overlooking a substantial amount of variation present in this habitat type. This project emphasizes the need for more precise information in the sagebrush vegetation layer that is used by the Department to predict state-wide distributions of SGCN. Sagebrush shrublands are exposed to a number of threats, including invasive plants, incompatible energy development and mining practices, and rural subdivision (WGFD 2010). As these threats continue to cause changes in or loss of sagebrush habitat, potentially causing species to shift statewide distributions, it is increasingly important to accurately predict species ranges for conservation and management activities.

ACKNOWLEDGEMENTS

Funding for this project was provided by the US Fish and Wildlife Service through State Wildlife Grants funds, for which the Department is extremely grateful. We also extend a special thanks to the county assessors and the Department's game wardens and regional biologists for their assistance in our efforts to contact private landowners during the initial survey. We are especially thankful to the many private landowners who graciously provided access to their lands. Wyoming Game and Fish Department nongame GIS technician S. Cornell and nongame biologists C. Atkinson, L. Van Fleet, and D. Wilckens provided invaluable assistance in survey design and field work.

LITERATURE CITED

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388-394.

Cudworth, N., L. Van Fleet, and M. Grenier. 2011. Monitoring trends and documenting distribution of swift fox in Wyoming. Pages 162-170 *in* Threatened, endangered, and nongame bird and mammal investigations (M. B. Grenier, Editor). Wyoming Game and Fish Department Nongame Program, Lander, USA.

Daubenmire, R. F. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Egoscue, H. J. 1979. *Vulpes velox*. Mammalian Species 122:1-5.

Finley, D. J., G. C. White, and J. P. Fitzgerald. 2005. Estimation of swift fox population size and occupancy rates in eastern Colorado. Journal of Wildlife Management 69:861-873.

Fryer, J. L. 2009. *Artemisia nova*. *In* Fire effects information system. US Department of Agriculture, Forest Service. Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed.us/database/feis (accessed 29 November 2011).

Higgins, K. F., J. L. Oldemeyer, K. J. Jenkins, G. K. Clamvey, and R. F. Harlow. 1996. Vegetation sampling and measurement. Pages 567-591 *in* Research and management techniques for wildlife and habitats 5th edition, revised (T. A. Bookhout, Editor). The Wildlife Society, Bethesda, MD, USA.

Howard, J. L. 1999. *Artemisia tridentata* subsp. *wyomingensis*. *In* Fire effects information system. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed/us/databases/feis (accessed 29 November 2011).

Jackson, V. L., and J. R. Choate. 2000. Dens and den sites of the swift fox, *Vulpes velox*. The Southwestern Naturalist 45:212-220.

Kamler, J. F., W. B. Ballard, E. B. Fish, P. R. Lemons, K. Mote, and C. C. Perchellet. 2003. Habitat use, home ranges, and survival of swift foxes in a fragmented landscape: conservation implications. Journal of Mammalogy 84:989-995.

Kilgore, D. L., Jr. 1969. An ecological study of the swift fox (*Vulpes velox*) in the Oklahoma panhandle. American Midland Naturalist 81:512-534.

Kitchen, A. M., E. M. Gese, and E. R. Schauster. 1999. Resource partitioning between coyotes and swift foxes: space, time, and diet. Canadian Journal of Zoology 77:1645-1656.

McWilliams, J. 2003. *Artemisia frigida*. *In* Fire effects information system. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed/us/databases/feis (accessed 29 November 2011).

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5:113-117.

Olson, T. L. 2000. Population characteristics, habitat selection patterns, and diet of swift foxes in southeast Wyoming. Thesis. University of Wyoming, Laramie, USA.

Olson, T. L., and F. G. Lindzey. 2002. Swift fox survival and production in southeastern Wyoming. Journal of Mammalogy 83:199-206.

Scott-Brown, J. M., S. Herrero, and J. Reynolds. 1987. Swift fox. Pages 433-411 *in* Wild furbearer management and conservation in North America (M. Novak, J. A. Baker, M. E. Obbard, and B. Mallock, Editors). Ontario Ministry of Natural Resources, Toronto, Canada.

Sovada, M. A., C. C. Roy, J. B. Bright, and J. R. Gills. 1998. Causes and rates of mortality of swift foxes in western Kansas. Journal of Wildlife Management 62:1300-1306.

Taylor, J. E. 2006. *Artemisia pedatifida*. *In* Fire effects information system. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed.us/databases/feis (accessed 29 November 2011).

Tirmenstein, D. 1999. *Chrysothamnus viscidiflorus*. *In* : Fire effects information system. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed/us/databases/feis (accessed 29 November 2011).

Uresk, D. W., K. E. Severson, and J. Javersak. 2003. Vegetative characteristics of swift fox denning and foraging sites in southwestern South Dakota. US Department of Agriculture, Forest Service, Research Paper RMRS-RP-38. Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Winward, A. H. 2004. Sagebrush of Colorado: taxonomy, distribution, ecology and management. Colorado Division of Wildlife, Department of Natural Resources, Denver, USA.

Wyoming Game and Fish Department [WGFD]. 2010. Wyoming state wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Vegetative characteristics ($\bar{x}$ ± SE) at grids classified as ≥50% sagebrush (*Artemisia* spp.) that were occupied (n=5) and unoccupied (n=5) by swift fox (*Vulpes velox*) in eastern Wyoming, September-November 2010. Vegetation was recorded in summer 2011. Visual obstruction was defined as the minimum height at which <50% of a 10-cm band was obscured by vegetation. P-value from paired t-test.

Characteristic	Occupied		Unoccupied		P-value
	$\bar{x}$	SE	$\bar{x}$	SE	
Canopy cover (%)	11.06	2.09	12.89	2.43	0.298
Maximum shrub height (cm)	20.30	3.28	29.57	4.83	0.061
15 m visual obstruction (cm)	36.40	5.98	43.85	7.21	0.209
25 m visual obstruction (cm)	45.10	8.01	53.95	8.98	0.208
Total number of shrubs	240.40	52.06	226.40	68.95	0.798
Shannon-Weiner diversity	2.46	0.05	2.90	0.49	0.576

Table 2. Percent observed and expected shrub composition in grids classified as ≥50% sagebrush (*Artemisia* spp.) that were occupied (n=5) by swift fox (*Vulpes velox*) in eastern Wyoming, September-November 2010. Shrub composition was recorded in summer 2011. Expected values based upon composition of unoccupied grids (n=5). Only the most common species (≥100 recorded observations) are included.

Shrub species	% Observed	% Expected
Birdfoot sagebrush	9.2	6.4
Black sagebrush	42.3	23.9
Fringed sagebrush	2.4	9.2
Green rabbitbrush	9.0	5.8
Wyoming big sagebrush	37.0	54.8

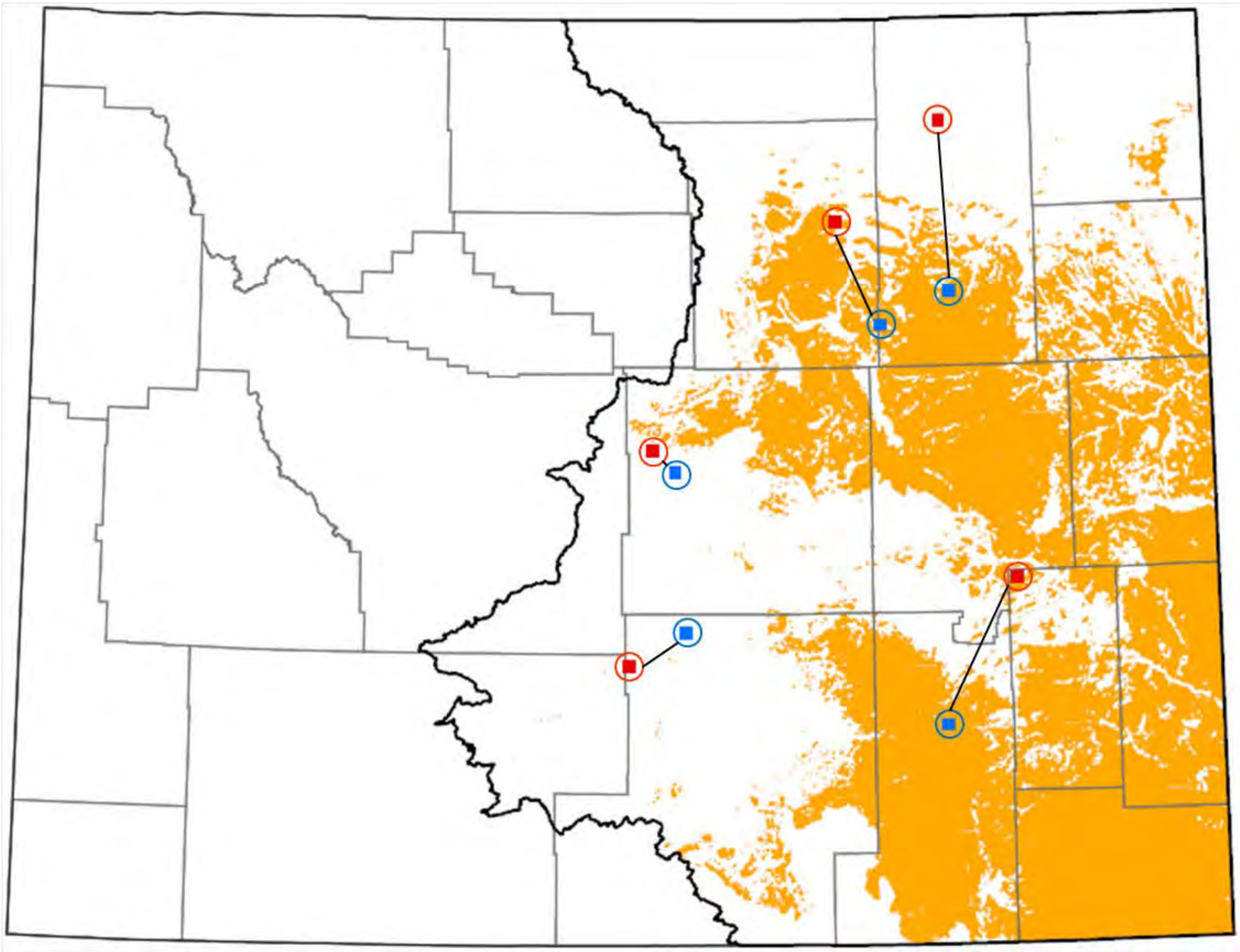

Figure 1. Locations of grids classified as ≥50% sagebrush (*Artemisia* spp.) that were occupied (blue squares; *n*=5) by swift fox (*Vulpes velox*) and the nearest grid classified as ≥50% sagebrush that was unoccupied (red squares; *n*=5) by swift fox, eastern Wyoming, September-November 2010. The predicted range is outlined in solid black, and the predicted distribution is shaded in orange. Counties are shown for reference.

SPECIES OF GREATEST CONSERVATION NEED – *BIRDS & MAMMALS*

CASPER REGIONAL NONGAME BIOLOGIST SUMMARY

STATE OF WYOMING

NONGAME BIRDS AND MAMMALS: Species of Greatest Conservation Need

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

PROJECT DURATION: 1 July 2012 – 30 June 2014

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Nichole Cudworth, Nongame Biologist

SUMMARY

In 2012, the Wyoming Game and Fish Department received funding through the State Wildlife Grants Program for a regional Nongame Biologist position in the Casper Regional Office. The impetus for this position was the recognition of a need for regional nongame personnel to facilitate communication and information exchange between the statewide Nongame Program and personnel in the Casper region The regional Nongame Biologist has been stationed in the Casper office since October 2012.

In December 2012, the Nongame Biologist provided an update to the Casper Region on the results of the Forest Bat Inventory, conducted by the Nongame Program from 2008-2011, as part of the All Region Meeting. In February 2013, the Nongame Biologist completed handouts for each of the wardens in the Casper Region detailing all avian and mammalian Species of Greatest Conservation Need (SGCN) present in each warden's district, as well as additional information on identification, habitat, activity patterns, and common survey techniques for seven "priority" SGCN. These species were identified by the Nongame Bird Biologist, Nongame Mammal Biologist, and Casper Wildlife Coordinator as priority species requiring additional observational data.

