teton raptor center

2025 Annual Conservation Reports

2025 Teton Raptor Center Research Personnel

Bryan Bedrosian; Conservation Director

Julie Polasik; Senior Research Biologist

Hilary Turner; Research Biologist/Volunteer Coordinator

Adrian Rouse; Field Biologist

Addie Wichman; Research Intern

Anna Wolke; Conservation Intern

Dr. Ellen Aikens; Research Associate - UWYO

Dr. Charles Preston; Research Associate

Step Wilson; Research Associate

Josh Layfield; Graduate Research Associate - UWYO

Zach Bordner; Graduate Research Associate – UWYO

2025 Conservation Volunteers

Andrea Brophy	Hannah Robart	Matt Hill
Anne Hare	Hugh Byron	Missy Whelan
Audrey Fanjoy	Jean Schreiber	Patti Mull
Becky Hawkins	John Norton	Porgy McClelland
Bev Boynton	Kim Springer	Raymond White
Bernie Wirth	Laura Timmerman	Steve Poole
Carlin Rosen	Linnea Gardner	Stew Harvey
Chris Bonter	Lisa Frieseske	Ty Cook
Deb Patla	Martha Glenn	Vivien Zepf

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Raptor Migration in south-central Montana
Identifying key Golden Eagle habitats, population trends, and marking techniques

2025 Annual Report

BBL Permit 24140
Montana Permit (RVRI) 2024-2021-W

Cooperators:

Rob Domenech; Raptor View Research Institute

Dr. Ellen Aikens; University of Wyoming, School of Computing and Statistics

Zach Bordner, Ellen Ye; University of Wyoming

Study personnel: Bryan Bedrosian, Step Wilson, Adrian Rouse, Hilary Turner, Julie Polasik, Addie Wichman, Anna Wolke, and Nathan Hough

Study Background & Objectives

Sagebrush steppe and grassland habitats that dominate much of the landscape across the West are increasingly at risk due to a variety of compounding factors including direct habitat loss, fragmentation, fire, invasive species, and grazing regimes. The cumulative effects from loss and disturbance in these habitats led to the decline and concern for many species in Wyoming, including Greater Sage-grouse, Golden Eagle, Ferruginous Hawk, mule deer, pygmy rabbit, Brewer's Sparrow, and Mountain Plover, among others. As the sagebrush steppe and grasslands of the Wyoming Basin and Great Plains become increasingly fragmented, understanding and conserving key areas for wildlife is vital for the long-term persistence of many species.

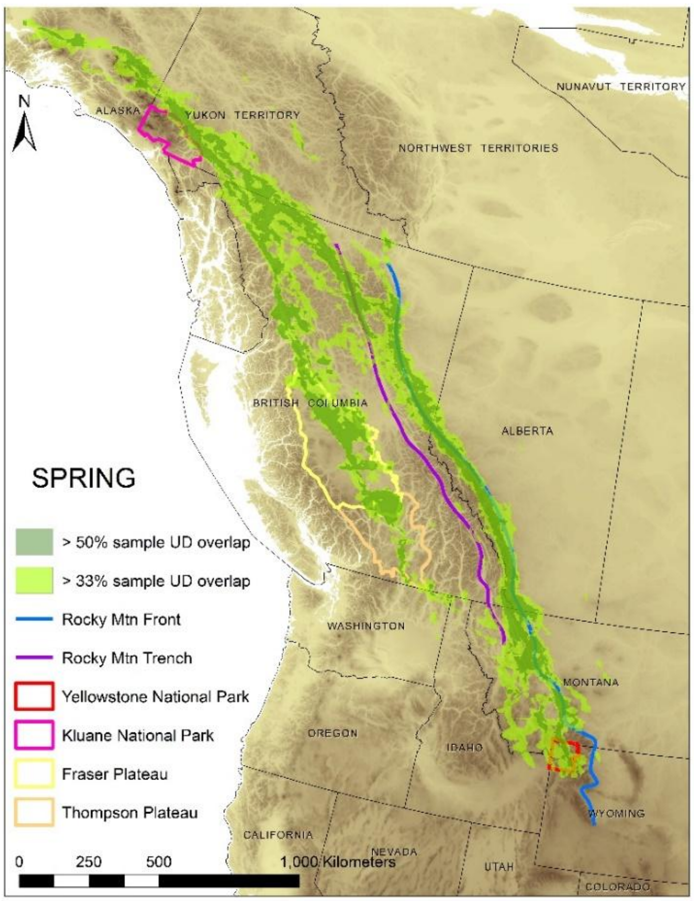
There is a growing concern for Golden Eagle populations in western North America due to declines in some local breeding populations, a 40% decline in migratory eagles, and new mortality risks due to direct collisions with turbines. Conservation of this species can be challenging due to complicated life-history traits. For example, Wyoming hosts the largest population of breeding Golden Eagles in the contiguous US, many young eagles from lower latitudes over-summer in Wyoming, and most migratory Golden Eagles from Canada and Alaska pass through or winter in the state. Golden Eagles are long-lived with slow reproduction and even a small increase in adult mortality can significantly impact populations. The main cause of mortality for Golden Eagles is starvation/disease (which is a direct result of habitat quality and prey availability), followed by poisoning, shooting, vehicle collisions, and electrocutions. While the majority of starvation deaths are in young eagles, roughly two-thirds of all adult mortalities are a result of anthropogenic causes. Any new causes of mortality such as collisions with wind turbines, lead poisoning and/or increases in shooting, trapping, power line electrocutions, car collisions, or starvation due to habitat degradation have the potential to significantly affect the population.

Wind energy development has been and is forecasted to significantly increase in the West. This is exemplified by the Chokecherry-Sierra Madre wind project that is currently under production in south-central Wyoming and will be the largest wind facility in the world with 1,000 turbines. In Wyoming alone, some estimate that there will be up to 500 eagle fatalities per year due to collisions with turbines. While alternative energy production is needed, placement of these facilities is typically outside of both the sage-grouse core areas and the areas being developed by oil and gas, leading to additional cumulative habitat loss. This novel development can significantly impact wildlife populations by further eliminating or fragmenting habitat in addition to causing direct mortality to bird and bat species.

Conservation of important habitats for eagles will not only help this iconic species but also help maintain the many other species within their range. Golden Eagles are an apex predator that rely on large tracts of habitat that host adequate numbers of prey (such as jackrabbits, cottontails, prairie dogs, and grouse) and serve as an indicator species of relative habitat quality and ecosystem health. Understanding and mapping key habitats for eagles will help identify the most productive habitats in Wyoming to target conservation efforts.

Because Golden Eagles are protected by both the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, the regulatory mechanisms and potential for litigation for any eagle mortalities has been a driving force behind many companies' decisions to not build new wind facilities. These mechanisms therefore provide a unique opportunity for habitat conservation by deterring new developments in areas that have demonstrated importance and high-use by Golden Eagles. Identifying and modeling high-use eagle areas can significantly affect development siting and help direct easement decisions to maximize conservation success. Further, a more detailed understanding of how eagles use "risky" habitats, such as roadways, and how they learn about habitats and disturbances, will allow for better predictions of important habitats and population trends. While we and other colleagues have been working diligently to address some of the recent concerns for Golden Eagle population trends across the West there are several key aspects of Golden Eagle ecology that are still unknown but needed to help inform agencies, managers, and conservation efforts. For example, we recently created the first population-level models of both spring and fall Golden Eagle migration corridors in the West by combining 65 eagles outfitted with solar-charging GPS transmitters from four different studies; three in Montana and one in Alaska (above). While we know that many migratory Golden Eagles move through or winter in Wyoming, the studies used in this initial analysis were all north of Wyoming, precluding us from defining key migration routes across most of Wyoming and further south.

The initial goal of this project was to identify key migration corridors and wintering habitat of adult Golden Eagles across Wyoming and further south. Mapping migration corridors in Wyoming requires capturing eagles while on migration before they reach Wyoming. In 2018, we located a migration pinch point in Southern Montana where we could outfit adult eagles with solar-powered GPS satellite backpack transmitters and track the adult eagles as they migrate through or winter in Wyoming. We achieved this goal and in 2023, we officially launched the final decision support tool resulting from these data and products: RaptorMapper.com.



A secondary objective of this study was to assess and use the study site in the Big Belts as a long-term Golden Eagle migration monitoring station. Preliminarily assessed in 2007 by Raptor View Research Institute (RVRI) biologists, the site appeared to be near a key pinch point for the eagle migration through Montana. In 2015, MT Audubon, MT Fish, Wildlife, and Parks, the Helena National Forest and other collaborators began annual monitoring of the migration about 11 miles north of our study site and ca. 1,400 feet higher in elevation. They confirmed that that count site at Duck Creek Pass hosted the most migrating Golden Eagles in the contiguous US. However, the count site is difficult to access and often precludes counting due to the high elevation and associated weather. In coordination with the team at the count site, we investigated potential correlations in migration counts between that site and our location.

