

**Golden Eagle Nesting Ecology in the Bighorn Basin:**  
Influence of Landscape Composition, Energy Development and other  
Human Activity on Golden Eagle Nesting Distribution, Success,  
Productivity, and Diet 2010 - 2013

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## INTRODUCTION

Golden eagles (*Aquila chrysaetos*) are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). The Act expressly prohibits “taking” of eagles, including injuring, killing, or disturbing eagles in a way that causes nest abandonment or reduced productivity. Even short-term loss of adults or reduced productivity is of particular concern because it takes several years for eagles to reach sexual maturity, they typically produce only one or two offspring per reproductive effort, and they do not necessarily reproduce every year after reaching sexual maturity (Kochert et al. 2002). Golden eagle populations are believed to be declining through at least a portion of the species’ range in the contiguous United States (Harlow and Bloom 1989, Kochert and Steenhof 2002, Kochert et al. 2002, Preston and Leppart 2004, Good et al. 2007, Farmer et al. 2008) due to a variety of anthropogenic factors. Habitat degradation, collisions with human structures, electrocutions, and human disturbance near nest sites are among the chief factors that negatively impact eagle populations.

Sagebrush-dominated ecosystems support most golden eagle nesting efforts in Wyoming. Loss or alteration of native sagebrush habitat due to invasion of exotic cheatgrass and associated large-scale fires (Kochert et al. 1999), residential and urban expansion (Boecker 1974, Scott 1985), and extensive agricultural development (Beecham and Kochert 1975, Craig et al. 1986) have negatively impacted eagle populations in intermountain basins and other lowlands through much of the West. Energy development, with its associated roads, well pads, and human activity, is another significant cause of sagebrush ecosystem alteration and potential impact on golden eagle

populations, especially in Wyoming and adjacent states (Madders and Walker 2002, Smith et al. 2010, Rowland et al. 2011).

Golden eagles are also highly vulnerable to electrocution and collisions with utility lines associated with exurban expansion and energy development (Franson et al. 1995, Lehman et al. 2007, Lehman et al. 2010). Between 2007 and 2009, more than 200 golden eagles and scores of other raptors were killed after being accidentally electrocuted in rural areas of Wyoming (T. Eicher, pers. comm.). Many of these incidents occurred along utility powerlines in or near oil fields and gas wells, including those in the Bighorn Basin, near Cody, Wyoming. Since 1991 there have been more than 1,000 documented eagle electrocutions across Wyoming, including at least 480 in the Bighorn Basin (T. Eicher, pers. comm.).

Recreational activity near golden eagle nests is another factor that can cause nest failure or reduced productivity (Scott 1985, Watson 1997, Kochert et al. 2002). Disturbance can include repeated off-road biking or all-terrain vehicle use, hiking, rock-climbing, target shooting, as well as intentional approach toward nests. Abandonment is most likely during the early stages of nesting, depending on the type and duration of disturbance, but disturbance at any stage of nesting can negatively affect productivity.

Habitat loss and alteration, energy development, and motorized and non-motorized recreation are increasing in sagebrush-steppe ecosystems in the Rocky Mountain West and Intermountain Basins, especially in the Greater Yellowstone region (e.g., Preston 2006). Energy development is accelerating especially rapidly in Wyoming and adjacent states in response to demand and economic opportunity. Across Wyoming, the number of oil wells increased by 73%, and the number of gas wells increased by

318% between 2000 and 2006 (Oakleaf et al. 2010). The importance of gaining a better understanding of golden eagle ecology and conservation issues was underscored during the National Golden Eagle Colloquium recently convened for federal and state agencies and eagle scientists (Pagel et al. 2010). Discussions at this colloquium stressed the need for both broad, regional and statewide landscape surveys to determine current status and distribution of golden eagles and more intensive, local studies to examine nesting dynamics of golden eagles in response to a variety of factors, including landscape composition, human activity, and independent fluctuations of weather and prey availability. These data are critical to establish a baseline context for evaluating golden eagle status and trends in relation to human activities decades into the future.