Upcoming projects in the Casper Region include assisting with Greater Sage-Grouse (*Centrocercus urophasianus*) lek counts, conducting Breeding Bird Survey routes, assisting with training for grassland bird surveys, continuing surveys for Preble's meadow jumping mice (*Zapus hudsonius preblei*), and assisting with swift fox (*Vulpes velox*) occupancy surveys.

HARVEST REPORTS

HARVEST OF RAPTORS FOR FALCONRY

STATE OF WYOMING

NONGAME BIRDS: Raptors

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

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2012 – 31 December 2012

PREPARED BY: Courtney Rudd, Nongame Biologist
Allen Deru, Game Warden

SUMMARY

In 2012, the Wyoming Game and Fish Department issued 41 falconry capture licenses. The number of licenses issued represented an increase from 2010 and 2011 (19 and 30 licenses, respectively), but is similar to those issued in 2007 (39). Licenses were issued for 25 residents and 16 nonresidents. Similar to 2011, capture success was greater for nonresidents (62.5%) than residents (40%). Residents filled 10 of 25 licenses; nonresidents filled 10 of 16 licenses. Northern Goshawks (*Accipiter gentilis*) and Red-tailed Hawks (*Buteo jamaicensis*) were the two most commonly captured species, with four captures of each species. All Northern Goshawk captures were taken by nonresidents, while three of four Red-tailed Hawk captures were taken by residents. Three captures each of American Kestrels (*Falco sparverius*) and Ferruginous Hawks (*Buteo regalis*) were reported. Although Golden Eagles (*Aquila chrysaetos*) were the second most common captured species in 2011, no individuals were captured during 2012. Additional species captured in 2012 include: Cooper's Hawk, (*Accipiter cooperii*) Merlin (*Falco columbarius*), Prairie Falcon (*Falco mexicanus*), and Great Horned Owl (*Bubo virginianus;* Table 1). The total number of birds captured in 2012 (n=20) was less than the mean number of captures from 1981-2011 (22.9 ± 1.5 birds). However, capture success for 2012 (49%) was slightly greater than the mean capture success from 1981-2011 (46.9% ± 2.3%; Table 2).

Table 1. Species and number of raptors captured by residents and nonresidents for falconry in Wyoming, 2012.

Species captured	Number of resident captures	Number of nonresident captures	Total captures
Cooper's Hawk	2	0	2
Northern Goshawk	0	4	4
Red-tailed Hawk	3	1	4
Ferruginous Hawk	0	3	3
American Kestrel	3	0	3
Merlin	1	0	1
Prairie Falcon	0	2	2
Great Horned Owl	1	0	1
Total	10	10	20

Table 2. Number of individuals captured and yearly capture success rate (%) for raptors taken for falconry in Wyoming, 1981-2012.

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

OTHER NONGAME – *BIRDS*

USING THE BREEDING BIRD SURVEY TO MONITOR POPULATION TRENDS OF AVIAN SPECIES IN WYOMING

STATE OF WYOMING

NONGAME BIRDS: Other Nongame

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations; Wyoming Governor's Endangered Species Account Funds; and National Park Service, United States Forest Service, Bureau of Land Management, United States Fish and Wildlife Service, and Bureau of Reclamation Cooperative Agreements

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Andrea Orabona, Nongame Biologist
Courtney Rudd, Nongame Bird Biologist
Unites States Geological Survey – Biological Resources Division

ABSTRACT

The Breeding Bird Survey has provided long-term monitoring of a variety of avian species in Wyoming since 1968. In 2012, volunteers surveyed 58 Breeding Bird Survey routes across the State. Overall, survey effort and number of detections per survey route have decreased, while the number of species detected per route has increased. Unlike previous years, population trend analysis was not available at the time of publication. Recruiting knowledgeable volunteers to conduct Breeding Bird Survey routes is critical to ensuring the success of the Breeding Bird Survey and our ability to continue to monitor breeding bird populations along roadside surveys.

INTRODUCTION

Forty-four nongame avian species are classified as Species of Greatest Conservation Need (SGCN) by the Wyoming Game and Fish Department (Department; WGFD 2010). However, only a small number of these are adequately monitored with species-specific surveys. Consequently, the Department utilizes data from other large-scale, multi-species survey efforts to monitor trends in avian populations. The Breeding Bird Survey (BBS) is used to monitor trends of breeding birds across North America. The BBS is sponsored jointly by the United States Geological Survey – Biological Resources Division (USGS-BRD; formerly the United States

Fish and Wildlife Service) and the Canadian Wildlife Service. Over 4,500 BBS routes are located across the continental US and Canada, with 108 established routes in Wyoming. The USGS-BRD has reviewed and analyzed data collected from the BBS since the survey's inception in 1966 in the East and 1968 in the West. BBS data provide indices of population abundance and can be used to estimate population trends and relative abundance of individual species at the continental, western region, statewide, and physiographic region scale. While 2011 population trend analysis had not been completed by publication time, it is available through 2010 for over 420 species of birds (Sauer et al. 2011). All raw data can be accessed on the BBS web site <http://www.pwrc.usgs.gov/bbs/>.

Our objectives in 2012 were to add additional data to the BBS and interpret current trends of nongame breeding birds in Wyoming. Due to the unavailability of 2011 population trend analysis at time of publication, the latter objective will be revisited during the preparation of next year's report.

METHODS

Volunteers are instructed to conduct BBS routes during the height of the avian breeding season when birds are most vocal. This is typically during the month of June, although routes in higher elevations can be conducted through the first week of July. Each route is 39.4 km long and consists of 50 stops spaced every 0.8 km. Beginning 0.5 hr before sunrise, observers record birds seen within a 0.4-km radius and all birds heard at each stop during a 3-min period. Each route is surveyed once annually, and data are submitted to the USGS-BRD for analysis. For all summary statistics on survey effort, we report averages ±SE. We only include data from those routes that had data submitted to the BBS by the due date. All analyses on abundance of breeding birds in Wyoming were conducted by USGS-BRD.

RESULTS

In 2012, observers surveyed approximately 2,527 of 3,511 (72 %) available routes in the US (USGS-BRD will not have final 2012 counts for available and surveyed routes until summer 2013). In Wyoming, observers attempted to survey 64 of the 108 (59%) established routes. We report results for 58 (90%) of the 64 attempted routes that were surveyed. The remaining six (9%) routes were surveyed but were not included in the analysis because data were not submitted to USGS-BRD by the due date (Table 1). Since 1990, the number of routes surveyed in Wyoming has decreased by 0.88 routes per year (P<0.001; R^2=0.5786; Fig. 1). Consistent with this trend, the number of routes surveyed in 2012 (i.e., 58 routes) was less than the mean number of routes completed from 1990-2011 (65.0 ±1.69 routes).

Observers detected a total of 26,699 individual birds representing 181 species in Wyoming (Table 2). Since 1990, the number of individuals detected has decreased by 5.0 individuals per route per year (P<0.001; R^2=0.570; Fig. 2), but the number of species detected has increased by 0.19 species per route per year (P<0.001; R^2=0.638; Fig. 3). Consistent with these trends, the number of individuals detected per route in 2012 (i.e., 458.6 ±39.2 individuals) was less than the mean number of individuals detected per route between 1990–2-11 (i.e., 536.8 ±9.1 individuals), but the number of species detected per route (i.e., 38.2 ±1.7 species) was similar to the mean number of species detected per route between 1990-2011 (i.e., 38.1 ±0.4 species).

DISCUSSION

A complete history of BBS observers and routes surveyed in Wyoming from 1968 through 2012 is available from the Department's Nongame Bird Biologist in the Lander Regional Office. Because the primary purpose of the BBS is to monitor population trends of avian species nationwide, it is important that each route is conducted annually, preferably by the same observer. However, in Wyoming fewer than 20 of the 108 total routes have been surveyed annually or with minimal interruptions in the annual survey cycle for >10 years. Most routes contain gaps in surveys of ≥2 years or have had ≥2 observers. There are several causes of BBS observer disruption: change in location or job duties during the course of an observer's career, loss of observers as they age and have increasing difficulty detecting vocalizations, and a limited pool of new and skillful observers in Wyoming from which to draw. In addition, as the degree of urbanization steadily increases, associated problems with safety and noise are an issue on some BBS routes. Dangerous routes have been altered or to address these problems, while the data gathered from progressively urbanized routes are important to the BBS's ability to measure changes on the landscape that birds are experiencing.

Overall, survey effort has decreased in the last 22 years. On average, the number of routes completed decreased by 0.88 routes per year. While 2012 recorded the third lowest number of routes completed since 1990 at 60 routes completed, this was an increase by 5 routes from 2011, advancing us from the 26-50% completion bracket to the 51-75% completion bracket. While the number of individual birds detected per route has decreased steadily, the number of species detected per route has increased over time. This increase in number of species per route is interesting, and may represent changes in species distributions or increases in identification skills of observers over time.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature and the Wyoming Governor's Office, for which the Department is extremely grateful. We would like to thank the many volunteers and biologists from this and other natural resources management agencies for their valuable contributions to the 2012 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

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. The North American Breeding Bird Survey, results and analysis 1966-2010. Version 12.07.2011. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Table 1. Latitudinal/longitudinal (latilong) degree block, observer, number of avian species detected, and number of individuals recorded for each Breeding Bird Survey route in Wyoming, 2012. Data are presented in numerical order by survey route. Late data are not included in analyses and are represented by 'not available.'

Route number and name	Latilong	Observer	Species	Individuals
1 – NE Entrance, YNP	1	Amanda Boyd	48	677
2 – Cody	2	Grace Nutting	31	252
3 – Otto	3	Observer needed		
4 – Basin	4	N/A – discontinued		
5 – Wyarno	5	John Berry	42	1163
6 – Clarkelen	6	N/A – discontinued		
7 – Sundance	7	Jennifer Adams	57	538
8 – Colter Bay	8	N/A – discontinued		
9 – Dubois	9	Jazmyn McDonald	55	324
10 – Midvale	10	Observer needed		
11 – Nowood	11	Donna Walgren	38	266
12 – Natrona	12	N/A – discontinued		
13 – Bill	13	Observer needed		
14 – Redbird	14	N/A – discontinued		
15 – Fontenelle	15	Carol Deno	52	443
16 – Elk Horn	16	Sid Johnson	Not available	Not available
17 – Bear Creek	17	Andrea Orabona	Not conducted	Not conducted
18 – Ervay	18	Jazmyn McDonald	31	246
19 – Brookhurst	19	Bruce Walgren	50	340
20 – Glenrock	20	N/A – discontinued		
21 – Dwyer	21	Martin Hicks	Not conducted	Not conducted
22 – Cumberland	22	Carol Deno	21	175
23 – McKinnon	23	N/A – discontinued		
24 – Patrick Draw		N/A – discontinued		
25 – Savery	25	Marie Adams	46	367
26 – Riverside	26	Steve Loose	46	749
27 – Buford	27	Suzanne Fellows	Not conducted	Not conducted
28 – Yoder	28	Jim Lawrence	50	1003
29 – Canyon		N/A – discontinued		
30 – Mammoth, YNP	1	Amanda Boyd	54	548
31 – West Thumb	--	N/A – discontinued		
32 – Hunter Peak	2	Kathryn Hicks	Not conducted	Not conducted
33 – Clark	2	Observer needed		
34 – no route		N/A – no route		
35 – Frannie	3	Observer needed		
36 – Moose	8	Christine Paige	44	479
37 – Lovell	3	Observer needed		
38 – Meeteetse	3	Jazmyn McDonald	55	596
39 – Ten Sleep	4	C.J. Grimes	45	370
40 – Dayton	4	Tracey Ostheimer	59	704