Finally, in 2020, we initiated a color banding component of this study to test the use of dual colored leg bands in unique combinations as a viable method for re-sighting Golden Eagles. With increased popularity in recent years of using game cameras on carcass sites for wildlife monitoring purposes, we recognized the opportunity to test a system for identifying eagles that utilized conventional leg bands in a new way. We anodized USGS and blank bands to be solid or dual-colored and developed a color combination scheme that resulted in >300 unique combinations. From 2020-2022 each eagle was given two bands - one on each leg – to produce a distinct color combination for each individual. In 2023, we started testing another color banding method, placing unique alpha-numeric plastic color bands on all captured Golden Eagles. These bands were yellow with a black alphanumeric code to allow for re-sighting banded eagles and identifying them to the individual level. This year, we switched the plastic color bands with metal color bands, using the same yellow color with black lettering (see photo), in hopes that they would be more durable than the plastic. These new color bands were placed on the right leg of banded Golden Eagles and standard USGS metal bands were placed on the left leg.

Results

To achieve our initial objective, we deployed 39 GPS transmitters on Golden Eagles captured at the research site between 2018-2021. Working with a collaborative team, we used the data collected from these eagles to develop seasonal models of winter, fall migration, and winter habitat for all of Wyoming and most of Montana. We have incorporated these models with updated breeding habitat models in a free, online decision support tool: RaptorMapper (https://raptormapper.com/). Additional details can be found at that site, we published this paper from that work in 2024, and several other publications are in progress.

In 2024, we developed a new collaboration with Dr. Ellen Aikens at University of Wyoming to begin collecting fine-scale movement and sensor data on young Golden Eagles to investigate lifetime learning. We are using a new high-frequency type of transmitter from E-Obs for this work and deployed 10 transmitters on males and 10 on females, spread out over the course of the 2024 capture season. This year, we deployed 17 more E-Obs transmitters (9 on males and 8 on females), again spread throughout the capture season. Another goal of this work is to compare behaviors of migrant eagles with locals (see Bighorn Basin report for details on tagging local eagles).

Since beginning this study in 2018, we have kept count records for all raptors passing the site, in consistent raptor migration count methodology. In 2025, we experienced dense cloud cover, snow, and rain which left our team unable to count for 6 days. In total, we observed for 152.2 hours from 23 September through 23 October. From 2018 to 2025, the number of hours we spent counting passing raptors varied (Table 1), but we consistently counted on days with good visibility, annually from September 27th to October 21st, allowing comparison of Golden Eagle passage rates (eagles/hour) between years (Figure 1). The passage rates among the past 5 years have been relatively consistent.

While observing migrating eagles, we classified individuals by age (hatch year, subadult, adult, and unknown). In 2025, we observed more unknown age eagles than any other year (Figure 2). This could have been because our highest eagle count days were subjected to flight conditions (including flight altitude and lighting) that made it difficult to accurately age birds.

Because it can be difficult to accurately separate hatch-years from sub-adults, we combined those two age classes during this same time period. We determined that 35% of the counted eagles were pre-adult, which was lower than 2024 (39%), but similar to other years from 2018-2023 (30%, 33%, 34%, 31%, 23%, and 36%, respectively). We also quantified the age and sex of captured eagles and continued to experience a strong male bias in captured eagles with 63% of eagles captured being males [all other years 63-72% males (Figure 3].

2025 was a fairly typical year, in that the weather was favorable early on in the season but as the season progressed, weather became variable. From October 11-15, we had 6 days of snow and low cloud ceilings that precluded counting and trapping at our location. We experienced similar “peaks and valleys” to counts in previous years. This can occur when eagles are held up by weather patterns and then make large movements immediately before or after severe weather. Indeed, our largest eagle count of the season (n=266) occurred on October 17, the day after counting was impossible due to the weeklong weather system (Figure 4).

From 2022-2025, we collected blood samples from captured raptors as part of our collaborative raptor blood chemistry study with the TRC rehabilitation team. Our rehabilitation team uses blood chemistry values calculated on an Abaxis Vetscan 2 machine to help diagnose and treat raptor patients, but many of the reference values for raptor species are based on small sample sizes of captive birds. By collecting samples from wild raptors, the team hopes to build a more robust database of reference values. So far, we collected and analyzed 81 blood samples from the following raptor species: Golden Eagle (GOEA; n=13), Sharp-shinned Hawk (SSHA; n=22), American Goshawk (AGOS; n=7), Merlin (MERL; n=13), Cooper’s Hawk (COHA; n=8), Red-tailed Hawk (RTHA; n=6), Northern Harrier (NOHA; n=3), Peregrine Falcon (PEFA; n=2), Prairie Falcon (PRFA; n=2), American Kestrel (AMKE; n=2), Broad-winged Hawk (BWHA; n=2), and Rough-legged Hawk (RLHA; n=1; Figure 5).

Excluding Golden Eagles, the seven most common species observed passing our field site from September 27th to October 21st were Sharp-shinned Hawk (187), American Kestrel (38), Red-tailed Hawk (38), Rough-legged Hawk (27), Bald Eagle (23), Cooper’s Hawk (23), and Merlin (14; Figure 6). This year, we only used starlings on the smaller bow-net in order so captures of small raptors such as Sharp-shinned Hawks and American Kestrels may have been negatively affected by not using sparrows. After Golden Eagles (74), Sharp-shinned Hawks were the most frequent species captured (41), followed by Cooper’s Hawks (8), Red-tailed Hawks (8), Merlins (7; Table 2). We banded all raptors with USGS bands and collected blood samples from as many raptors as we could.

Table 1. Number of Golden Eagles observed and captured, hours of effort, and corresponding passage and capture rates from 9/27 to 10/21 each year.

Year	Golden Eagles Observed	Observation Hours	Passage Rate (eagles/hr)	Golden Eagles Captured	Capture Rate
2018	1307	120.7	10.8	75	5.7%
2019	1382	138.1	10.0	114	8.2%
2020	785	117.7	6.7	78	9.9%
2021	753	134.1	5.6	60	8.0%
2022	1193	158.9	7.5	99	8.3%
2023	914	139.5	6.6	71	7.8%
2024	1150	188.2	6.1	129	11.2%
2025	829	120.9	6.9	66	8.0%

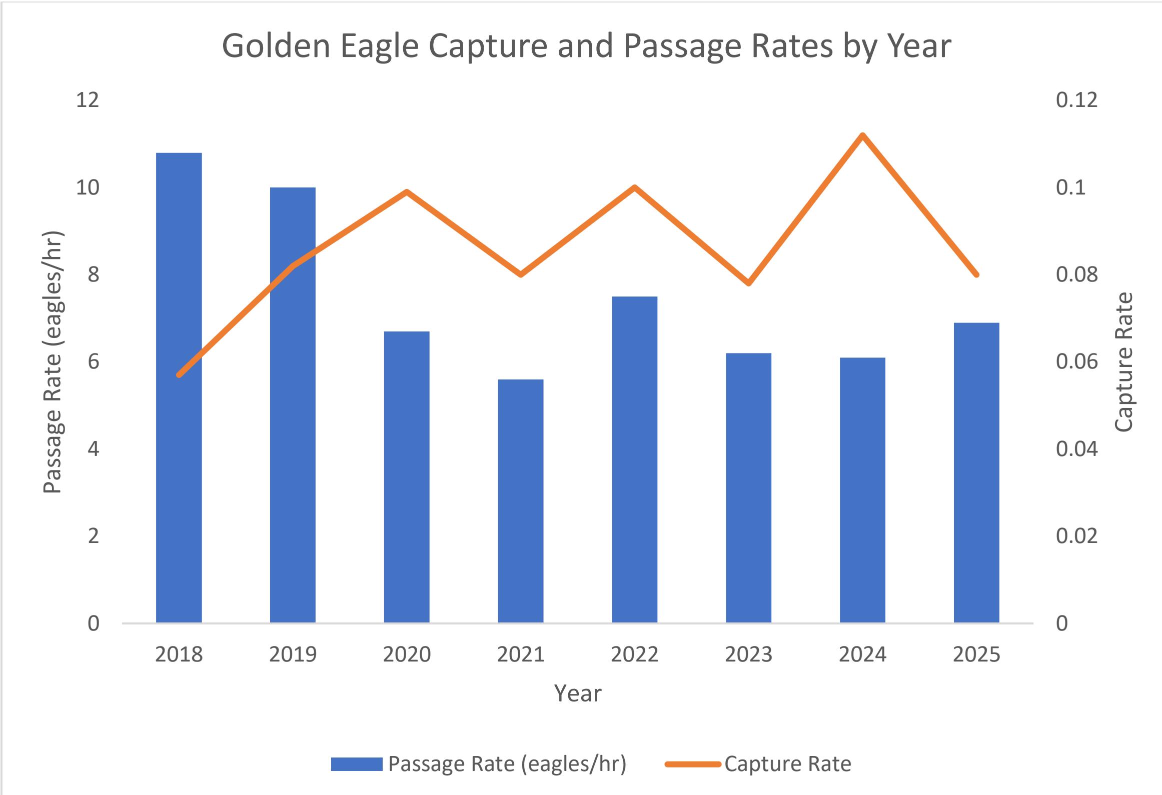


Figure 1. Golden Eagle (GOEA) passage and capture rates by year for the observation period of 9/27 to 10/21. Passage rate is based on eagles observed per hour and capture rates are based on the proportion of GOEAs observed that were caught.