In 2009, the Draper Museum of Natural History, in partnership with the Bureau of Land Management, initiated a five-year study to determine golden eagle nest occurrence and distribution, and annual nesting occupancy, activity, success, and productivity in a multiple land-use study site in Wyoming's Bighorn Basin. Our overarching goals are to establish a strong foundation to evaluate future golden eagle status in the study area in relation to environmental change and provide information and insights to help guide golden eagle management decisions in multiple-use landscapes across western North America. The study is being conducted over multiple years to help identify and partition the confounding effects of annual fluctuations in weather and prey availability. We are also integrating our scientific research with a diverse suite of educational programs to engage and inform the public regarding conservation of raptors and other wildlife.

The primary objectives of our study include:

1. Inventory and monitor golden eagle nesting efforts and results in a multiple land-use study area that encompasses intense recreation, energy development, agriculture, and other land uses in the Bighorn Basin to lay the foundation for comparisons far into the future
2. Determine food habits of nesting golden eagles to identify impacts of human activities on eagle diet
3. Document annual fluctuations of primary prey (i.e. lagomorphs) within the study area to identify impacts of human activities on these important eagle prey
4. Determine the relationships among nesting parameters and weather, landscape composition and land use variables to sort out impacts of anthropogenic and non-anthropogenic sources of variation
5. Document nesting behavior of adults and chicks at selected nests to determine effects of behavior on reproductive success and productivity and factors affecting nesting behavior
6. Create field-based educational experiences for the public to introduce them to golden eagle ecology and the importance of sagebrush-steppe landscapes.

This report summarizes our efforts and results related to objectives 1-3 above through the 2011 summer field season. We cannot adequately analyze data related to objectives 4-5 until all the data collection is completed.

## STUDY AREA

The Bighorn Basin lies at the eastern edge of the Greater Yellowstone Ecosystem, in northwestern Wyoming. It is one of the last large, virtually intact native sagebrush-steppe tracts left in the Intermountain West. Except for a narrow gap to the northwest, the Basin is surrounded by high elevation ecosystems of the Absaroka, Beartooth, and Bighorn mountain ranges. Flat and rolling terrain is broken sharply by sandstone outcroppings, cliffs, and ravines. Depending on local soil characteristics and topography, native vegetation is dominated by a complex of shrubs, e.g., big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), saltbush (*Atriplex* spp.) and rabbitbrush (*Chrysothamnus* spp.), grasses, e.g., bluebunch wheatgrass (*Agropyron spicatum*), western wheatgrass (*Agropyron smithii*), Sandberg bluegrass (*Poa sandbergerii*), and needle-and-thread (*Stipa comata*), and forbs, e.g., scarlet globemallow (*Sphaeralcea coccinea*) and penstemon (*Penstemon* spp.). Plains cottonwood and willows occupy wetter drainages. Invasive species include cheatgrass (*Bromus tectorum*), tamarisk (*Tamarix* spp.), and Russian olive (*Elaeagnus angustifolia*).

The large, relatively unbroken swath of sagebrush-steppe habitat in the Bighorn Basin provides important seasonal or year-round sustenance for wildlife native to the Greater Yellowstone Ecosystem. Mammals using the Basin either year-round or seasonally include pronghorn (*Antilocapra americana*), mule (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*), free-ranging horse (*Equus ferrus*), white-tailed prairie dog (*Cynomys ludovicianus*), white-tailed jackrabbit (*Lepus townsendii*), desert cottontail (*Sylvilagus audubonii*), black bear (*Ursus americanus*), badger (*Taxidea taxus*), coyote (*Canis*

*latrans*), red fox (*Vulpes vulpes*), and bobcat (*Felis rufus*). Occasionally, grizzly bears (*Ursus arctos*) wander into the Basin, and cougars (*Puma concolor*) occur persistently in the area. Gray wolves (*Canis lupus*) range around and within the area, especially near livestock operations.