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
41 – Bald Mountain	4	Observer needed		
42 – Crazy Woman	5	Grace Nutting	43	192
43 – Schoonover	5	Observer needed		
44 – Arvada	5	Donald Brewer	31	449
45 – Recluse	6	Observer needed		
46 – Soda Well	6	Observer needed		
47 – Piney		N/A – discontinued		
48 – Seely		N/A – discontinued		
49 – Upton	7	Laurie Van Fleet	32	742
50 – Moskee		N/A – discontinued		
51 – Alpine	8	Susan Patla	50	381
52 – Wilson	8	Observer needed		
53 – Horse Creek	9	Eva Crane	48	310
54 – no route		N/A – no route		
55 – Crowheart	9	James Downham	Not conducted	Not conducted
56 – Ethete	10	Jim Downham	Not conducted	Not conducted
57 – Anchor	10	Pat Hnilicka	Not conducted	Not conducted
58 – Gebo	10	Jazmyn McDonald	39	397
59 – Arminto	11	Heather O'Brien	30	331
60 – Lysite	11	Greg Anderson	21	450
61 – Worland	11	C.J. Grimes	36	353
62 – Teapot Dome	12	Observer needed		
63 – Mayoworth	12	Observer needed		
64 – Sussex	12	Bill Ostheimer	39	499
65 – Harland Flats	13	Observer needed		
66 – Pine Tree	13	Observer needed		
67 – Highlight		N/A – discontinued		
68 – Riverview	14	Observer needed		
69 – Newcastle	14	Laurie Van Fleet	32	733
70 – Raven	14	Nichole Cudworth	26	405
71 – Soda Lake	15	Observer needed		
72 – Buckskin Mountain	15	Lara Oles	Not available	Not available
73 – Daniel		N/A – discontinued		
74 – Boulder	16	Susan Patla	45	435
75 – Big Sandy	16	Susan Patla	44	350
76 – Farson	16	Sid Johnson	Not available	Not available
77 – Fiddler Lake	17	Eva Crane	41	266
78 – Sand Draw	17	Jazmyn McDonald	25	326
79 – Sweetwater	17	Stan Harter	Not conducted	Not conducted
80 – Gas Hills	18	Courtney Rudd	18	255
81 – Bairoil	18	Greg Hiatt	21	185
82 – Lamont	18	Greg Hiatt	39	249
83 – Pathfinder	19	Laurie Schwieger	33	323

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
84 – Leo	19	Donna Walgren	36	223
85 – Shirley	19	Linda Drury	22	248
86 – Warbonnet	20	James Lawrence	57	451
87 – Fletcher Peak	20	Gloria Lawrence	56	445
88 – Shawnee	20	Observer needed		
89 – Meadowdale	21	Martin Hicks	Not conducted	Not conducted
90 – Lusk	21	Gloria Lawrence	28	840
91 – Lingle	21	Observer needed		
92 – Diamondville		N/A – discontinued		
93 – Mountain View	22	Martin Hicks	Not conducted	Not conducted
94 – no route		N/A – discontinued		
95 – Green River		N/A – discontinued		
96 – Reliance	23	Observer needed		
97 – Rock Springs	23	Fern Linton	30	209
98 – Black Rock		N/A – discontinued		
99 – no route		N/A – no route		
100 – no route		N/A – no route		
101 – Wamsutter	25	Tony Mong	Not conducted	Not conducted
102 – Rawlins	25	Observer needed		
103 – Baggs	25	Tony Mong	Not conducted	Not conducted
104 – Walcott	26	Frank Blomquist	46	439
105 – Fox Park	26	Observer needed		
106 – Ryan Park	26	Debbie Wagner	39	277
107 – Sybille Canyon	27	Ian Abernethy	51	646
108 – Rock River	27	Matt Carling	Not available	Not available
109 – Harmony	27	Observer needed		
110 – Cheyenne	28	Chuck Seniawski	23	357
111 – Chugwater	28	Chuck Seniawski	28	441
112 – Pine Bluff	28	Chuck Seniawski	22	513
120 – Welch	20	Chris Michelson	39	336
123 – Flaming Gorge	23	Observer needed		
147 – Rozet	6	Observer needed		
148 – Seely 2	7	Mary Yemington	41	502
150 – Government Valley	7	Jennifer Adams	42	701
167 – Thunder Basin	13	Nichole Cudworth	21	313
173 – Rye Grass	15	Observer needed		
192 – Carter	23	Observer needed		
195 – Seedskadee	23	Observer needed		
198 – Black Rock 2	24	Andrea Orabona	11	201
204 – Basin 2	4	Observer needed		
206 – Caballa Creek	6	Sandra Johnson	31	450
208 – Moran	8	Susan Wolff	Not available	Not available
212 – Bucknum	12	Larry Keffer	Not available	Not available

Table 1. Continued.

Route number and name	Latilong	Observer	Species	Individuals
214 – Hampshire	14	Observer needed		
224 – Patrick Draw III		N/A – discontinued		
250 – Moskee 2	7	Jennifer Adams	Not conducted	Not conducted
524 – Patrick Draw VI	24	Laurie Van Fleet	23	315
900 – Hayden Valley		N/A – discontinued		
901 – Yellowstone, YNP	1	Amanda Boyd	48	1921
902 – Pryor Flats	1	Observer needed		

Table 2. Number of individuals and relative abundance of each species detected on Breeding Bird Survey routes in Wyoming, 2012. Data are presented in phylogenetic order. The 30 most abundant species detected on BBS routes in 2012 are denoted by an asterisk.

Order	Species (common name)	Number detected	Relative abundance (%)
Anseriformes	*Canada Goose	1488	5.57
	Trumpeter Swan	7	0.03
	Gadwall	10	0.04
	American Wigeon	66	0.25
	*Mallard	181	0.68
	Blue-winged Teal	16	0.06
	Cinnamon Teal	7	0.03
	Northern Shoveler	20	0.07
	Northern Pintail	9	0.03
	Green-winged Teal	13	0.05
	Canvasback	1	<0.01
	Redhead	3	0.01
	Ring-necked Duck	34	0.13
	Lesser Scaup	22	0.08
	Bufflehead	2	0.01
	Barrow’s Goldeneye	21	0.08
	Common Merganser	21	0.08
	Ruddy Duck	1	<0.01
Galliformes	Northern Bobwhite	1	<0.01
	Chukar	3	0.01
	Gray Partridge	2	0.01
	Ring-necked Pheasant	105	0.39
	Ruffed Grouse	2	0.01
	Greater Sage-Grouse	92	0.34
	Dusky Grouse	1	<0.01
	Sharp-tailed Grouse	30	0.11
	Wild Turkey	32	0.12
Podicipediformes	Eared Grebe	22	0.08
	Western Grebe	3	0.01
Suliformes	Double-crested Cormorant	5	0.02
Pelecaniformes	American White Pelican	57	0.21
	Great Blue Heron	17	0.06
Accipitriformes	Turkey Vulture	59	0.22
	Osprey	2	0.01
	Bald Eagle	5	0.02
	Northern Harrier	13	0.05
	Northern Goshawk	2	0.01
	Broad-winged Hawk	1	<0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
	Swainson's Hawk	24	0.09
	Red-tailed Hawk	92	0.34
	Ferruginous Hawk	27	0.10
	Golden Eagle	25	0.09
Falconiformes	American Kestrel	54	0.20
	Merlin	2	0.01
	Peregrine Falcon	1	<0.01
	Prairie Falcon	9	0.03
Gruiformes	Sora	4	0.01
	American Coot	16	0.06
	Sandhill Crane	69	0.26
Charadriiformes	Killdeer	169	0.63
	Mountain Plover	1	<0.01
	American Avocet	27	0.10
	Spotted Sandpiper	52	0.19
	Willet	26	0.10
	Upland Sandpiper	47	0.18
	Long-billed Curlew	9	0.03
	Wilson's Snipe	120	0.45
	Wilson's Phalarope	14	0.05
	Franklin's Gull	1	<0.01
	California Gull	19	0.07
	Unid. Gull	8	0.03
Columbiformes	Rock Pigeon	83	0.31
	Eurasian Collared-Dove	28	0.10
	*Mourning Dove	744	2.79
Strigiformes	Great Horned Owl	7	0.03
	Burrowing Owl	3	0.01
	Short-eared Owl	6	0.02
Caprimulgiformes	Common Nighthawk	134	0.50
	Common Poorwill	1	<0.01
Apodiformes	Broad-tailed Hummingbird	14	0.05
Coraciiformes	Belted Kingfisher	6	0.02
Piciformes	Lewis's Woodpecker	4	0.01
	Red-headed Woodpecker	1	<0.01
	Williamson's Sapsucker	1	<0.01
	Red-naped Sapsucker	8	0.03
	Downy Woodpecker	4	0.01
	Hairy Woodpecker	9	0.03
	American Three-toed Woodpecker	5	0.02

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Piciformes	Northern Flicker	154	0.58
Passeriformes	Olive-sided Flycatcher	7	0.03
	Western Wood-Pewee	121	0.45
	Willow Flycatcher	24	0.09
	Least Flycatcher	2	0.01
	Hammond's Flycatcher	18	0.07
	Dusky Flycatcher	48	0.18
	Cordilleran Flycatcher	12	0.04
	Say's Phoebe	46	0.17
	*Western Kingbird	187	0.70
	Eastern Kingbird	63	0.24
	Loggerhead Shrike	62	0.23
	Plumbeous Vireo	25	0.09
	*Warbling Vireo	272	1.02
	Red-eyed Vireo	2	0.01
	Gray Jay	12	0.04
	Blue Jay	10	0.04
	Pinyon Jay	5	0.02
	Clark's Nutcracker	50	0.19
	*Black-billed Magpie	417	1.56
	*American Crow	170	0.64
	Common Raven	170	0.64
	*Horned Lark	1965	7.36
	Tree Swallow	134	0.50
	Violet-green Swallow	101	0.38
	Northern Rough-winged Swallow	115	0.43
	Bank Swallow	108	0.40
	*Cliff Swallow	1122	4.20
	*Barn Swallow	192	0.72
	Black-capped Chickadee	33	0.12
	Mountain Chickadee	70	0.26
	Bushtit	1	<0.01
	Red-breasted Nuthatch	41	0.15
	White-breasted Nuthatch	13	0.05
	*Rock Wren	209	0.78
	House Wren	129	0.48
	Marsh Wren	1	<0.01

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	American Dipper	2	0.01
	Golden-crowned Kinglet	1	<0.01
	*Ruby-crowned Kinglet	272	1.02
	Mountain Bluebird	165	0.62
	Townsend's Solitaire	16	0.06
	Veery	17	0.06
	Swainson's Thrush	26	0.10
	Hermit Thrush	50	0.19
	*American Robin	1092	4.09
	Gray Catbird	36	0.13
	Northern Mockingbird	1	<0.01
	*Sage Thrasher	491	1.84
	Brown Thrasher	2	0.01
	*European Starling	419	1.57
	Cedar Waxwing	30	0.11
	Chestnut-collared Longspur	9	0.03
	McCown's Longspur	75	0.28
	Ovenbird	40	0.15
	Orange-crowned Warbler	6	0.02
	MacGillivray's Warbler	35	0.13
	Common Yellowthroat	59	0.22
	American Redstart	14	0.05
	*Yellow Warbler	324	1.21
	Chestnut-sided Warbler	1	<0.01
	Yellow-rumped Warbler	149	0.56
	Wilson's Warbler	12	0.04
	Yellow-breasted Chat	9	0.03
	*Green-tailed Towhee	228	0.85
	Spotted Towhee	85	0.32
	Cassin's Sparrow	2	0.01
	*Chipping Sparrow	207	0.78
	Clay-colored Sparrow	10	0.04
	*Brewer's Sparrow	810	3.03
	*Vesper Sparrow	1100	4.12
	*Lark Sparrow	310	1.16
	*Sage Sparrow	199	0.75
	*Lark Bunting	1723	6.45
	*Savannah Sparrow	187	0.70
	Grasshopper Sparrow	100	0.37
	Fox Sparrow	9	0.03
	Song Sparrow	144	0.54

Table 2. Continued.