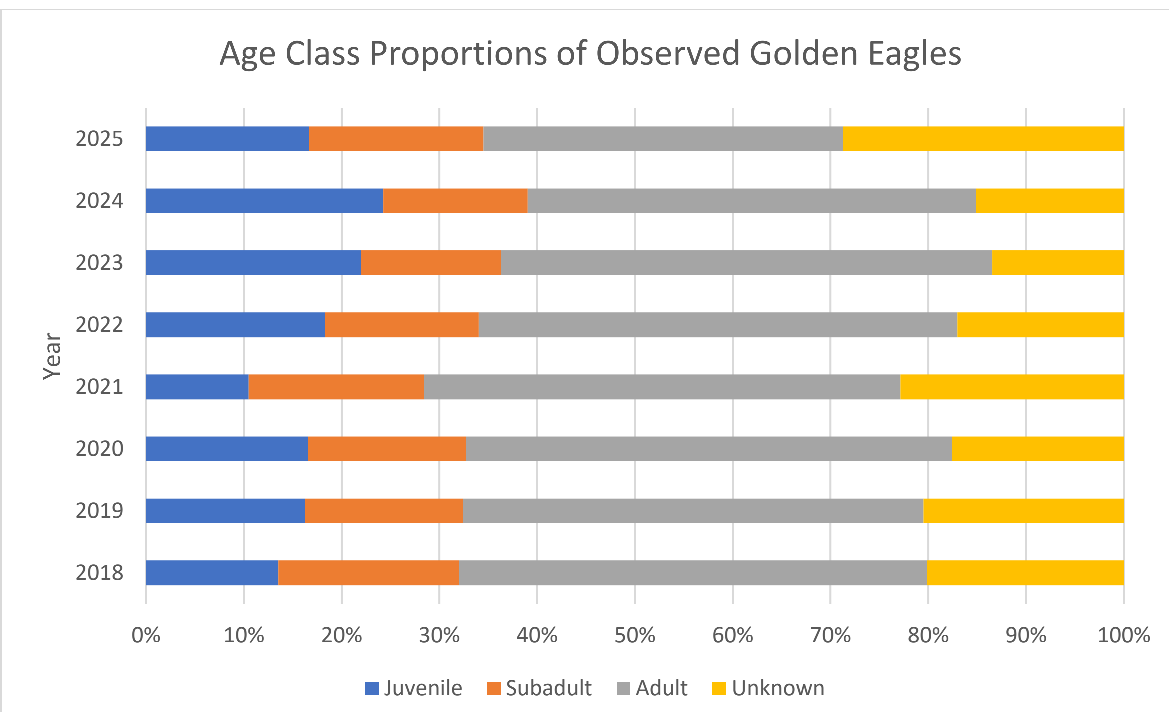


Figure 2. Age class proportions of observed Golden Eagles each year during 9/27 to 10/21 period.

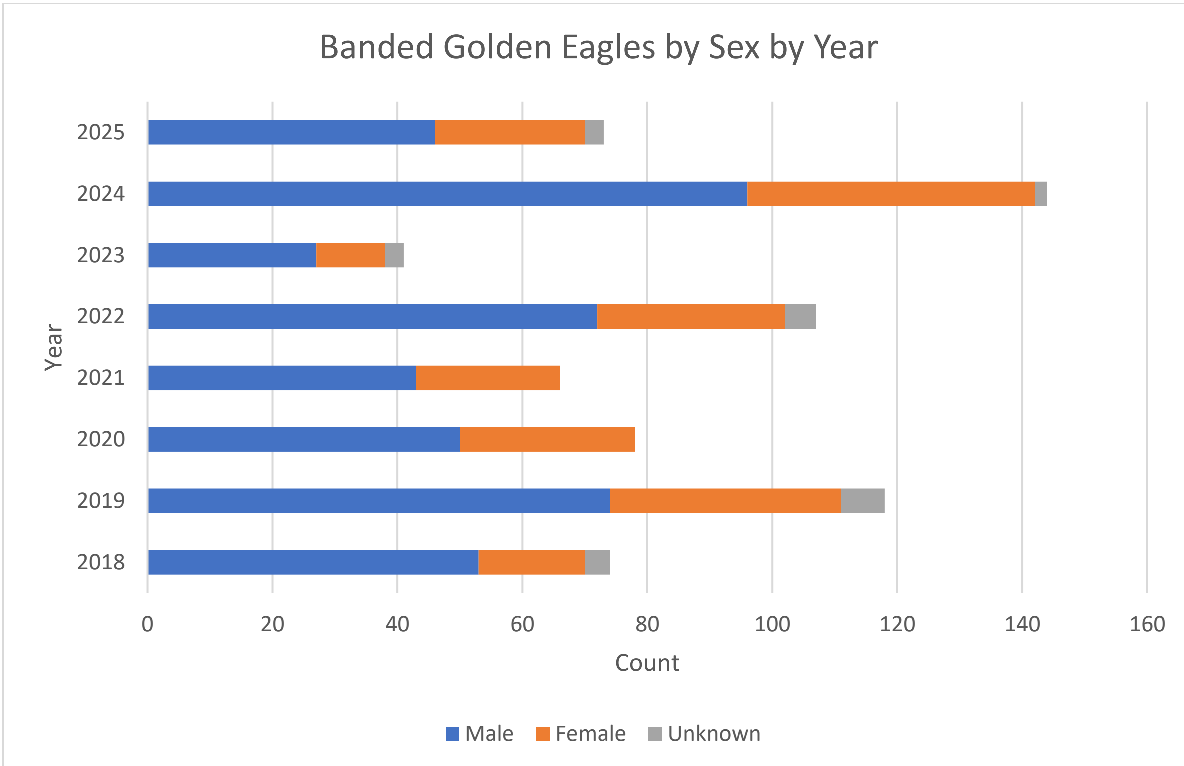


Figure 3. Count of Golden Eagles banded each year by sex.

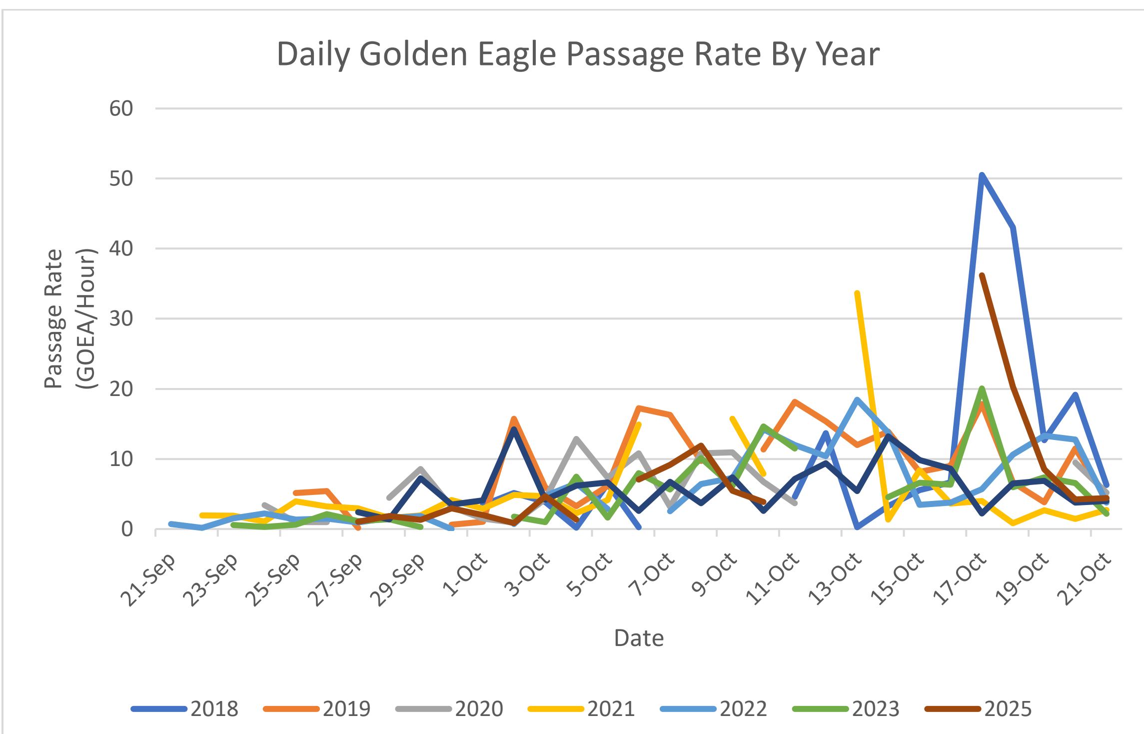


Figure 4. Daily passage rates of Golden Eagles (GOEA) based on GOEAs observed per hour each day from 2018 to 2025.

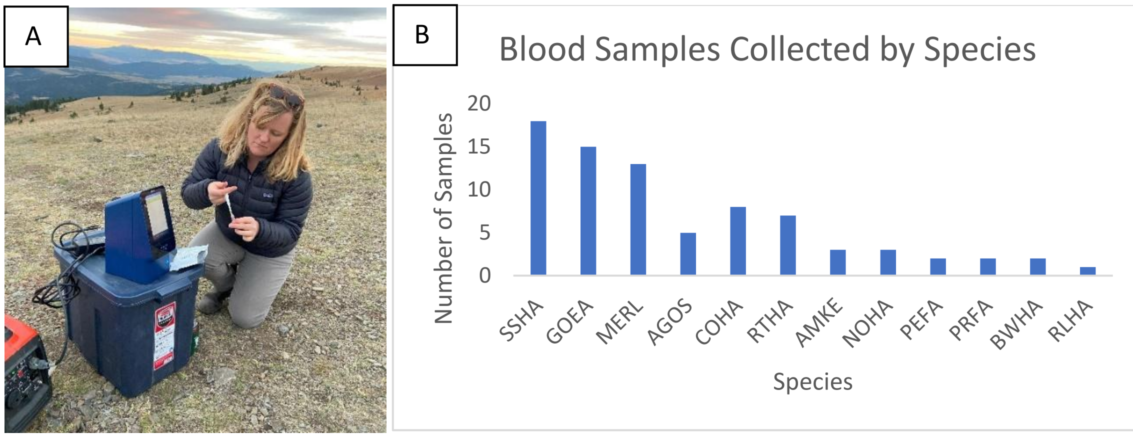


Figure 5. A) Preparing a raptor blood sample for analysis on an Abaxis machine; B) Number of blood samples collected and analyzed for different raptor species between 2022 and 2025 in the Big Belts.