Birds (seasonal or year-round residents) include greater sage-grouse (*Centrocercus urophasianus*), sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow (*Spizella breweri*), vesper sparrow (*Pooecetes gramineus*), lark bunting (*Calamospiza melanocorys*), western meadowlark (*Sturnus neglecta*), long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), golden (*Aquila chrysaetos*) and American bald eagles (*Haliaeetus leucocephalus*), red-tailed (*Buteo jamaicensis*), rough-legged (*B. lagopus*), and Swainson's hawks (*B. swainsoni*), prairie falcon (*Falco mexicanus*), great-horned (*Bubo virginianus*), long-eared (*Asio otus*), short-eared owls (*Asio flammeus*), and burrowing owls (*Athene cunicularia*). The Bighorn Basin is among the world's remaining strongholds for greater sage-grouse populations (Harrell 2008).

Land ownership in the Bighorn Basin is divided among private and public hands, with the majority of public land administered by the Bureau of Land Management. Land use includes urban and exurban residential development, significant energy development, livestock grazing, and extensive motorized and non-motorized recreation. Additionally, the area is traversed by a maze of paved and unpaved transportation corridors. It is an increasingly popular area for hunting and other outdoor recreation. The Bighorn Basin is experiencing a period of rapid environmental change in response to weather fluctuations, increased recreational use, exurban residential sprawl, and significantly increased energy development, including the potential for wind energy development.

Our study area encompasses approximately 2,500 km<sup>2</sup> in the northwestern corner of the Bighorn Basin, near Cody, Wyoming. The area is bordered approximately by Powell and Lovell, Wyoming to the north, Meeteetse, Wyoming to the south, the western extent of the Buffalo Bill Reservoir to the west, and Greybull, Wyoming to the east. Vegetation, geomorphology, and human land use in our study area are representative of the Bighorn Basin as a whole.

## **METHODS**

Each year, we conduct fixed-wing aerial surveys in mid-March to early April to search for golden eagle nest areas and document whether the sites are occupied and any nests within an area is active (e.g., McIntyre 2002, McIntyre et al. 2006, Lehman et al. 1998). A nest area is defined as one or more alternate nests determined as being used or having been used by a single pair of eagles in a given year (Steenhof and Newton 2007). A nest area is determined to be occupied if two adult eagles are observed within the area, or if there is evidence that one or more nests have been recently refurbished or used (i.e., fresh greenery or egg present). A nest area is considered active if an egg, chick, or incubating/brooding eagle is present at any nest. We conduct fixed-wing surveys again in late June – early July to determine nest success (at least one chick reaching average fledging age, i.e., 51 days of age) and productivity (the number of chicks reaching fledging age). Between aerial surveys, we conduct ground surveys as needed to verify nest status. Between six and eight nests per season are selected (on basis of accessibility to observation point) for more intense monitoring. Each of these nests is monitored for at least six hours per week until fledging or nest failure. Volunteers contributed 548 hours

and more than 3,400 travel miles to the project in 2011. We initiated roadside surveys in 2010, and continued these in 2011 to develop a relative index to abundance of lagomorphs (i.e., white-tailed jackrabbits *Lepus townsendii*, cottontails *Sylvilagus* spp.) in four geographic zones of our study area. In each of the four zones of the area, one 8-km (5-mile) secondary roadside transect was established. During one full moon night in May, June, and July (in 2011 we added March and eliminated the May survey), beginning between 2100 and 2200 hours Mountain Daylight Time, each transect was surveyed using two observers and a spotlight. Each survey lasted between 45 and 60 minutes. To assess nesting food habits, we collect prey remains from a sample of nests (determined by accessibility) after chicks fledged or nests were abandoned. In partnership with Dr. John Campbell and his students at Northwest College, Powell, Wyoming, we have begun quantifying landscape composition (primarily percentage of shrub cover), amount of energy development (e.g., numbers/sizes of structures, roadways, powerlines, etc. associated with energy development), and other human activity (e.g., recreational use, powerlines, etc.) surrounding each nest area at 1, 2, and 3 km intervals. These characterizations are ongoing, but will be completed in 2012, and integrated into our final analyses of relationships between nesting parameters, weather, landscape composition and land use at the end of the 2013 field season. We began experimental capture/banding operations in 2010, banding four young eagles with known nest origins, and will intensify banding at least through 2013 to provide information on mortality and movements. After initially considering patagial markers to identify individual eagles, we've chosen to mark birds with less intrusive, individually-coded colored leg bands.