Order	Species (common name)	Number detected	Relative abundance (%)
Passeriformes	Lincoln's Sparrow	103	0.39
	White-crowned Sparrow	96	0.36
	Dark-eyed Junco	217	0.81
	Western Tanager	44	0.16
	Black-headed Grosbeak	32	0.12
	Blue Grosbeak	9	0.03
	Lazuli Bunting	30	0.11
	Dickcissel	17	0.06
	Bobolink	19	0.07
	*Red-winged Blackbird	1209	4.53
	*Western Meadowlark	3790	14.20
	Yellow-headed Blackbird	32	0.12
	*Brewer's Blackbird	940	3.52
	*Common Grackle	259	0.97
	Great-tailed Grackle	1	<0.01
	*Brown-headed Cowbird	344	1.29
	Orchard Oriole	1	<0.01
	Bullock's Oriole	89	0.33
	Cassin's Finch	32	0.12
	House Finch	16	0.06
	Red Crossbill	82	0.31
	*Pine Siskin	269	1.01
	American Goldfinch	76	0.28
	Evening Grosbeak	3	0.01
	House Sparrow	160	0.60
	Total Individuals	26699	
	Total Species	181	

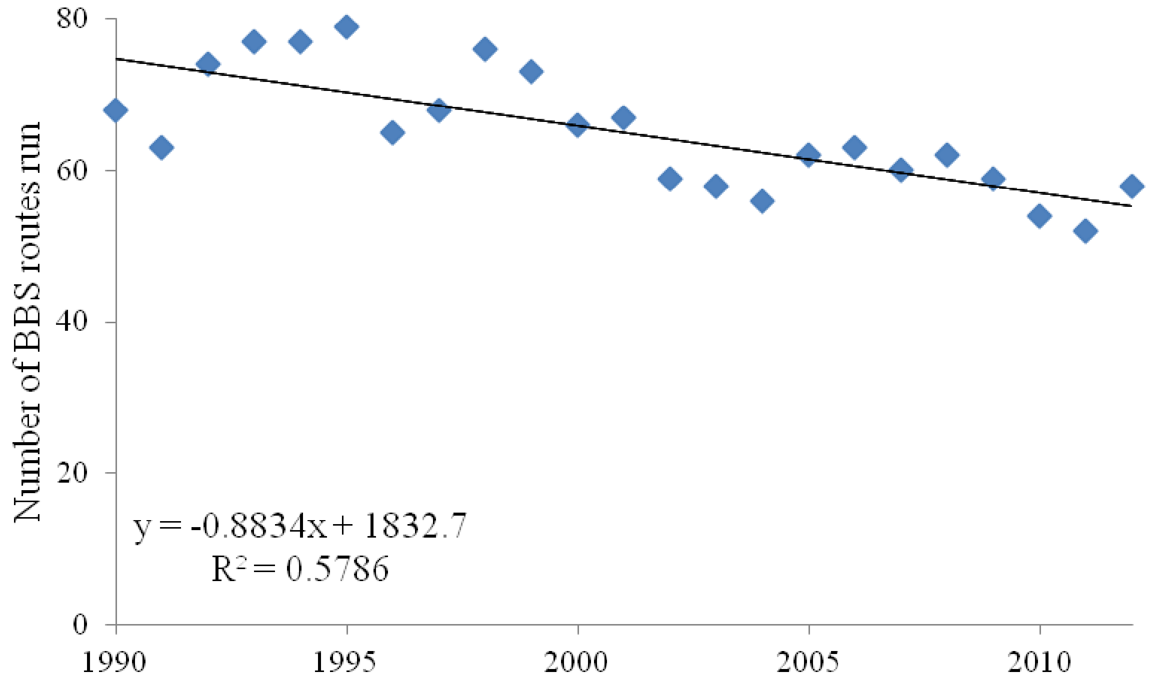

Figure 1. Number of Breeding Bird Survey routes completed in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

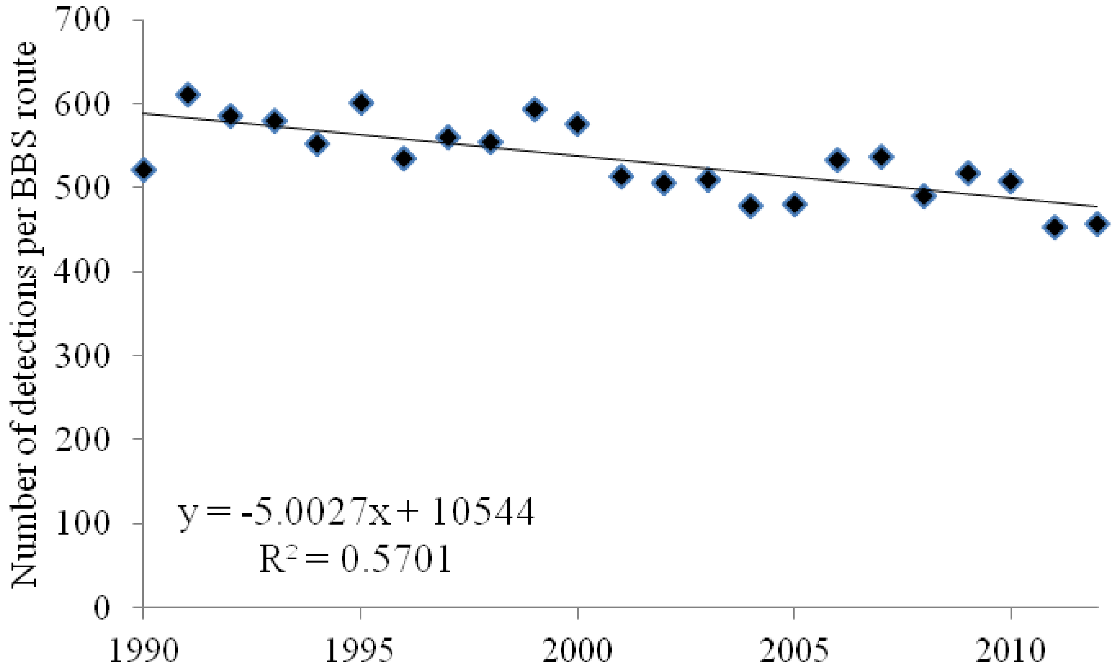

Figure 2. Average number of individual detections of birds per Breeding Bird Survey route in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

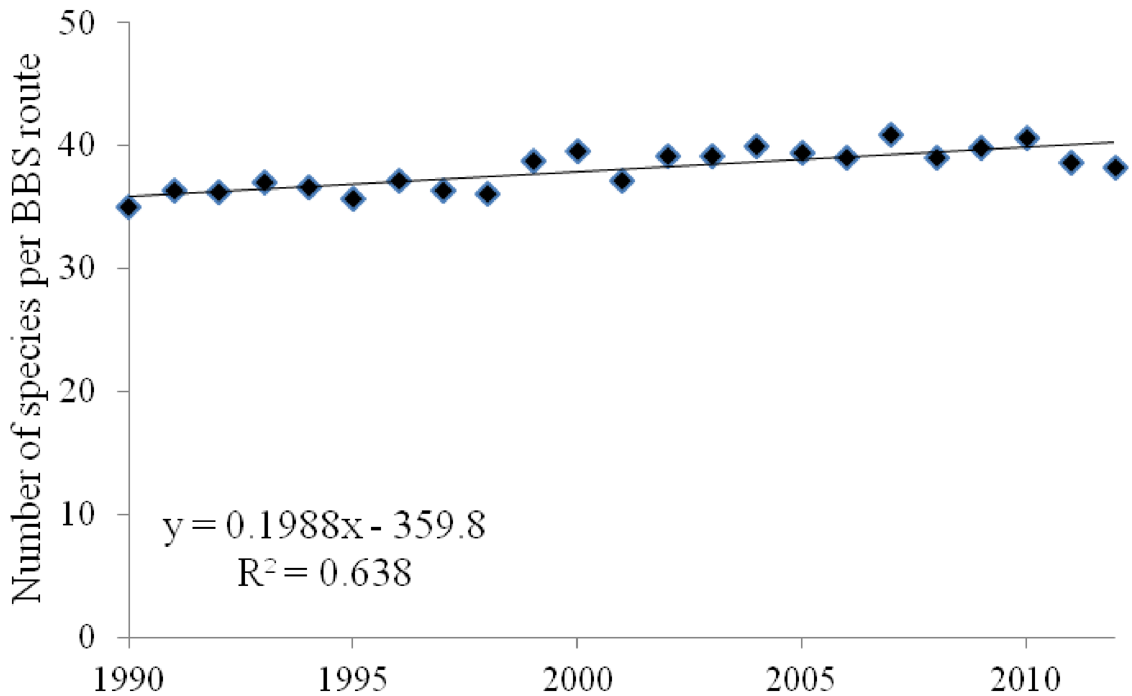

Figure 3. Average number of species detected per Breeding Bird Survey route in Wyoming, 1990-2012. Only currently active routes with data submitted to the Breeding Bird Survey by the due date are included in the analysis. The trend line is shown for reference.

WYOMING PARTNERS IN FLIGHT AND INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS

STATE OF WYOMING

NONGAME BIRDS: Species of Greatest Conservation Need

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations, Wyoming Governor's Endangered Species Account Funds, Bureau of Land Management Cooperative Agreement #L08AC13184, United States Fish and Wildlife Service State Wildlife Grants, and United States Forest Service

PROJECT DURATION: Annual

PERIOD COVERED: 15 April 2012 – 14 April 2013

PREPARED BY: Andrea Orabona, Nongame Bird Biologist
Nichole Cudworth, Nongame Biologist
Chris White, Rocky Mountain Bird Observatory
Nick Van Lanen, Rocky Mountain Bird Observatory
David Hanni, Rocky Mountain Bird Observatory

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 (WGFD 2010). Monitoring is a key component of the Wyoming Bird Conservation Plan (Nicholoff 2003). Through cooperative funding via Wyoming Partners in Flight, we have implemented the Integrated Monitoring in Bird Conservation Regions (formerly Monitoring Wyoming's Birds) program, which allows us to estimate density, population size, occupancy, and detection probabilities for numerous avian species, including Species of Greatest Conservation Need. In 2012, we completed 2,413 point counts on all 191 planned grids within 4 Bird Conservation Regions in Wyoming, and detected 173 species, including 26 Species of Greatest Conservation Need. We determined density estimates from 2009-2011 for 13 Species of Greatest Conservation Need, 5 of which provided robust density estimates, and 115 additional avian species, 78 of which provided robust density estimates. We determined occupancy from 2010-2011 for 15 Species of Greatest Conservation

Need, 7 of which provided robust occupancy estimates, and 121 additional avian species, 76 of which provided robust occupancy estimates. The Integrated Monitoring in Bird Conservation Regions design allows us to monitor trends of avian Species of Greatest Conservation Need that may be overlooked or under-represented by other survey techniques, including sagebrush- and grassland-obligate species; permits slight modifications to the design in order to investigate other priority species as needs arise; reduces monitoring costs through coordination and collaboration with monitoring partners; and can be stepped up to evaluate population parameters on a regional scale.

INTRODUCTION

Long-term data analyses indicate that trends for many populations of North American landbirds have declined due to land use changes; habitat loss, fragmentation, and deterioration; pesticide use; and human influences and disturbance (Robbins et al. 1989, Peterjohn et al. 1995, Sauer et al. 1996, Boren et al. 1999, Donovan and Flather 2002). The international Partners in Flight (PIF) program was initiated in 1990 to address and reverse these declines. The PIF mission is to help species at risk and to keep common birds common through voluntary partnerships that benefit birds, habitats, and people. State, regional, national, and international Bird Conservation Plans comprehensively address the issues of avian and habitat conservation on a landscape scale. The North American Bird Conservation Initiative (NABCI) was initiated in 1998 to ensure the long-term health of North America's native bird populations through effective conservation initiatives, enhanced coordination among the initiatives, and increased cooperation among the governments and citizens of Canada, the US, and Mexico (NABCI 2012).

The state PIF working group, Wyoming Partners in Flight (WYPIF), was established in 1991 and is comprised of participants from the Wyoming Game and Fish Department (Department), Bureau of Land Management (BLM), US Forest Service (USFS), US Fish and Wildlife Service, Bureau of Reclamation, National Park Service, Rocky Mountain Bird Observatory (RMBO), Audubon Rockies and affiliate chapters, Wyoming Natural Diversity Database (WYNDD), University of Wyoming, and The Nature Conservancy. The Department's Nongame Bird Biologist has served as the WYPIF chairperson since its inception. As a group, WYPIF produced the Wyoming Bird Conservation Plan, Version 2.0 (Plan; Nicholoff 2003). The Plan presents objectives for populations of birds and major habitat groups in the State, Best Management Practices to benefit birds, and recommendations to ensure that birds and the habitats they require remain intact and viable into the future through proactive and restorative management techniques. Many components of the Plan have been used to develop portions of the Wyoming State Wildlife Action Plan (WGFD 2010).