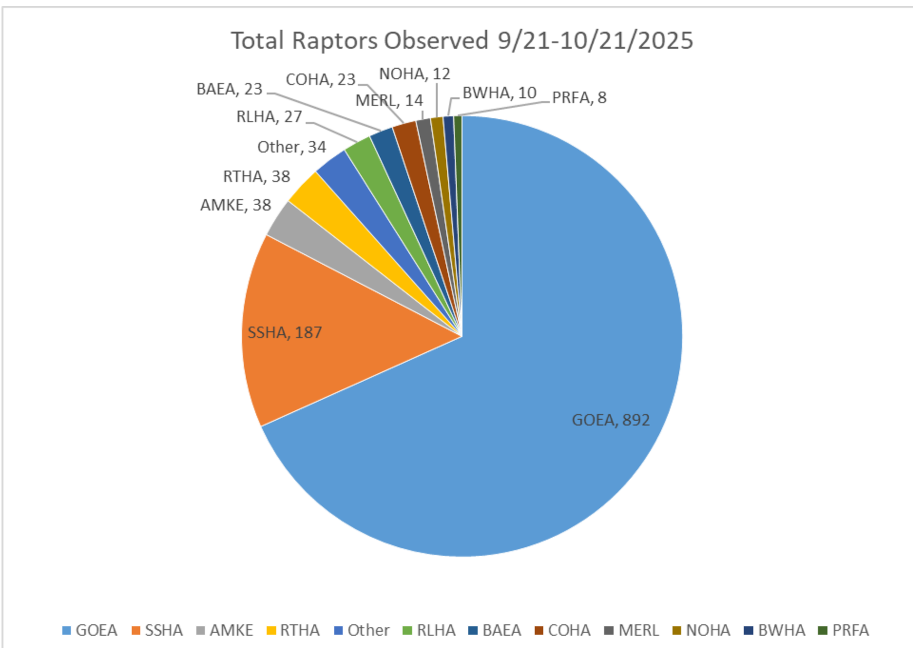


Figure 6. Total Raptors (1306) observed during 9/21 to 10/21 in 2025.

Table 2. Number of birds banded by species in 2025.

2025 Banded Birds by Species	
GOEA	66
SSHA	29
RTHA	8
COHA	7
MERL	6
NOHA	1
BWHA	1
Total	126

Discussion

The study site in the Big Belt Mountains remains an extremely effective location to monitor the continental population of Golden Eagles on migration. We captured more Golden Eagles in 2024 than any previous year and deployed color bands on nearly all eagles captured. Our success in 2025 was affected by weather, as is common during this time of year in the Big Belt Mountains. We have only had two seasons with lower total observation hours than in 2025, and only 2021 saw fewer eagles captured during the season. The timing of migration appeared to be dictated by weather patterns, as has been seen in the past.

We have been able to collect data to inform several study objectives. We are pleased at the breadth of information and studies that are benefiting from our tagging efforts in the Big Belts, ranging from blood analysis, genetics, tagging methods, habitat mapping, and behavior studies. Just as important is the training we can provide future and existing biologists. We have trained many graduate students on transmitter deployments, blood sampling, and proper tagging and handling techniques. We hosted students from Wyoming this year, in addition to TRC interns.

Several interesting captures occurred this year. Early on in the season, we captured several Golden Eagles with noteworthy injuries. Eagles showed a broken toe (1), broken talons (2), a broken hock (1), and fractured keel (2). All injuries were healed and were not related to the capture process. Additionally, two birds presented with suspected avian pox and one had eyelid inflammation. We also captured an adult male eagle with a collapsed globe in its right eye. This was particularly interesting because the bird came into the trap set as a normal bird would have, providing anecdotal evidence that one-eyed birds may be capable of hunting and surviving for at least some time in the wild (Figure 7).

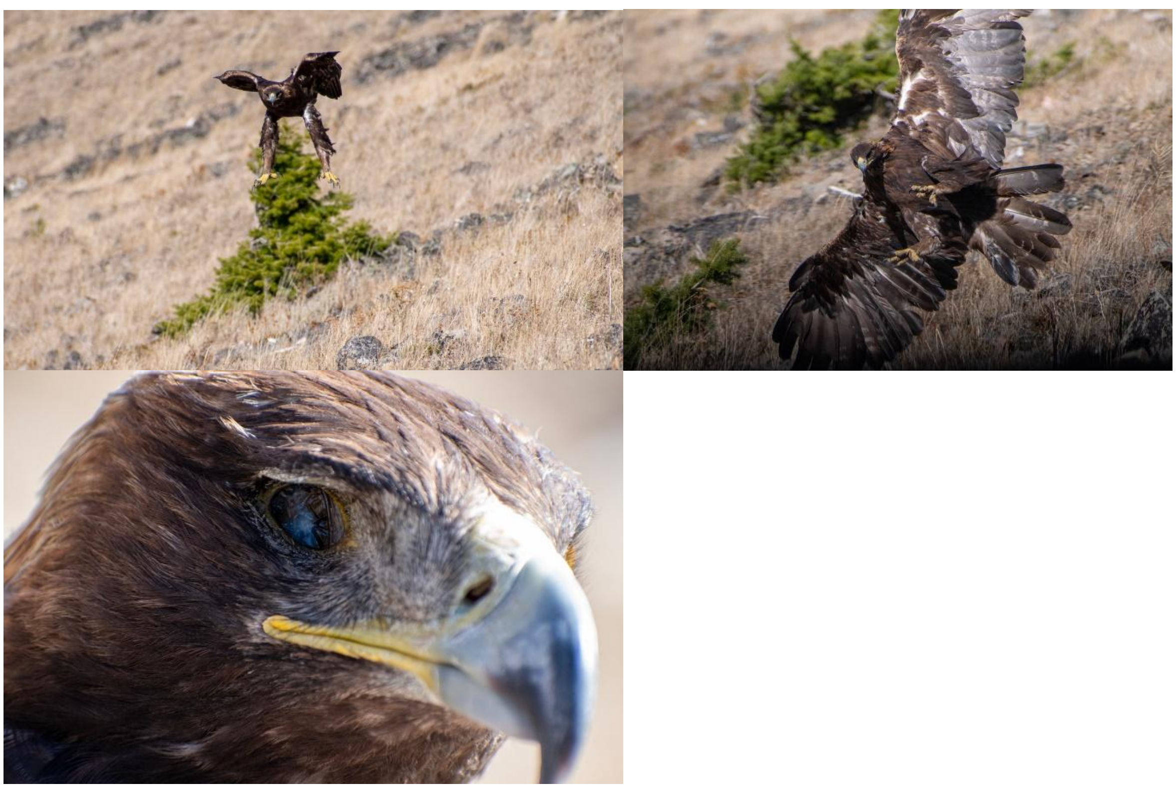


Figure 7. A one-eyed adult male Golden Eagle approaches our trap set as any normal wild bird would and a photo of the eagle's collapsed globe. Photos by Steve Poole

We recaptured one Golden Eagle originally tagged in 2024 as a hatch year. The plastic color band placed on the bird was cracked and worn, so we replaced it with a new metal color band. In 2024, we captured an eagle that had completely lost its plastic color band in one year, which prompted the shift to metal in 2025. We hope that these new color bands will be more durable, allowing for more re-sights on our color-banded Golden Eagles. Additionally, we hope to refine our SEO for Golden Eagle color band re-sights and improve the functionality of our website to gain more information on our banded birds.

We will continue to conduct this study in future years to build the long-term trend data from our observations and provide additional data for the following studies and purposes:

- Habitat selection of migratory Golden Eagles
- Lifetime learning of Golden Eagles
- Evaluation of auxiliary marking techniques for Golden Eagles
- Baseline blood chemistry for wild, healthy raptors
- Understanding the link between lead ingestion in migratory eagles
- Influence of fine-scale weather on migration routes and timing
- Creation of educational content and conservation films
- Training students and biologists

Acknowledgments

Data collection was conducted by Bryan Bedrosian, Step Wilson, Adrian Rouse, Hilary Turner, Julie Polasik, Addie Wichman, Anna Wolke, and Nathan Hough. We could not have conducted this work without significant support from the Raptor View Research Institute, Helena National Forest (Denise Pengeroth and Aaron Webber) and Montana Fish, Wildlife and Parks (Allison Bagley, Kristina Smucker). Funding was provided by Teton Raptor Center and the Cross Charitable Foundation. We are so grateful to Kris Kaufman and Joe and Shae Bast for providing housing and helping our crew stay warm and dry. And finally, we thank the many volunteers and partners who visited us at the site and helped collect data on some of our busiest days.