## RESULTS 2009-2011

Nesting parameters — After our 2011 early season aerial surveys and ground-truthing, we re-examined and revised nest area designations from 2009 and 2010. From additional nest-site visits and critical examination, we eliminated some nest areas as being redundant, belonging to other raptor species, or as not likely to have been used by eagles for several years. We have now confirmed at least 60 distinct golden eagle nest areas located within the study area (Figure 1 map available qualified researchers upon request). Nests areas are distributed unevenly in the study area, conforming to the distribution of prominent sandstone outcrops and other topographic relief. Density of nest areas discovered through 2011 across the study area is 41.91 km<sup>2</sup>/nest area, with highest densities occurring in Sheep Mountain Zone (23.4 km<sup>2</sup>/nest area) and Oregon Basin (28.6 km<sup>2</sup>/nest area). Focusing only on active nest areas, overall density was 132.4 km<sup>2</sup>/active nest in 2011, with highest density in Polecat Bench Zone (92.8 km<sup>2</sup>/active nest). Nest occupancy, activity, success and productivity were similar among nest areas in 2009 and 2010, but declined dramatically in 2011 (Table 1). Only 70% of occupied nest areas (territories) included active nests, and nest success (74%) and productivity (1.21 fledglings per successful nest) were lower this year than in 2009 (93% and 1.48, respectively) or 2010 (85% and 1.43, respectively).

Year	Nest Areas	Occupied	Active	Successful	No. Fledglings
2009	37	30	27	25	37
2010	51	31	27	23	33
2011	60	27	19	14	17

**Table 1. Results of nest surveys 2009-2011.**

Food Habits — We re-examined prey remains from 2009 and 2010, in addition to examining 2011 prey remains, at the conclusion of the 2011 field season. Table 2 lists the minimum number of individuals identified in each species or category, i.e., if we identified three hind feet as cottontail, the minimum number of cottontails in this sample was two. In some cases, a bird species was represented by a single feather, i.e., one individual, in a sample. Even if several feathers of a species were present, we counted this as one individual unless two skulls, three wings, etc. were present. Thus far, we have identified a minimum of 466 individuals from the remains of 18 different nests. Cottontails were the most frequently occurring prey in each year of the study thus far, but the diet was much more varied in 2011 than in either 2009 or 2010. Species counted as “other” in Table 2 include a variety of ground squirrels and other rodents, snakes, and small to medium-sized birds, including common raven (*Corvus corax*), northern flicker (*Colaptes auratus*), and magpie (*Pica pica*), among others. Several small bones have not yet been identified with certainty.

Year	Cottontail spp.	White-tailed Jackrabbit	Pronghorn	Greater Sage-grouse	Other	Total
2009	121 (86%)	2	3	1	14	141
2010	134 (82%)	4	5	1	19	163
2011	100 (62%)	5	12	3	42	162
Total	355 (76%)	11	20	5	75	466