One of the highest priority objectives throughout the Plan for populations of birds is to implement *Monitoring Wyoming's birds: the plan for count-based monitoring* (Leukering et al. 2001). Monitoring of populations is an essential component of effective wildlife management and conservation (Witmer 2005, Marsh and Trenham 2008). Besides improving distribution data, monitoring allows us to evaluate populations of target species and detect changes over time (Thompson et al. 1998, Sauer and Knutson 2008), identify species that are at risk (Dreitz et al. 2006), and evaluate responses of populations to management actions (Lyons et al. 2008, Alexander et al. 2009) and landscape and climate change (Baron et al. 2008, Lindenmayer and Likens 2009).

For the 12th consecutive year, biologists from the Department, BLM, RMBO, USFS, Audubon Rockies, and WYNDD have collectively implemented a BLM-cooperative assistance agreement that provides funding for this collaborative effort. The agreement allows us to execute a statewide monitoring program for birds and revise distributions and estimate abundance of numerous avian species, including Species of Greatest Conservation Need (SGCN; WGFD 2010). Funding is also provided to develop educational materials and improve outreach opportunities that focus on birds in Wyoming. The RMBO is responsible for implementing the monitoring program, which originally focused on six habitats in Wyoming (i.e., aspen, grassland, juniper woodland, mid-elevation conifer, montane riparian, and shrub-steppe) under the Monitoring Wyoming's Birds design. Since 2009, this monitoring program, now called Integrated Monitoring in Bird Conservation Regions (IMBCR), incorporates a region-wide approach and uses a stratified, spatially balanced, grid-based design (Hanni et al. 2009). The BLM, USFS, and Department (through State Wildlife Grants support) contribute funding to the program, and WYNDD assists in program monitoring. Audubon Wyoming assists with inventory and monitoring for those species that require techniques other than point-counts (e.g., Monitoring Avian Productivity and Survivorship [MAPS] bird banding stations), producing and distributing educational materials on birds and their habitats, and providing nature-based outreach opportunities for the public. The Department conducts annual monitoring for SGCN that require species-specific survey methods [e.g., Common Loon (*Gavia immer*) American Bittern (*Botaurus lentiginosus*), Long-billed Curlew (*Numenius americanus*), Mountain Plover (*Charadrius montanus*), and raptors), prints and distributes PIF educational materials, and provides point data via the Wildlife Observation System database.

METHODS

In Wyoming's portion of the IMBCR, we conducted surveys within four of the five Bird Conservation Regions (BCRs; Fig. 1). The five BCRs that occur in Wyoming, plus an additional two in other states (i.e., BCRs 11 and 34), comprised the IMBCR sampling frame for 2012.

Within these seven BCRs, 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). We overlaid BCRs with 1-km^2 sample grids. We randomly selected sample grids and used a 4 × 4 array spaced 250 m apart to establish 16 survey points within each sample grid (Hanni et al. 2009).

Prior to surveys, field technicians completed an intensive training program covering protocols, bird identification, and distance estimation. Field technicians used IMBCR sampling protocols established by RMBO to conduct point counts (Buckland et al. 2001, Hanni et al. 2009). These technicians surveyed grids in the morning from 0.5 hr before sunrise to 1100 hrs. They surveyed each survey point for 6 min to facilitate estimation of site occupancy. For each bird detected, field technicians recorded species, sex, horizontal distance from the observer, minute of detection, and type of detection (e.g., song, call, visual). Other information, such as flyovers, clusters, and the presence of species difficult to detect, was also noted. Technicians recorded time, ambient temperature, cloud cover, precipitation, and wind speed at the start and end of each grid. They also recorded vegetation data within a 50-m radius of each survey point and included dominant habitat type, structural stage, relative abundance, percent cover and mean height of trees, species of shrubs, grass height, and groundcover. Distance from a road, if within 100 m, was also recorded.

Biometricians from RMBO used Distance 6.0 to estimate detection probabilities (Thomas et al. 2010). They used the SPSURVEY package in Program R to estimate density, population size, and its variance for each bird species (T. Kincaid, unpubl. data). Lastly, they used a removal design to estimate detection probability for each species (MacKenzie et al. 2006).

RESULTS

In 2012, the IMBCR program encompassed 3 states (Colorado, Montana and Wyoming), portions of 10 additional states, 2 entire USFS Regions (Regions 1 and 2), and portions of 2 additional USFS Regions in all or part of 8 BCRs (White et al. 2012).

Between 20 May and 23 July 2012, field technicians completed 2,413 point counts on all 191 grids that were planned for surveys within 4 of the 5 BCRs in Wyoming (Figs. 1-2). Statewide results were obtained by compiling and jointly analyzing data from 32 of 35 strata (Table 1). The BCR 9 portion of Wyoming, USFS Region 4 stratum in BCR 10, and the Wasatch National Forest stratum in BCR 16 were not sampled in 2012 because funding for these surveys was unavailable.

A total of 173 species were detected, including 26 SGCN. RMBO biometricians were able to estimate density from 2009-2011 for 13 SGCN, 5 of which provided robust estimates (i.e., CV <50%; Table 2). Density was estimated for an additional 115 avian species, 78 of which provided robust density estimates. RMBO biometricians estimated occupancy from 2010-2011 for 15 SGCN, 7 of which provided robust estimates (i.e., CV <50%; Table 3). Occupancy was determined for an additional 121 avian species, 76 of which provided robust occupancy estimates. Density and occupancy estimates for 2012 had not been completed in time to include in this report.

Annual and multi-year reports, species accounts, and density estimate tables and graphs from this monitoring program are available on the RMBO Avian Data Center web site (RMBO 2012).

DISCUSSION

The methods used by RMBO to monitor avian populations for the IMBCR are used to estimate both density and occupancy for each species when sample sizes were large enough.

These robust data not only allow for continuous monitoring of species trends, but also provide information on species abundance and distribution, habitat associations, and evaluation of land management activities (White et al. 2012). The IMBCR provides density and occupancy estimates for a number of avian SGCN at risk in Wyoming due to habitat loss or alteration or for which data on population and trends are lacking. Consequently, the IMBCR provides the Department with an opportunity to monitor trends of avian SGCN that may be overlooked or under-represented by other survey techniques.

Currently, RBMO is finishing the Avian Data Center (ADC) automated data analyses, which will ensure that the occupancy and density estimates generated from the automated analyses are similar to the preceding analyses done by-hand. Once completed, the analyses will be able to run all occupancy and density data through the automated process from the current year back to 2009, the first year of IMBCR implementation. RMBO will also post all habitat data under the Monitoring Wyoming's Birds protocol from 2000-2009 to the current IMBCR grid-based design. The ADC automated analyses and habitat data release will be presented by the end of July 2012.

As in previous years, the 2012 IMBCR will provide robust density and occupancy estimates for avian SGCN in Wyoming, which helps fill gaps in current monitoring efforts by the Department. Data collected on all species, including SGCN, help address a number of management challenges, including data deficiencies, habitat loss or degradation, and population declines. Specifically, the IMBCR program provides a quantified approach for monitoring the American Three-toed Woodpecker (*Picoides tridactylus*). This species is found in higher elevation mature and old-growth coniferous forests, and is classified as a Native Species Status Unknown (NSSU) due to unknown population status and trends resulting from existing monitoring efforts that were insufficient to adequately detect this species (WGFD 2010). Three additional species, Brewer's Sparrow (*Spizella breweri*), Sage Sparrow (*Amphispiza belli*), and Sage Thrasher (*Oreoscoptes montanus*), are considered sagebrush obligates, and the Grasshopper Sparrow (*Ammodramus savannarum*), Lark Bunting (*Calamospiza melanocorys*), 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 2010). Consequently, by monitoring SGCN, the IMBCR program can provide an indication of trends for these species, as well as a suite of sagebrush and grassland associated species. However, several SGCN, including the Lewis's Woodpecker (*Melanerpes lewis*), Willow Flycatcher (*Empidonax traillii*), Bobolink (*Dolichonys oryzivorus*), Chestnut-collared Longspur (*Calcarius ornatus*), and Dickcissel (*Spiza americana*), have not been detected in sufficient numbers to estimate occupancy or density. If this trend continues, we will need to implement a more targeted approach for these species to obtain adequate population information.

The IMBCR's spatially balanced sampling design is more efficient than simple random sampling and can increase precision in density, occupancy, and detection probability estimates (Stevens and Olsen 2004, White et al. 2012). Additionally, this sampling design provides the flexibility to generate population estimates at various scales relevant to land and wildlife management agencies, enabling managers to use population estimates to make informed management decisions about where to focus conservation efforts. It also allows sampling of all habitats, which enables managers to relate changes in bird populations to changes on the landscape over time. These results support both local and regional conservation efforts in Wyoming. Moreover, the IMBCR design allows us to monitor trends of avian SGCN that may be omitted or inadequately represented by other survey techniques, permits slight modifications to the design in order to investigate other priority species as needs arise, and reduces monitoring costs through coordination and collaboration with monitoring partners.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Wyoming State Legislature, Wyoming Governor's Office, Bureau of Land management, US Fish and Wildlife Service, and US Forest Service, for which the Department is extremely grateful. We wish to thank BLM biologists M. Gorges and D. Saville for their tireless efforts and invaluable assistance in securing funding for the IMBCR program. We also thank the RMBO for implementing the IMBCR program, particularly J. Birek, J. Blakesley, D. Hanni, M. McLaren, D. Pavlacky, R. Sparks, N. Van Lanen, C. White and the many field technicians that assisted with the surveys. We also greatly appreciate the collaborative efforts of the regional IMBCR team in making this program a success. Finally, we would like to thank all the individuals who contribute to the success of WYPIF through their respective agencies and organizations; WYPIF thrives because of our collective efforts.

LITERATURE CITED

Alexander, J. D., J. L. Stevens, G. R. Geupel, and T. C. Will. 2009. Decision support tools: bridging the gap between science and management. Pages 283-291 *in* Tundra to tropics: connecting birds, habitats and people. Proceedings of the 4th International Partners in Flight Conference, 13-16 February 2008 (T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson, Editors). Partners in Flight, McAllen, Texas, USA.

Baron, J. S., S. H. Julius, J. M. West, L. A. Joyce, G. Blate, C. H. Peterson, M. Palmer, B. D. Keller, P. Kareiva, J. M. Scott, and B. Griffith. 2008. Some guidelines for helping natural resources adapt to climate change. International Human Dimensions Programme on Global Environmental Change Update 2:46-52.

Boren, J. C., D. M. Engle, M. W. Palmer, R. E. Masters, and T. Criner. 1999. Land use change effects on breeding bird community composition. Journal of Range Management 52:420-430.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, United Kingdom.

Donovan, T. M., and C. H. Flather. 2002. Relationships among North American songbird trends, habitat fragmentation, and landscape occupancy. Ecological Applications 12:364-374.

Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: an example using Mountain Plovers. Condor 108:700-706.

Hanni, D. J., C. M. White, J. A. Blakesley, G. J. Levandoski, and J. J. Birek. 2009. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Leukering, T., M. F. Carter, A. Panjabi, D. Faulkner, and R. Levad. 2001. Monitoring Wyoming's birds: the plan for count-based monitoring. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Lindenmayer, D. B., and G. E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24:482-486.

Lyons, J. E., M. C. Runge, H. P. Laskowski, and W. L. Kendall. 2008. Monitoring in the context of structured decision-making and adaptive management. Journal of Wildlife Management 72:1683-1692.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, Burlington, Massachusetts, USA.

Marsh, D. M., and P. C. Trenham. 2008. Current trends in plant and animal population monitoring. Conservation Biology 22:647-655.

Nicholoff, S. H., compiler. 2003. Wyoming bird conservation plan. Version 2.0. Wyoming Partners In Flight. Wyoming Game and Fish Department, Lander, USA.

North American Bird Conservation Initiative [NABCI]. 2012. North American Bird Conservation Initiative, USA. http://www.nabci-us.org/aboutnabci/Charter-only.pdf (accessed 4 June 2013).

Peterjohn, B. G., J. R. Sauer, and C. S. Robbins. 1995. Population trends from the North American Breeding Bird Survey. Pages 3-39 *in* Ecology and management of Neotropical migratory birds (T. E. Martin and D. M. Finch, Editors). Oxford University Press, New York, New York, USA.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proceedings of the National Academy Sciences 86:7658-7662.