Resident Golden Eagle behavior in north-central Wyoming

Examining the impacts of recreation disturbance on nesting eagles using e-Obs transmitters, trail cameras, and audio recording units

2025 Annual Report

WGFD Permit 33-1455

<u>Cooperators:</u>

Dr. Ellen Aikens Lab, University of Wyoming

Dr. Chuck Preston and Corey Anco, Buffalo Bill Center of the West, Draper Museum of Natural History

Destin Harrell, US Fish and Wildlife Service

Study personnel: Zach Bordner, Ellen Ye, Bryan Bedrosian, Adrian Rouse, Hilary Turner, Step Wilson, Chloe Hernandez, and Addie Wichman

Background

The overarching goal of nearly all wildlife and species-level management is to maintain viable populations. This is typically achieved by maintaining stable breeding populations, resulting from management of adequate habitat, reduction in perturbations of breeding individuals, enhancing foraging opportunities, reduction of mortality rates, or a combination of these factors. For at-risk or declining wildlife populations, offsetting declines in reproduction or increasing survival are typically most immediate and effective in slowing population declines, while more lasting management occurs through habitat protection and enhancements. These objectives are not mutually exclusive.

Golden Eagles (*Aquila chrysaetos*) are a Species of Greatest Conservation Need and occur throughout Wyoming year-round, with breeding populations across most shrub-steppe and grassland habitats in the state (Wallace et al. 2019, Bedrosian et al. 2019). There has been considerable attention given to Golden Eagles for the past several years due to increasing population-level risk from wind energy generation as a novel source of mortality and stable-to-declining populations across the west (Millsap et al. 2022). The Bighorn Basin of Wyoming hosts some of the best breeding habitat in the state (Dunk et al. 2019), which primarily consists of cliff nesting structure with vast expanses of open sage-steppe foraging habitat throughout the region (Preston et al. 2017b). Maintaining and enhancing core breeding populations in key areas across the species range, like the Bighorn Basin, will be critical to the maintenance of eagle populations across the country. For example, Hunt et al. (2017) estimated that reproduction from 216 breeding eagle pairs were necessary to offset the eagle mortality of just one wind facility that had annual mortality rate of 55 eagles/yr. While the Bighorn Basin does not currently have large-scale wind development, the adjacent Powder River and Shirley Basins are among the fastest growing wind energy regions in Wyoming and the West; wind development is also expanding in adjacent regions of Montana. Hence, maintaining and increasing eagle production in the surrounding areas like the Bighorn Basin may be critical to maintaining populations in Wyoming

Despite having some of the best predicted nesting habitat in the coterminous United States (Dunk et al. 2019) and some of the best demographic rates when rabbit populations are high (e.g., 2009, 2015-17; Preston et al. 2021), the eagle population in the Bighorn Basin has been experiencing some of the lowest demographic rates in the region for the past five years (Wallace et al. 2019, Bedrosian et al. 2019, Preston et al. 2021). Ongoing research in the Bighorn Basin has consisted of monitoring annual reproductive performance at between 35 and 73 Golden Eagle territories annually since 2009, providing key baseline information on territory occupancy and productivity (Preston et al. 2021). This project has also documented the clear link between Golden Eagle nest productivity and prey abundance in this region (Preston et al. 2017a). While rabbit abundance in Wyoming is cyclic (Fedy and Doherty 2011), the abundance of rabbits declined recently with the emergence of Rabbit Hemorrhagic Disease (RHDV2). The normal cyclic nature of rabbit abundance has been altered due to the emergence of RHDV2, which led to some of the lowest documented productivity rates of Golden Eagles in 2022 across 14 years of monitoring in the Bighorn Basin (Preston et al. 2022).

While declining prey abundance is suppressing demographic rates (Preston et al. 2017a, Preston et al. 2022) in a key area hosting some of the best eagle nesting habitat in the country (Dunk et al. 2019), added anthropogenic stressors are likely to exacerbate this decline in eagle reproduction. For example, Golden Eagles are known to be sensitive to the effects of human disturbance during the breeding season (Kochert et al. 2002). Similar to many areas of the West, the Bighorn Basin has been experiencing a rapid and significant increase in outdoor recreation activities, including off-highway vehicle (OHV) use which includes motorcycles, side by sides, all-terrain vehicles, rock crawling jeeps and more (Figure 1). Other recreational activities include: e-bikes, wildlife watching, hiking, drone flying, and mountain biking. Off-highway vehicle recreation, in particular, has increased by 42% in the US from 1999-2004 (Cordell et al. 2005) and is expected to grow by another 56% by 2060 (Bowker et al. 2012). The OHV recreation and rental industry have significantly increased recently in Cody, Wyoming and often refer riders to BLM lands in the Bighorn Basin (C. Preston, pers. obs). Recently, studies in Idaho have shown that increased OHV use has negatively impacted both Golden Eagle territory occupancy and nest productivity of eagles (Steenhof et al. 2014, Spaul and Heath 2016).

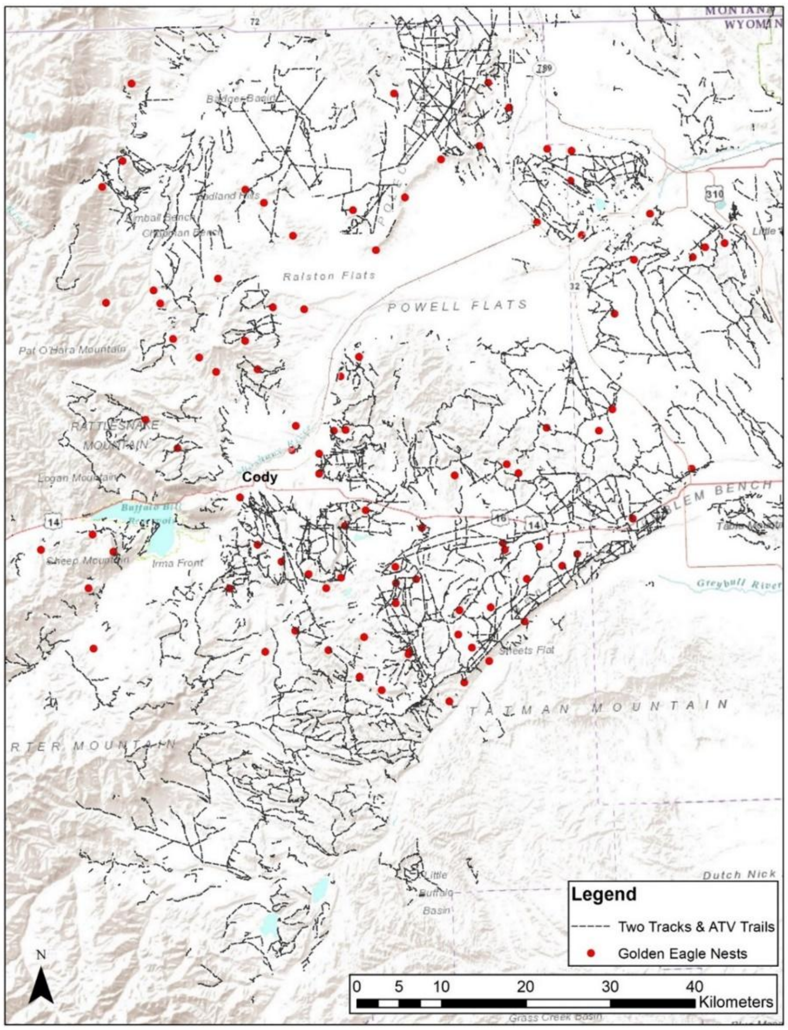


***Figure 8**. Golden Eagle nest locations, known two tracks, and ATV trails within the Bighorn Basin.*

Shrub-steppe habitats with abundant public lands and nesting habitat for Golden Eagles, such as the Bighorn Basin, present a scenario in which areas of high recreation use overlap with critical nesting habitat for Golden Eagles (Figure 1). Previous researchers have found that eagle territories were less likely to be occupied in areas with higher OHV use than areas with low OHV use (Spaul and Heath 2016). In cases where territories were occupied, it was determined that pedestrians who arrived near eagle nests on motorized vehicles in the vicinity of nests caused eagles to flush from nests (Spaul and Health 2017), having a negative impact on nest success (Spaul and Heath 2016). Similarly, research based on 40 years of data, documented reduced Golden Eagle nesting productivity in areas of high OHV use, including OHV parking and motorized vehicle play areas, when compared to territories with little or no motorized recreation (Steenhof et al. 2014). Eagles foraging on their breeding territories were also found to be negatively impacted by OHV use, with eagles 12 times more likely to flush when perched away from nests than while at nests (Spaul and Health 2017). Flushing from either foraging perches or nests occurred when recreational activities were 300 - 1300 m away from eagles (Spaul and Heath 2017). Recently, at least three territories with both regular successful breeding historically and recently increased OHV use have remained unoccupied or unsuccessful in the Bighorn Basin (C. Preston, unpul. data) These results indicate that high OHV activity in the proximity of nesting and foraging Golden Eagles can negatively influence their productivity, and potentially their survival if foraging success decreases as a result.