**Table 2. Prey remains (minimum number of individuals) from eagle nests sampled 2009-2011.**

Lagomorph surveys — We initiated lagomorph surveys in 2010, after it became

clear from our 2009 food habits investigations that rabbits and hares comprised an overwhelming proportion of eagle diet in our study area. We adjusted our survey protocol slightly in 2011 to make most efficient use of our resources and to capture information regarding the relative abundance of lagomorphs during three key phases of the golden eagle nesting season, i.e., laying and incubation phase in mid-March, nestling period in mid-June, and fledging and early post-fledging period in mid-July. The results (Figure 2) show a dramatic decrease in lagomorphs detected from 2010 to 2011. These results summarize numbers of rabbits and hares observed in all four survey routes during each survey period. No surveys were conducted in March 2010 or in May 2011. In general, cottontails increased through the eagle nesting season in 2010, but declined through the season in 2011. Cottontails were far more abundant in 2010 (blue bars) than 2011 (purple bars). Except for July 2010, white-tailed jackrabbits were infrequently encountered in our study area in either 2010 (yellow bars) or 2011 (aqua bars).

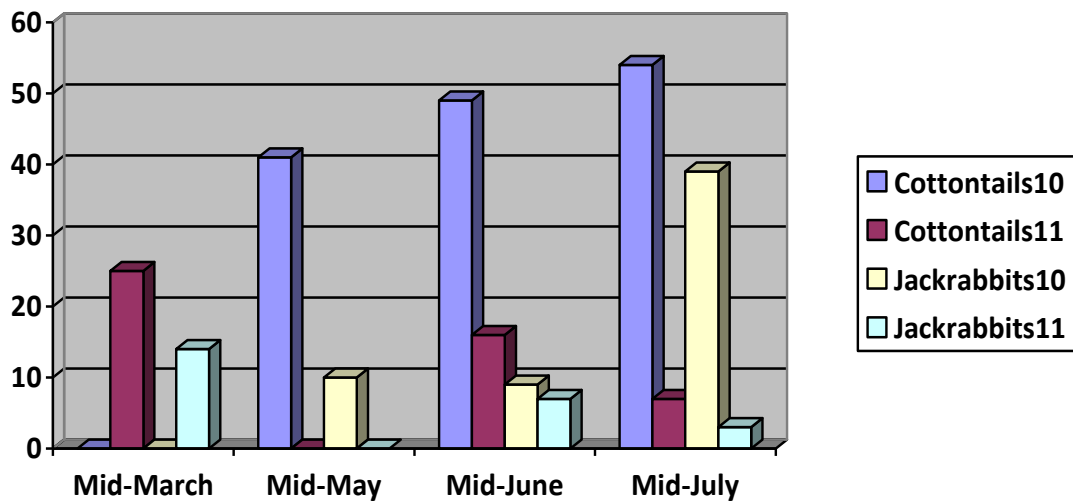


Figure 2. Lagomorphs detected during surveys in 2010 and 2011.

Educational initiatives — We led five field trips and presented seven lectures/programs to introduce public audiences (total 772 participants) to golden eagles and sagebrush-steppe ecology between October 2010 and the end of September 2011. Additionally, we published a magazine article updating our fieldwork for public audiences (Preston 2011).

## **DISCUSSION**

The lands within and adjacent to Bureau of Land Management holdings in the northwestern portion of Wyoming's Bighorn Basin support a significant population of nesting golden eagles. The overall density of nest areas currently identified ( $41.9 \text{ km}^2$  /nest area) falls well within the density range (29 to  $252 \text{ km}^2$ /nesting pair) reported in the peer-reviewed literature (Kochert et al. 2002), although results should be evaluated carefully due to variations in how densities are calculated and reported. We have chosen to report overall nest area density as well as nest density of active nests only, and to also group nest densities within distinctive, topographically-defined zones of our study area. Nest area densities in portions of our study area, specifically Sheep Mountain Zone ( $23.4 \text{ km}^2$  / nest area) and Oregon Basin Zone ( $28.6 \text{ km}^2$ /nest area), are among the highest densities reported in North America (Kochert et al. 2002), possibly due to the clumped distribution of nesting substrates (i.e., sandstone outcrops) and relatively high lagomorph abundance. However, we must exercise caution in comparing nest area density with active nest density and comparing data among highly variable study areas across western North America. Densities of active nests within our study area in 2011 are much lower than densities of all nest areas identified in our study area. As we have become more