Rocky Mountain Bird Observatory [RMBO]. 2013. The Rocky Mountain Bird Observatory Avian Data Center, Brighton, Colorado, USA. http://rmbo.org/v3/avian/Home.aspx (accessed 4 June 2013).

Sauer, J. R., G. W. Pendleton, and B. G. Peterjohn. 1996. Evaluating causes of population change in North American insectivorous birds. Conservation Biology 10:465-478.

Sauer, J. R., and M. G. Knutson. 2008. Objectives and metrics for wildlife monitoring. Journal of Wildlife Management 72:1663-1664.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California, USA.

White, C. M., N. J. Van Lanen, D. C. Pavlacky Jr., J. A. Blakesley, R. A. Sparks, M. F. McLaren, J. J. Birek, and D. J. Hanni. 2013. Integrated monitoring in bird conservation regions (IMBCR): 2012 annual report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Witmer, G. W. 2005. Wildlife population monitoring: some practical considerations. Wildlife Research 32:259-263.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

Wyoming Partners in Flight [WYPIF]. 2002. Growing grassland birds: best management practices for grasslands to benefit birds in Wyoming. Wyoming Game and Fish Department, Lander, USA.

Table 1. Number of strata and survey grids in each Bird Conservation Region (BCR) in Wyoming in the 2012 Integrated Monitoring in Bird Conservation Regions program.

BCR name	BCR number	Number of strata	Number of grids
Great Basin	9	0	0
Northern Rockies	10	20	107
Southern Rockies/Colorado Plateau	16	3	39
Badlands and Prairies	17	6	31
Shortgrass Prairie	18	3	14

Table 2. Estimated density (individuals per km^2), population size ($\widehat{N}$), percent coefficient of variation (% CV), and number of independent detections (*n*) of avian Species of Greatest Conservation Need on 192 grids surveyed throughout Wyoming from 2009-2011. Density estimates are considered robust if % CV <50%.

Species	Year	D	$\widehat{N}$	% CV	*n*
American Three-toed Woodpecker	2009	0.26	48436	33	12
American Three-toed Woodpecker	2010	0.41	101950	36	25
American Three-toed Woodpecker	2011	0.28	71550	29	24
Brewer's Sparrow	2009	44.26	8328561	24	828
Brewer's Sparrow	2010	29.75	7481986	13	804
Brewer's Sparrow	2011	30.69	7707408	15	824
Chestnut-collared Longspur	2010	0.44	109983	54	6
Grasshopper Sparrow	2009	2	376107	37	45
Grasshopper Sparrow	2010	3.35	843508	31	98
Grasshopper Sparrow	2011	3.96	994665	24	185
Lark Bunting	2009	17.71	3331982	32	937
Lark Bunting	2010	16.85	4236699	26	814
Lark Bunting	2011	14.14	3550626	28	814
Long-billed Curlew	2011	0.16	41209	86	3
McCown's Longspur	2009	2.69	505993	60	26
McCown's Longspur	2010	1.7	427797	50	34
McCown's Longspur	2011	1.65	414502	68	50
Pygmy Nuthatch	2009	0.06	11493	61	4
Pygmy Nuthatch	2010	0.03	6868	81	2
Pygmy Nuthatch	2011	0.08	19321	77	2
Sage Sparrow	2009	5.57	1047864	18	281
Sage Sparrow	2010	5.01	1260838	23	252
Sage Sparrow	2011	5.79	1453124	21	271
Sage Thrasher	2009	2.78	522260	16	231
Sage Thrasher	2010	2.63	661911	18	284
Sage Thrasher	2011	2.31	581212	13	405
Sandhill Crane	2009	0	113	101	1
Sandhill Crane	2010	0.01	2812	87	9
Sandhill Crane	2011	0.06	14455	55	19
Swainson's Hawk	2009	0.09	16237	57	9
Swainson's Hawk	2010	0.01	3587	77	4
Swainson's Hawk	2011	0.02	4496	71	3
Upland Sandpiper	2010	0.15	38587	71	12
Upland Sandpiper	2011	0.12	30357	54	22

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 avian Species of Greatest Conservation Need on 192 grids surveyed throughout Wyoming from 2009-2011. Occupancy estimates are considered robust if % CV <50%.

Species	Year	ψ	SE	% CV	n
American Three-toed Woodpecker	2010	0.034	0	34	12
American Three-toed Woodpecker	2011	0.067	0	9	15
Ash-throated Flycatcher	2010	0	0	71	1
Brewer's Sparrow	2010	0.541	0.1	9	80
Brewer's Sparrow	2011	0.505	0.1	10	77
Chestnut-collared Longspur	2010	0.033	0	64	3
Grasshopper Sparrow	2010	0.128	0	28	27
Grasshopper Sparrow	2011	0.103	0	27	26
Lark Bunting	2010	0.199	0	18	37
Lark Bunting	2011	0.144	0	20	37
Lewis's Woodpecker	2011	0.003	0	90	1
McCown's Longspur	2010	0.045	0	52	5
McCown's Longspur	2011	0.022	0	47	4
Mountain Plover	2010	0	0	71	1
Pygmy Nuthatch	2010	0.001	0	59	2
Pygmy Nuthatch	2011	0.008	0	58	2
Sage Sparrow	2010	0.191	0	20	24
Sage Sparrow	2011	0.161	0	18	23
Sage Thrasher	2010	0.252	0	18	34
Sage Thrasher	2011	0.238	0	16	33
Swainson's Hawk	2010	0.017	0	101	2
Upland Sandpiper	2010	0.038	0	77	5
Upland Sandpiper	2011	0.024	0	83	6
Willow Flycatcher	2010	0.06	0	67	4

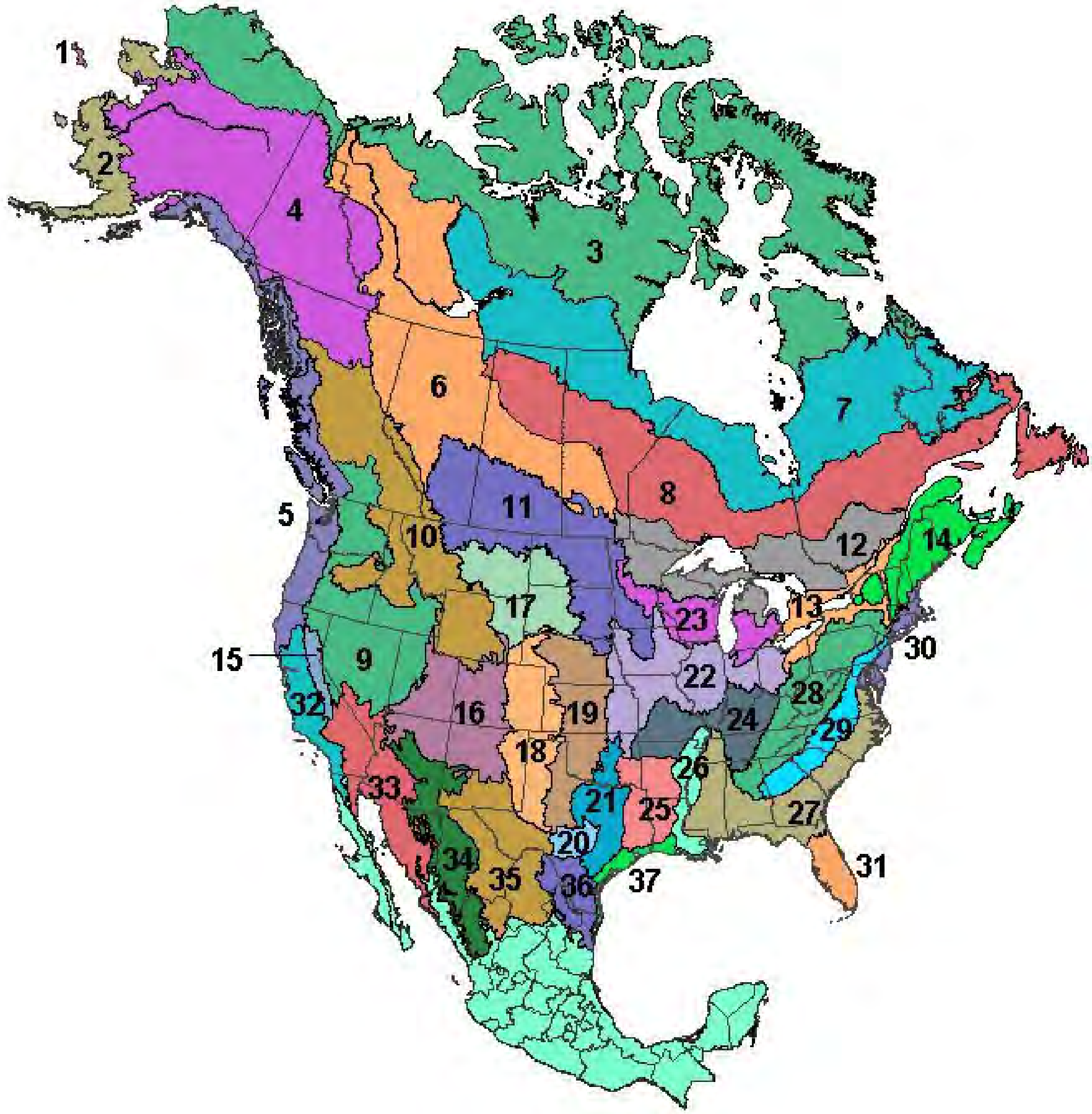

Figure 1. The North American Bird Conservation Region (BCR) map, excluding Hawaii and Mexico. Portions of BCRs that occur in Wyoming are: 9 – Great Basin, 10 – Northern Rockies, 16 – Southern Rockies/Colorado Plateau, 17 – Badlands and Prairies, and 18 – Shortgrass Prairie. Surveys were conducted in four of the five BCRs in 2012; BCR 9 was not included because funding was unavailable.

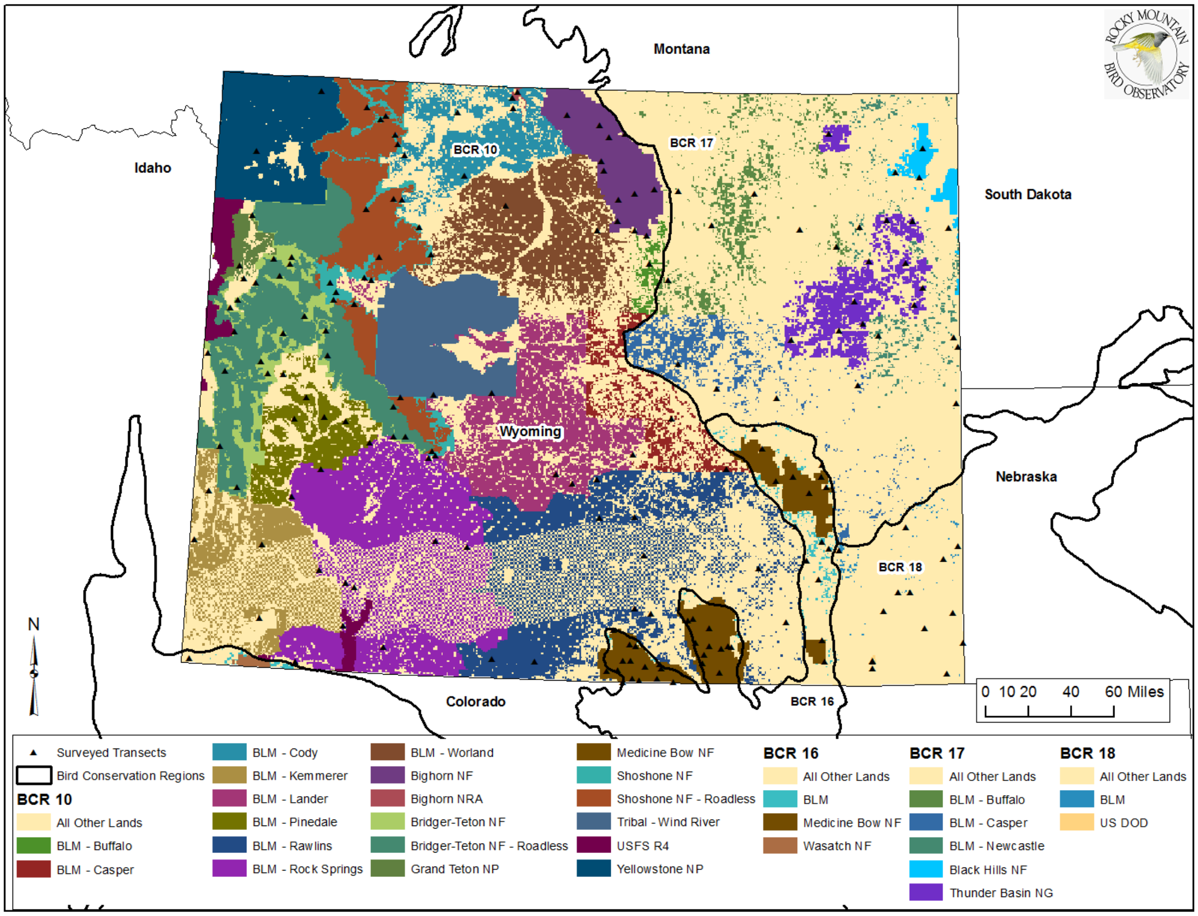

Figure 2. Location of Integrated Monitoring in Bird Conservation Regions survey grids in Wyoming in 2012.