Simulation models have been used to assess the effects of different mitigation methods for limiting the negative effects of OHV and related pedestrian activity on nesting eagles (Pauli et al 2017, D'Acunto et al. 2018). Pauli et al. (2017) used an individual-based model (IBM) to determine if changes in tolerance to disturbance could mitigate negative effects of pedestrian and OHV activity to eagles. They found that while tolerance in the form of genetic inheritance or habituation decreased the negative effects on eagle populations, these tolerance mechanisms were not sufficient to allow eagle populations to withstand moderate increases in recreation over time (Pauli et al 2017). Individual-based models have also been used to assess if trail closures would be effective at reducing impacts to nesting eagles (D'Acunto et al. 2018). In their simulated scenarios with IBMs they found that trail closures within 600 m of nests were most effective at reducing flushing of incubating GOEAs from nests, while closing all but the most highly used trails was most effective for reducing flushing of foraging eagles (D'Acunto et al. 2018). However, if human activity was doubled within an eagle territory, trail closures which closed all but the high-use trails to OHV activity (but not pedestrian activity) were not as effective at reducing eagle flushing and trail density had more of an impact on eagles flushing (D'Acunto et al. 2018).

Previous research has begun to understand the negative influence OHV activity can have on nesting Golden Eagles, more detailed information is necessary to guide management actions related to OHV activity and nesting Golden Eagles in Wyoming. The initial research on OHV use was largely based on very limited, direct behavioral observations of eagles around nests and foraging areas but did not look at impacts across the entire breeding home range or the annual cycle. Further, the previous studies occurred in the Morley Nelson Snake River Birds of Prey National Conservation Area, where eagles largely nest along a linear corridor of the Snake River. The Bighorn Basin has much more heterogeneous habitat and varied terrain. These factors likely result in differences in both OHV use and eagle behavior. Understanding the movements and behaviors of Golden Eagles with high frequency fix GPS transmitters with advanced accelerometer and magnetometer sensors would be an effective way to determine how Golden Eagles respond to OHV activity not only immediately around the nest or in occasionally used foraging areas, but across their entire breeding home ranges and over the entirety of the year. Understanding their movements and habitat use within their large home ranges relative to OHV activity can provide important information on the effects of OHV use and eagle demographics, spatial scale of disturbance effects, and the temporal scale of eagle avoidance behaviors throughout the breeding season. This information can be used to help guide land management and mitigation efforts for nesting

Golden Eagles in the vicinity of OHV activity in a key nesting region for Golden Eagles in Wyoming that is already experiencing natural breeding stressors.

Bureau of Land Management resource management plans restrict disturbing and disrupting activities within 0.5 miles of the Golden Eagle nests during the nesting season. These limitations do not typically apply to casual use by the public. These timing limitations apply as appropriate to permitted activities. Eagles have maintained territories in a variety of circumstances within the study area including along highways, gravel roads, near industrial development, and in remote secluded habitat. It is unclear how much habituation occurs and to what degree a nesting pair might be disturbed by adjacent OHV use and other recreational activities.

Limited research has documented the impacts of OHV activity on behavior, territory occupancy, and productivity of nesting Golden Eagles. Our goal is to build on this initial understanding of negative effects of OHV use on eagle behavior and demographics in the Bighorn Basin with the express goal of helping inform potential travel management of OHV use in Wyoming. With recent declines in productivity observed in Golden Eagles in the Bighorn Basin, the added stress from recreational impacts could result in further population declines in the region. Specifically, the goal of this project is to document and understand the effects of OHV intensity and proximity of use on the behaviors and subsequent productivity of breeding Golden Eagles in the Bighorn Basin. We will meet our goal through data collection and assessment on three different scales: (1) individual Golden Eagle behaviors, (2) home range use, and (3) population impact level. The individual behavior level will use fine-scale movement and behavior data obtained from GPS transmitters on individual eagles that will allow us to determine nesting and disturbance behaviors (e.g., incubation, flushing, prey provisioning, etc.). At the home range use level, we will use location data to assess shifts in home ranges or core areas throughout the breeding season and annual cycle to determine if there are changes in response to OHV activity, with a secondary focus on other non-motorized recreational activities (e.g., hiking, biking). Breeding season home ranges and core areas will be mapped on a weekly to monthly basis to assess changes in home range use across the season relative to recreational use. At the population level we will assess nest occupancy and productivity across the entire study area in relation to OHV trail density. We will use these three scales to assess if OHV activity in the Bighorn Basin is having a negative impact on eagles at individual, territory and population levels.

Objectives

Specific study questions to determine if OHV use in the Bighorn Basin is negatively affecting nesting eagles

1. Does intensity and frequency of OHV use increase stress behaviors (i.e., flushing) of both nesting females and foraging males?
2. What is the variability among breeding individuals to anthropogenic stressors?
3. Do eagles alter their home ranges, habitat use, or core areas to avoid OHV and anthropogenic recreational activities?
4. Are there nest site or home range characteristics that may reduce stress responses?

5. At what frequency, duration, and timing does OHV use negatively impact occupancy and demographics of nesting Golden Eagles?

This project is being conducted in close coordination with TRC Research Associate, Dr. Chuck Preston. He is leading the long-term population monitoring of Golden Eagles within the study area (see Monitoring Report). Other close collaborators include Destin Harrell (USFWS), Corey Anco, and the Draper Natural History Museum.

Additionally, we are collaborating with Ellen Aikens and Zachary Bordner at the University of Wyoming to deploy transmitters on fledgling Golden Eagles as part of a lifetime learning study for the species.

Methods

Field Work

We purchased 20 E-obs 45g transmitters to deploy on breeding Golden Eagles in Bighorn Basin, WY. In late February 2024, we deployed two of these units on adult male Golden Eagles. In 2025, we began our trapping efforts at the start of February. Previously known active territories were surveyed from the ground to confirm breeding activity (i.e. adult pairs, nest building, territorial displays). Once we confirmed activity within territories, we attempted to trap adults using a variety of methods including net launchers with roadkill, and bal-chatris, dho-gazzas, and bow nets with live bait such as pigeons and pheasants. Traps were maintained (battery/bait changes, snow removal, etc.) pre-dawn or post-dusk to minimize detection of our traps by target birds. We monitored active territories where traps were set continually from about a mile away during all daylight hours. We also used cellular trail cameras to monitor activity at some of our traps remotely. After limited trapping success in the winter season, we returned in May to try again using a dho-gazza with live bait setup at known occupied territories. Once eagles were trapped, we banded them with USGS and color bands, drew blood, and took a variety of morphological measurements before attaching a transmitter with a breakaway harness.

e-Obs Transmitters

In October 2024, the cell carrier in Wyoming (Union Wireless) disconnected all 3G networks in the state, moving to LTE and 5G connections. Unbeknownst to us, this effectively cut cell communications to the transmitters too since they only connect via 2G and 3G networks. When the 3G networks in Wyoming were disconnected, our e-Obs transmitters still tried to find and connect to the network daily but unable were continually unable to find a 2G or 3G tower. This led to significant battery drain and essentially stopped the units from gathering or sending data. Therefore, all of the adults we tagged with e-Obs transmitters in 2024 no longer connect to cell towers to transmit the large amounts of data they are collecting.

In an effort to retrieve the large amounts of data stored on the devices, we found a workable solution for the transmitters we have already deployed. The units connect to the cell networks, but also can function as remote download transmitters, transferring data via a handheld UHF signal to a handheld base station. Because the eagles we are targeting for this study are territorial, they seldom leave their territories. Therefore, we developed new programming for the transmitters that will function more as a remote download transmitter and only check in via SMS. SMS is a cell network technology older than 3G but still functional in Wyoming. We cannot download the vast amount of data via SMS, but we can receive daily check-ins from the unit to know where it is and status. We are then able to download the stored data from the unit several times a year by traveling to the eagle territories and using a BaseStation to download the data. We sent all undeployed transmitters back to the manufacturer for replacement with new units which will be compatible with the recently updated LTE/5G cell network within our study area.

Territory Monitoring

At each territory where adult eagles were tagged, we deployed trail cameras and autonomous recording units (ARUs) to quantify disturbance levels in those territories during the breeding season. We plan to use BirdNET software to analyze the ARU disturbance data and volunteers for trail camera data analysis.

In 2025, we surveyed accessible territories during our February trapping efforts for occupancy and activity, but we then returned to the study site in mid-March to conduct more comprehensive aerial surveys to confirm nesting activity. In 2024, we conducted aerial surveys in mid-April in 2024 due to conflict with another study, but returned to the mid-March time frame this year, which is a more ideal for confirming nesting activity. During our aerial surveys year, we continued to target the Pole Cat and Oregon Basin study areas for complete nest surveys, but also expanded our surveys into neighboring areas within the study area (Figure 2).