familiar with the study area, we have discovered additional nest areas each year, even after adjusting for redundancies. This argues for the importance of long-term studies and caution in drawing inferences from short-term data. Some golden eagle nest areas are difficult to locate in remote, varied terrain. While nesting activity, success, and productivity were similar in 2009 and 2010, we detected a marked decline in these parameters in 2011, again underscoring the importance of long-term, geographically-focused studies to help understand golden eagle ecology and population dynamics. The nesting decline in 2011 coincided with a decline in numbers of lagomorphs detected in our surveys from 2010 to 2011. Though clear interpretations or cause-and-effect relationships are premature with the data currently in hand, these results are suggestive that lagomorph availability strongly drives golden eagle nesting activity and success, and may thus exert a profound influence on golden eagle population dynamics in the Bighorn Basin. If this is true, energy development and other human activities in the Basin that influence lagomorph abundance and availability could exert an important indirect influence on the golden eagle population. Although nesting eagles included more species in their diet in 2011 compared with 2009 and 2010, cottontails remained the most frequently occurring species found in nest remains. These data should be interpreted with care due to some prey remains possibly being more easily detected than others. There is no indication, however, that another prey species can replace the critical importance of lagomorphs in golden eagle diet in our study area. Prairie dogs and other ground squirrels are important primary or secondary prey in the diet of golden eagles in other regions (Kochert et al. 2002), but are relatively uncommon in the Bighorn Basin (pers. observation). Greater sage-grouse are rabbit-sized and fairly common in the study area,

but have been detected only rarely in our prey remains. This may be due to the grouse effectively using the relatively dense sagebrush cover in our study area during summer.

## **STATUS OF PROJECT AND FUTURE WORK**

We remain on target with each of our project objectives, and encountered no unanticipated obstacles in 2011. After three years, we believe we have detected virtually all golden eagle nest areas in our study area, and our volunteer corps is well-trained and extremely helpful. We are currently producing new nest area distribution maps showing annual nesting results, and will integrate these maps with all future reports. Our public education programming has become very popular with local and even national audiences, and we anticipate expanding our audiences via our website and through K-12 ecological science curricula related to the eagle project.

Through at least 2013, we will continue golden eagle nesting surveys and monitoring and lagomorph surveys. In 2012, we intend to add two more lagomorph survey routes to the study. We will also continue collecting prey remains at nest sites and are exploring additional funding to install remote still and video cameras at selected nests to gain further insights into food habits and nesting behavior; this is especially important given assertions by some that eagles are significant predators on greater sage-grouse (Kidston 2011).

Our ongoing banding/marking operations will continue to help identify eagle individuals and determine site fidelity, mortality, and individual movements, and we are continuing to explore a partnership with the University of Wyoming Berry Center for Conservation Biodiversity to analyze DNA from shed eagle feathers (e.g., Rudnick et al.

2005) to better understand demographics of our study population. In 2011, we began a partnership with Yellowstone National Park to expand our study to include golden eagle nesting in the Park. Pending additional funding, we will continue this work to provide a broader context to interpreting golden eagle nesting ecology in the Bighorn Basin.

We are continuing to map landscape characteristics in our study area so that by the end of the 2013 season, we will be able to relate golden eagle nesting parameters, food habits, and relative lagomorph abundance to landscape composition, and landscape alteration due to energy development, exurban expansion, recreation, and other human activities. Multivariate statistical techniques, such as logit analysis (Preston and Beane 1996) will be used to tease apart the potential confounding effects of interrelationships among the variables. Similarly, we will continue intensive monitoring of sample nests each year and complete analyses of nesting behavior observations in relation to these same factors at the end of the study.

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