OTHER NONGAME – *MAMMALS*

AN EVALUATION OF SIZE AND DISTRIBUTION OF COLONIES OF WHITE-TAILED PRAIRIE DOGS (*CYNOMYS LEUCURUS*) NEAR MEETEETSE, WYOMING FOR SYLVATIC PLAGUE VACCINE TRIALS

STATE OF WYOMING

NONGAME MAMMALS: White-tailed Prairie Dog

FUNDING SOURCE: United States Fish and Wildlife Service Section 6

PROJECT DURATION: 1 May 2012 – 31 July 2012

PERIOD COVERED: 15 April 2012 – 14 April 2013

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

ABSTRACT

Populations of prairie dogs (*Cynomys spp*.) have declined due to disease (e.g., sylvatic plague), drought, and anthropogenic effects since the 1800s (Ubico et al. 1988, Lybecker et al. 2002, Nistler 2009). The United States Geological Survey National Wildlife Health Center developed an oral vaccine for sylvatic plague to overcome the drawbacks of current management actions (e.g., expensive, time consuming, inefficient, etc.). In 2012, we evaluated the Pitchfork Ranch to determine its suitability for field trials of the vaccine. During July, personnel delineated the boundaries of active colonies of white-tailed prairie dogs using a GPS to determine the size and distribution of colonies on the Pitchfork Ranch. We delineated 36 active colonies which had a total area of 494.6 ha (Range: 0.1-110.0 ha; SD: 27.8). Our results suggested ≥ four sites had the potential to be used in field trials. If field trials were to be implemented at the Pitchfork Ranch, we recommend using the larger colonies, limiting experimental plots to no more than one per colony, utilizing colonies north of the ranch complex, and remapping active colonies in the future.

INTRODUCTION

Populations of white-tailed (*Cynomys leucurus*; WTPD) and black-tailed prairie dogs (*C. ludovicianus*) have experienced sharp declines over the past 200 years (Ubico et al. 1988, Nistler 2009). Disease, drought, and anthropogenic impacts have all contributed to this decline (Lybecker et al. 2002). The disease sylvatic plague (plague) is known to cause dramatic declines in abundance of prairie dogs, usually causing >90% mortality in individuals (Cully and Williams 2001, Eisen et al. 2007). The bacterium *Yersinia pestis*, known to cause plague, is transmitted through infected flea bites, aerosolized saliva, or consumption of an infected animal (Arbaji et al. 2005, Eisen et al. 2007, Nistler 2009). The endangered black-footed ferret (*Mustela nigripes*; ferret), which depends on colonies of prairie dogs for shelter and food, is also extremely vulnerable to this disease (Jachowski and Lockhart 2009, Grenier et al. 2009). Mitigating the impacts of plague is a pressing objective for those concerned with the management of prairie dogs and ferrets (Rocke 2012).

Previous management actions aimed at mitigating the spread of plague have used pyrethroid insecticides to dust burrows and kill fleas (Nistler 2009). Insecticides are not species-specific and non-target arthropods are often negatively affected (Nistler 2009, Jachowski et al. 2010). More than 170 vertebrate species are associated with colonies of prairie dogs (Miller et al. 1994), of which ≥29 rely on arthropods for their diet in-part or entirely, including several Species of Greatest Conservation Need--Mountain Plover (*Charadrius montanus*), Burrowing Owl (*Athene cunicularia*), and Lark Bunting (*Calamospiza melanocorys*; Nistler 2009, WGFD 2010). Dusting burrows can also be expensive and labor intensive, which is problematic for small programs with limited resources (Rocke 2012). Recently, new methods such as systemic insecticides have been developed to mitigate negative impacts on non-target arthropods. Although systemic insecticides can be applied more rapidly and by personnel with less training when compared to dusting, they have been shown to be less effective than pyrethroid insecticides (Jachowski et al. 2010). Considering the negative effects and shortcomings of established management actions, opportunities exist for advancements in technology and technique.

The United States Geological Survey (USGS) National Wildlife Health Center and the University of Wisconsin recently developed an oral sylvatic plague vaccine (SPV) for the prophylaxis vaccination of prairie dogs. The vaccine and medium received noteworthy results in uptake and effectiveness among prairie dogs during preliminary evaluations in the lab (Rocke et al. 2010, Rocke 2012). The next phase of trials, scheduled to begin in 2013, is designed to evaluate SPV's efficacy on prophylaxis vaccinations of individuals in-situ. This novel approach has the potential to provide improvements in several areas of management, such as cost and effectiveness. Hypothetically SPV can be distributed by airplane or all terrain vehicles, thus greatly reducing personnel costs and increasing efficiency of application. SPV has the potential to be highly effective at reducing the transmission rate of plague, allowing abundance and distribution of prairie dogs to increase (P. Gober, pers. comm.). These potential benefits of SPV may have the ability to revolutionize current management approaches and improve the conservation of prairie dogs and ferrets.

In collaboration with USGS and the Western Association of Fish and Wildlife Agencies, we evaluated suitable habitat for a potential site to use in the 2013 field trials for SPV. Meeteetse, Wyoming, a potential site for field trials, has particular importance to the history and conservation of prairie dogs and ferrets. Thought to be extinct by the late 1970s, a small population of ferrets was discovered in 1981 on colonies of WTPD near Meeteetse, Wyoming (Fagerstone and Biggins, 2011). By 1985, plague and canine distemper spread among the colonies and caused severe decline in abundance of both WTPD and ferrets (Forrest et al. 1988). The last remaining ferrets were rescued by WGFD in 1987 and taken into captivity to form the founder population for a captive breeding program (Biggins et al. 2001, Jachowski et al. 2011). Since then, the abundance of WTPD near Meeteetse, Wyoming has remained relatively low due to the persistence of plague, hindering any potential development of reintroduction attempts for ferrets. In part, these reasons represent our interest for utilizing the Pitchfork Ranch, Meeteetse, Wyoming for field trials of SPV.

We had several objectives for this project in 2012. Our main objective was to evaluate the current size and distribution of colonies of WTPD at the Pitchfork Ranch near Meeteetse, Wyoming. Our secondary objective was to determine the suitability of the site for field trials of SPV, and to assess habitat for potential releases of ferrets in the future. During July and August, 2012, we delineated the boundaries of colonies of WTPD to determine if the Pitchfork Ranch met the requirements (i.e., size of occupied area and distribution of colonies) for field trials. The purpose of this report was to summarize and discuss our findings in light of the upcoming field trials for SPV, and provide recommendations for implementing those trials at the Pitchfork Ranch.

METHODS

The Pitchfork Ranch, located 27 km west-southwest of Meeteetse, Wyoming, encompassed both public and private lands. Average annual precipitation was 3 cm, and habitat contained rolling hills and flat benches with level to gentle slopes. The dominant vegetative species on or near colonies were either junegrass (*Koeleria cristata*), or sagebrush (*Artemisia tridentate*) and junegrass (Collins and Lichvar, 1986). During spring of 2012, we spoke with land managers and conducted aerial surveys by fixed-wing aircraft to record approximate locations of colonies of WTPD on the Pitchfork Ranch. We used the data and GIS (ArcGIS 10.0, ESRI, Redlands, CA) to create maps that personnel utilized to find, evaluate, and delineate active portions of colonies from the ground between10 July and 31 July 2012. Not every colony was represented on the maps; therefore, we evaluated and delineated additional active colonies as we detected them from the ground.

We evaluated colonies on the Pitchfork Ranch from the ground to determine the status of burrows of WTPD prior to delineating boundaries. We only delineated the boundary of colonies if active burrows were observed at the site. We considered burrows to be active if we detected individual WTPD by sight or sound, or observed fresh scat (e.g., still moist or green in the middle), or recent diggings. Generally, we followed guidelines established by Biggins et al. (1993) for delineating colonies. Personnel walked the perimeter of each colony, followed active burrows, and recorded waypoints with a GPS unit (Garmin GPSMAP 62st) every 10-15 m. We considered burrows that were active and >50 m from the nearest active burrow to be an outlier when no other active burrows were located nearby. We excluded the outliers from the boundary of the colony to maintain a conservative estimate of the area occupied by WTPD. We downloaded waypoints to a laptop, imported these data into GIS, and used them to create polygons from which we calculated the area (ha) for each colony.

RESULTS

We delineated a total of 36 colonies on the Pitchfork Ranch (Fig. 1.). The colonies of WTPD occupied a total area of 494.6 ha (Range: 0.1-110.0 ha). The mean area was 13.7 ha (SD: 27.8). In general, more individuals were heard or seen near the center of large colonies during the survey. Few to no individuals were heard or seen on smaller colonies, which appeared to be remnants of larger colonies that were no longer active. In these cases, there were clusters of active burrows surrounded by dilapidated or caved in burrows. Out of the approximately 85 potential sites we detected by airplane or on foot, only 42% resulted in the delineation of active colonies of WTPD. We also observed other species of wildlife on or near the colonies, including pronghorn antelope (*Antilocapra Americana*), white-tailed jackrabbit (*Lepus townsendii*), Horned Lark (*Eremophila alpestris*), and Mountain Plover.

DISCUSSION

Our results suggested that sufficient area existed for selecting ≥ two paired experimental plots for field trials at the Pitchfork Ranch in 2013. The areas which were suitable for experimental plots appeared to have more abundant WTPD than elsewhere on the ranch. The USGS recommended experimental plots have similar abiotic (e.g., habitat, size, elevation, etc.) and biotic (e.g., density of prairie dogs and burrows, persistence of plague, etc.) characteristics. The USGS also recommended experimental plots have a physical or topographical barrier between areas, and grazing of cattle and shooting of prairie dogs be prohibited during the project. The experimental plots we delineated fulfilled many of the recommendations listed above. In addition, the owners of the Pitchfork Ranch have agreed to restrict grazing and shooting access to colonies containing experimental plots. For these reasons, we recommend using the Pitchfork Ranch for field trials of SPV in 2013.

The size and distribution of colonies of WTPD on the Pitchfork Ranch were not sufficient to support ferrets during our surveys. Large prairie dog complexes with high abundance of individuals are required for ferrets to survive, and these characteristics were not observed in 2012 on the Pitchfork Ranch (Jachowski et al. 2011). However, during the mid 1980s, the data from this area show that 25 of 37 colonies of WTPD, which encompassed a total of 3,100 ha (Range 2.5-740 ha), were occupied by ferrets (Forrest et al. 1988, Fagerstone and Biggins 2011). The differences between these two datasets can be attributed to epizootics of disease, which have been shown to reduce abundance of WTPD and ferrets on the Pitchfork Ranch (Forrest et al. 1988, Ubico et al. 1998). Similar epizootics of plague continue to impact the abundance and distribution of prairie dogs on the Pitchfork Ranch and across the West (Jachowski and Lockhart 2009). Current management actions lack the practicality for widespread use at most sites. SPV has the potential to successfully mitigate the impacts of plague while being more efficient. Additionally, SPV has the potential to increase the suitability of the Pitchfork Ranch for future reintroductions of ferrets.