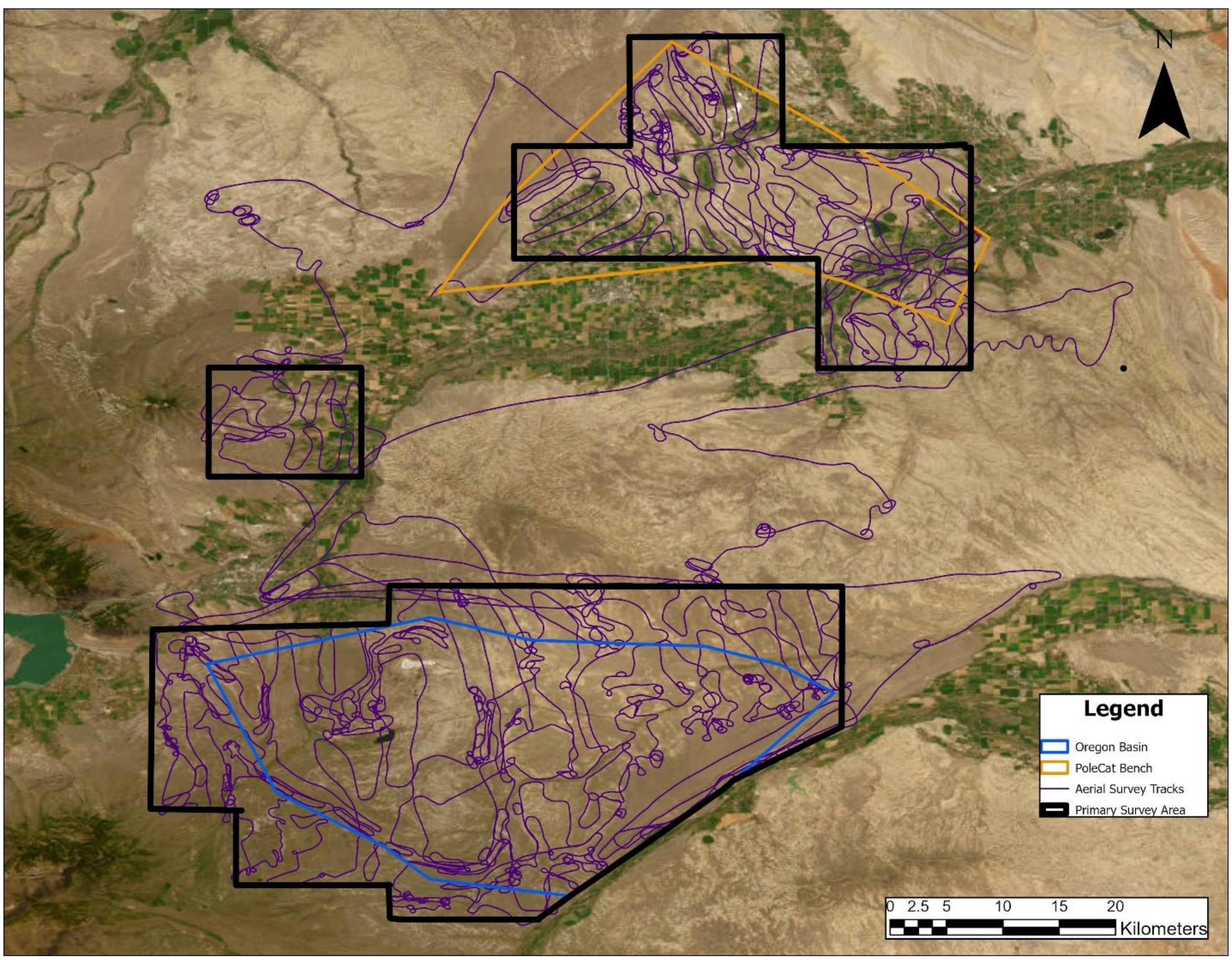


Figure 2. *Aerial survey tracks in Bighorn Basin in March 2025. Flights prioritized full coverage of Oregon Basin and Polecat regions, but we also expanded our surveys into neighboring areas.*

Ground surveys were conducted throughout the breeding season to confirm nest activity after the initial aerial surveys in March. Detailed monitoring of active nests was completed by the team and partners (See Preston et al. 2024).

In collaboration with Dr. Ellen Aikens at the University of Wyoming, we returned to the Bighorn Basin later in the breeding season to tag fledgling Golden Eagles within the study area for the lifetime learning study.

Home Range Analysis

We calculated breeding season and year-round home ranges for adult Golden Eagles using the ctmm package in R. Home ranges were calculated as 95% Autocorrelated Kernel Density Estimates (AKDEs) and were based on locations from April 1-June 30 for the breeding season and January 1-December 31 for the year-round ranges.

Results

Adult Trapping and Data Downloads

In 2025, we trapped and deployed transmitters on five breeding adult Golden Eagles on four additional territories. An adult male at Eagle Nest Creek was captured in February on a bow net with live prey and during the May trapping attempts, we captured the female from this territory on a dho-gazza with live prey. We are excited to have both members of a pair tagged for the first time.

During our February field stint, we successfully downloaded data from most of the tagged eagles still present in the Bighorn Basin, including some fledglings from the previous summer. We were unable to connect to the male from Territory 30, which is presumed dead or gone.

We returned to Bighorn Basin in November to download more data from our tagged birds. We achieved complete data downloads from the Territory 1 male, Eagle Nest Creek male, Downer female, and Aqua female and we got a partial download from the Territory 127 female. We were not able to connect to the Eagle Creek Female during this time.

Aerial Surveys and Nest Fate

During our April aerial surveys, we found 28 Golden Eagle nests to be occupied (Figure 3). Unfortunately, this year, Golden Eagles had remarkably low productivity in the Bighorn Basin. We hoped to tag the chick from the Eagle Nest Creek, but the nest failed a few weeks before the young fledged. The nest at Territory 127 also failed, but the Aqua and Downer nests both successfully produced young. We tagged the Downer chick around the time of fledging.

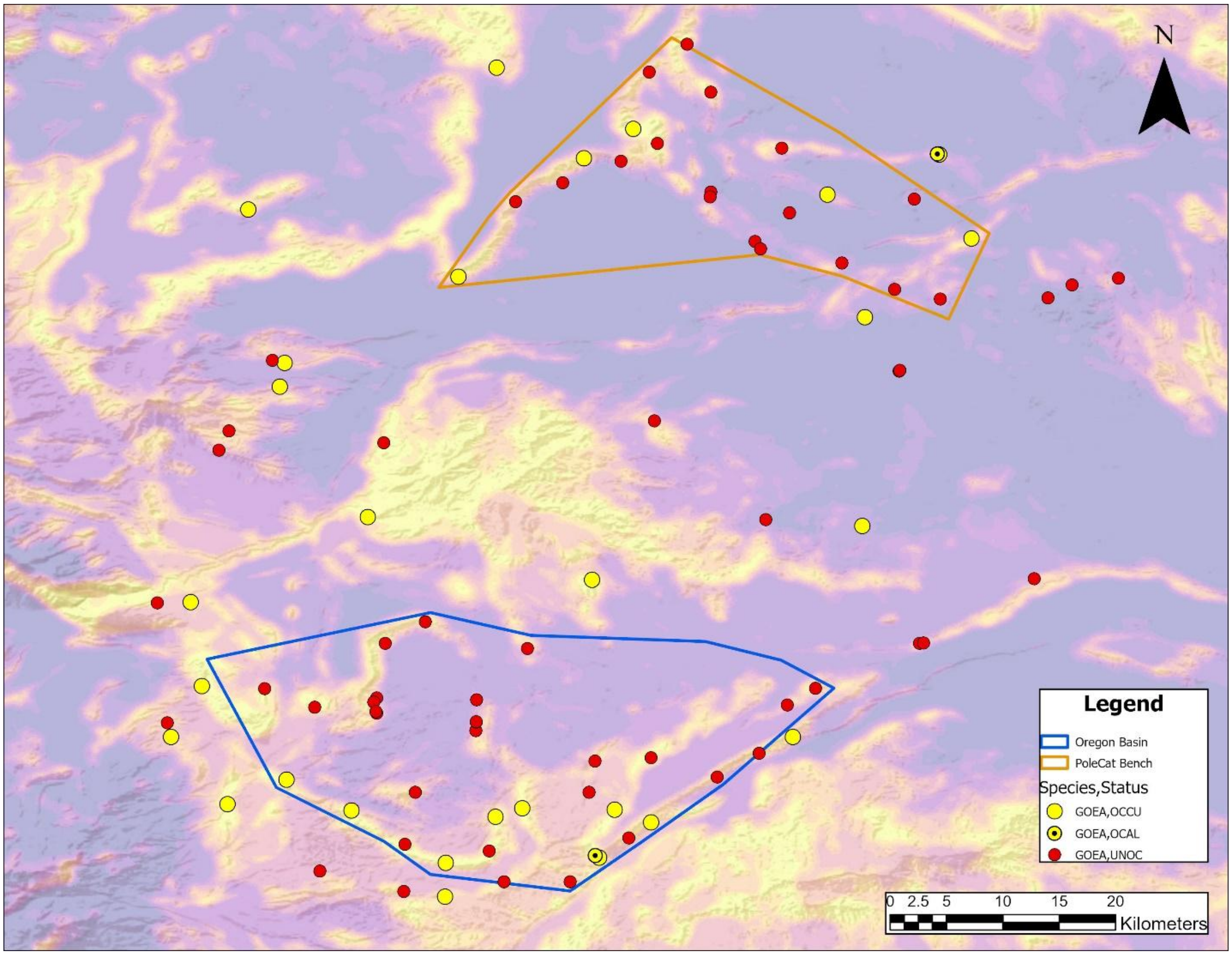


Figure 3. *Golden Eagle nests by status that were determined from aerial flights in 2025. The PoleCat Bench and Oregon Basin studies areas have complete nest surveys, while other historic nests outside these study areas were checked for occupancy. Background is predicted relative nesting density (raptormapper.com).*

Adult Movement Data

We collected millions of locations from seven tagged birds since 2024 (Figure 4). Home range analysis revealed that despite being highly territorial during the breeding season (Figure 5), many of our tagged eagles seem to expand their home range during other parts of the year (Figure 6).