We experienced warm, sunny mornings, hot mid-days, and afternoons with light rain showers while conducting the surveys. Although some may speculate we observed fewer active burrows than may have been present due to weather, we disagree. We modified our techniques to compensate for weather conditions that may have affected the activity of WTPD. Heavy rains can wash pellets down burrows and WTPD have been reported to retreat deep underground to avoid the heat of the day (Keinath 2004). After heavy rains, we made an extra effort to look deeper into burrows to observe pellets that might have been washed down by rain water. To circumvent the heat avoidance behavior, we modified the timing of surveys to include early mornings and late afternoons. We believe our diligence improved our ability to detect WTPD and resulted in an accurate assessment of the area.

We have several recommendations for proceeding with trials of SPV on the Pitchfork Ranch. First we recommend placing the experimental plots on larger colonies. During our surveys, more individuals were heard or seen on larger colonies and, therefore, we hypothesize it will be easier to trap the minimum required number of WTPD. Secondly, we recommend using no more than one plot per colony and separating colonies by a geographic barrier to minimize movements of WTPD between experimental plots. Minimizing movement will help maintain geographic closure, which is important for estimating abundance. Thirdly, we recommend utilizing colonies located north of the ranch house. The landowners have agreed to restrict access (i.e., grazing, shooting, or trespassing) to the area, and it contained larger colonies (i.e., more abundant WTPD). Lastly, we recommend re-delineating active colonies in the future to track changes in size and distribution of colonies of WTPD on the Pitchfork Ranch. We hypothesize that our recommendations, if followed, will assist personnel in successfully implementing field trials of SPV. The success of this project is important not only to WTPD, ferrets, and the Wyoming Game and Fish Department (Department), but also to the local community.

ACKNOWLEDGEMENTS

This project was made possible by the United States Fish and Wildlife Service Section 6 Funds, and with the cooperation and support of the Pitchfork Ranch. We would like to thank the United States Forest Service for the use of their cabin during the length of our stay. We would also like to thank several Department personnel, including C. Atkinson for assistance with ground surveys, N. Cudworth for conducting aerial surveys, and the Cody Region, specifically J. Olson, for their assistance.

LITERATURE CITED

Arbaji A., S. Kharabsheh, S. Al-Azab, M. Al-Kayed, Z. S. Amr, M. Abu Baker, and M. C. Chu. 2005. A 12-case outbreak of pharyngeal plague following the consumption of camel meat, in north-eastern Jordan. Anals of Tropical Medicine and Parasitology 99:789-793.

Biggins, D. E., B. J. Miller, L. R. Hanebury, B. Oakleaf, A. H. Farmer, R. Crete, and A. Dood. 1993. A technique for evaluating black-footed ferret habitat. Pages 73-88 *in* Management of prairie dog complexes for the reintroduction of the black-footed ferret (J. L. Oldenmeyer, D. E. Biggins, B. J. Miller, and C. R. Crete, Editors). Biological Report No.13. US Fish and Wildlife Service, Washington D.C.

Biggins, D. E., T. M. Livieri, and S. W. Breck. 2001. Interface between black-footed ferret research and operational conservation. Journal of Mammalogy 92:699-704.

Collins, E. I., and R. W. Lichvar. 1986. Vegetation inventory of current and historic black-footed ferret habitat in Wyoming. Great Basin Naturalist Memoirs 8:85-93.

Cully, J. F., and E. S. Williams. 2001. Interspecific comparisons of sylvatic plague in prairie dogs. Journal of Mammalogy 82:894-905.

Eisen, B. J., R. E. Enscore, B. J. Biggerstaff, P. J. Reynolds, P. Ettestad, T. Brown, J. Pape, D. Tanda, C. E. Levy, D. M. Engelhaler, J. Cheek, R. Bueno Jr., J. Targhetta, J. A. Montenieri, and K. L. Gage. 2007. Human plague in the southwestern United States, 1957-2004: spatial models of elevated risk of human exposure to *Yersinia pestis*. Journal of Medical Entomology 44:530-537.

Fagerstone, K. A., and D. E. Biggins. 2011. Black-footed ferret areas of activity during late summer and fall at Meeteetse, Wyoming. Journal of Mammalogy 92:705-709.

Forrest, S. C., D. E. Biggins, L. Richardson, T. W. Clark, T. M. Campbell III, K. A. Fagerstone, and E. T. Thorne. 1988. Population attributes for the black-footed ferret (*Mustela nigripes*) at Meeteetse Wyoming, 1981-1985. Journal of Mammalogy 69:261-273.

Grenier, M., S. W. Buskirk, and R. Anderson-Sprecher. 2009. Population indices versus correlated density estimates of black-footed ferret abundance. Journal of Wildlife Management 73:669-676.

Jachowski, D. S., and J. M. Lockhart. 2009. Reintroducing the black-footed ferret *Mustela nigripes* to the great plains of North America. Small Carnivore Conservation 41:58-64.

Jachowski, D. S., S. Skipper, and M. E. Gompper. 2010. Field evaluation of imidacloprid as a systemic approach to flea control in black-tailed prairie dogs, *Cynomys ludovicianus*. Journal of Vector Ecology 36:100-107.

Jachowski, D. S., R. A. Gitzen, M. B. Grenier, B. Holmes, and J. J. Millspaugh. 2011. The importance of thinking big: large-scale prey conservation drives black-footed ferret reintroduction success. Biological Conservation 144:1560-1566.

Keinath, D. A. 2004. Species assessment for white-tailed prairie dog (*Cynomys leucurus*) in Wyoming, prepared for United States Department of the Interior, Bureau of Land Management, Wyoming State Office, Cheyenne, Wyoming. Wyoming Natural Diversity Database, University of Wyoming Laramie, USA.

Lybecker, D., B. L. Lamb, and P. D. Ponds. 2002. Public attitudes and knowledge of the black-tailed prairie dog: a common and controversial species. BioScience 52:607-613.

Miller, B., G. Ceballos, and R. Reading. 1994. The prairie dog and biotic diversity. Conservation Biology 8:677-681.

Nistler, C.M. 2009. A review of prairie dog population demographics and implications for management in Montana. Report prepared for Montana Fish, Wildlife, and Parks, Helena, USA.

Rocke, T. E., N. Pussini, S. R. Smith, J. Williamson, B. Powell, and J. E. Osoriao. 2010. Consumption of baits containing raccoon pox-based plague vaccines protects black-tailed prairie dogs (*Cynomys ludovicianus*). Vector-Borne and Zoonotic Diseases 10:53-58.

Rocke, T. E. 2012. Sylvatic plague vaccine and management of prairie dogs: US Geological Survey Fact Sheet 2012–3087. National Wildlife Health Center, Madison, Wisconsin, USA.

Ubico, S. R., G. O. Maupin, K. A. Fagerstone, and R. G. McLean. 1988. A plague epizootic in the white-tailed prairie dogs (*Cynomys leucurus*) of Meeteetse, Wyoming. Journal of Wildlife Diseases 24:399-406.

Wyoming Game and Fish Department [WGFD]. 2010. State wildlife action plan. Wyoming Game and Fish Department, Cheyenne, USA.

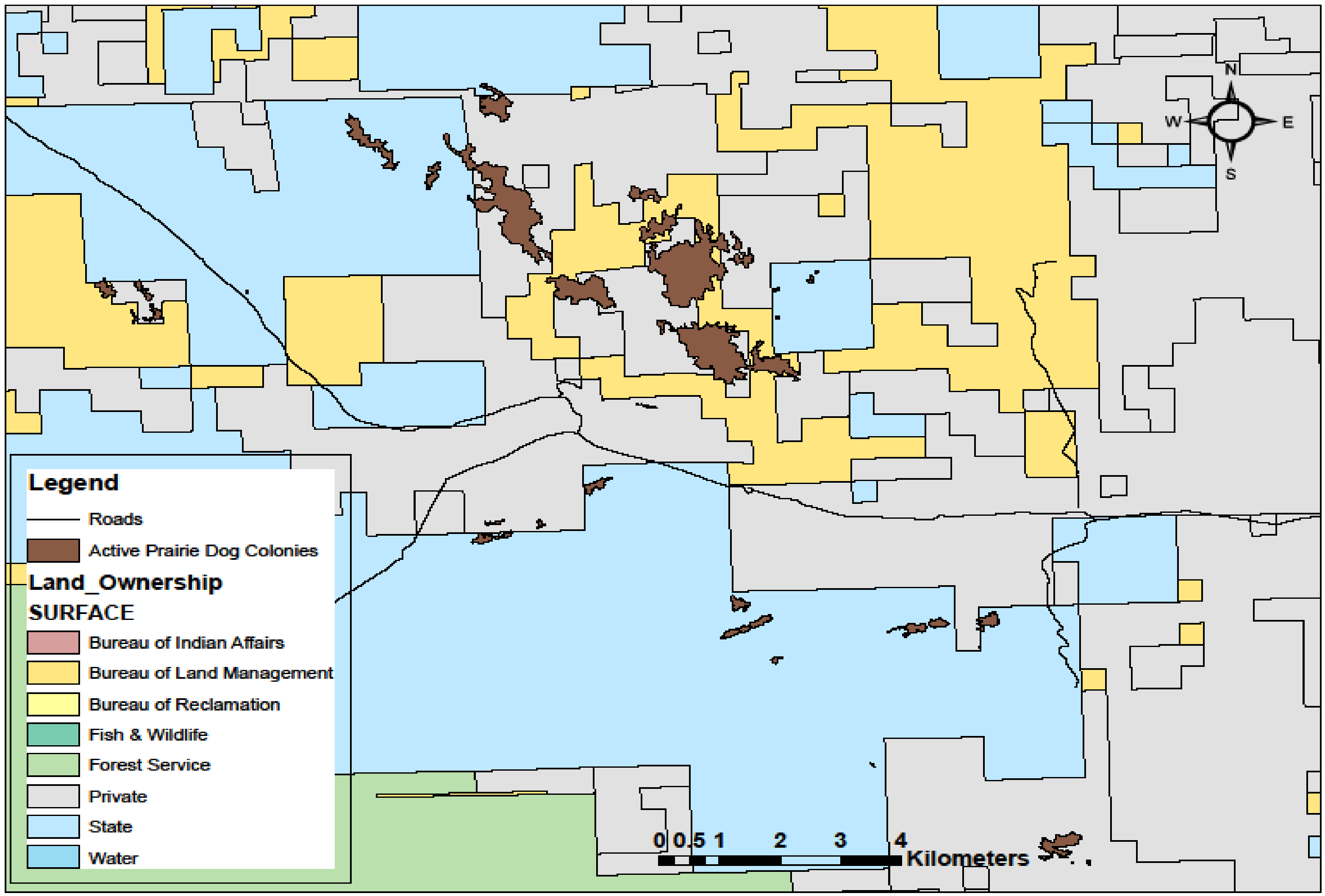

Figure 1. Distribution of active colonies of white-tailed prairie dogs (*Cynomys luecurus*) we delineated between 10 July and 31 July 2012 near Meeteetse, Wyoming. We delineated 36 active colonies, which had a total area of 494.6 ha (Range: 0.1-110.0 ha; SD: 27.8). Colonies where white-tailed prairie dogs were not detected are not represented.

TECHNICAL COMMITTEES AND WORKING GROUPS

WYOMING BIRD RECORDS COMMITTEE

STATE OF WYOMING

NONGAME BIRDS: Rare and Unusual Birds

FUNDING SOURCE: Wyoming State Legislature General Fund Appropriations

PROJECT DURATION: Annual

PERIOD COVERED: 1 January 2012 – 31 December 2012

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

SUMMARY

The Wyoming Bird Records Committee (WBRC) was established in 1989 to accomplish the following goals.

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

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

As of 31 December 2012, the WBRC has reviewed 1,256 reports of rare and unusual birds in Wyoming. Of those reports, 1016 (81%) have been accepted and 240 (19%) have not been accepted. Eleven reports have been submitted thus far in 2013 and are awaiting review.

The Wyoming Bird Records Committee Database is a dynamic document, updated once or twice a year following the WBRC meetings. All WBRC reports for 2012, as well as Rare and Unusual Bird Forms are available from the Nongame Bird Biologist in the Lander Regional Office.

ACKNOWLEDGEMENTS

Funding was provided by the Wyoming State Legislature General Fund Appropriations, 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: J. Adams, B. Hargis, G. Johnson, J. Maley, C. Michelson, and S. Patla.