The Territory 1 male is the only bird in this study for which we have data during both years. In 2024, this individual successfully raised one nestling, but in 2025 he did not breed. There is a noticeable difference in this individual's home range size between the two years (Figure 7).

The Eagle Nest Creek female and Territory 127 female also both exhibited large-scale movements since being tagged this past May. The Eagle Nest Creek nest failed at the end of June, just a few weeks before the chick would have fledged. Territory 127 failed in mid-June. After the nests failed, both females undertook broader movements than they showed while the nest was active. The Territory 127 female travelled several miles away from her territory within weeks of her nest failing (Figures 4, 5, 6). Similarly, in 2024, the Territory 30 male's nest failed close to fledging, and he also showed an expanded home range size.

The failed outcome of the nests in these territories may potentially explain the larger home range sizes for these individuals throughout the year and, for the Territory 127 female during the latter part of the breeding season. While we were not able to connect to the female from the other failed nest (Eagle Nest Creek), we did download data from the male at that territory. Despite nest failure, the Eagle Nest Creek male has continued to exhibit high breeding territory fidelity.

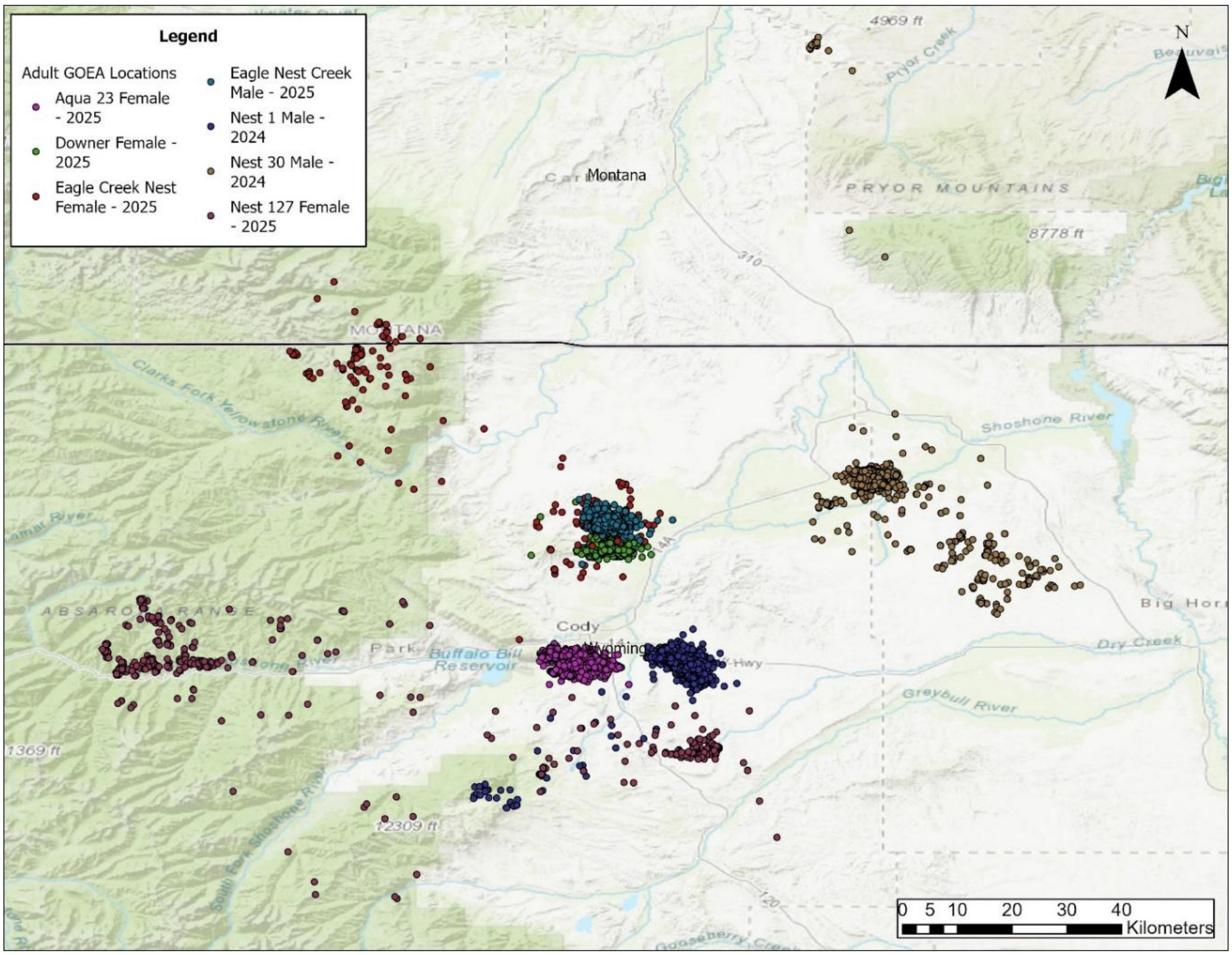


Figure 9. *Year-round locations of seven adult, breeding Golden Eagles tagged in 2024-2025 with locations subsampled to 1 location/hour.*

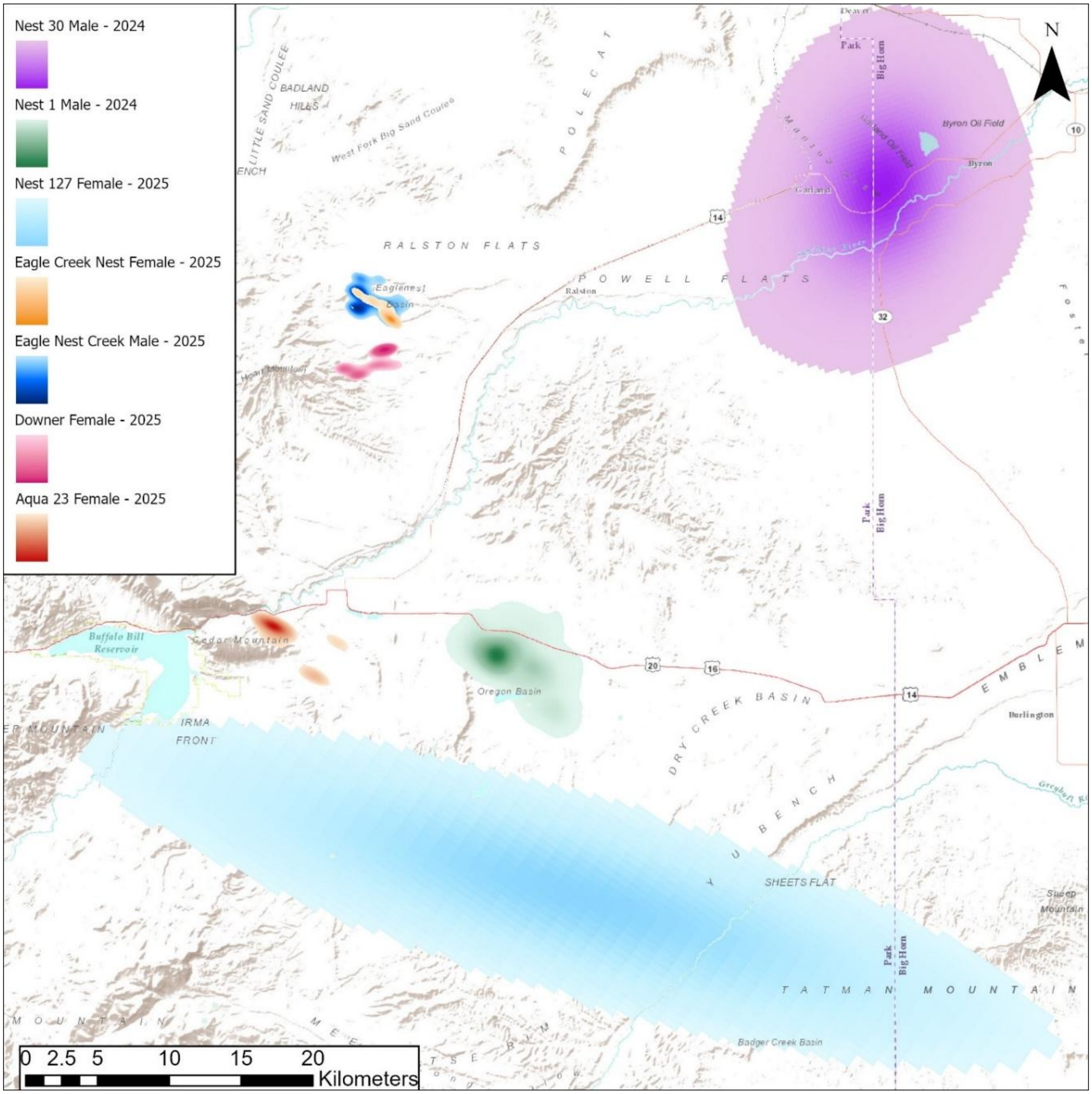


Figure 10. *Breeding season home ranges of nesting Golden Eagles for 2024 and 2025, based on 95% auto-correlated kernel density estimates (AKDEs) from April 1- June 30, where darker colors represent areas of higher use within a home range.*

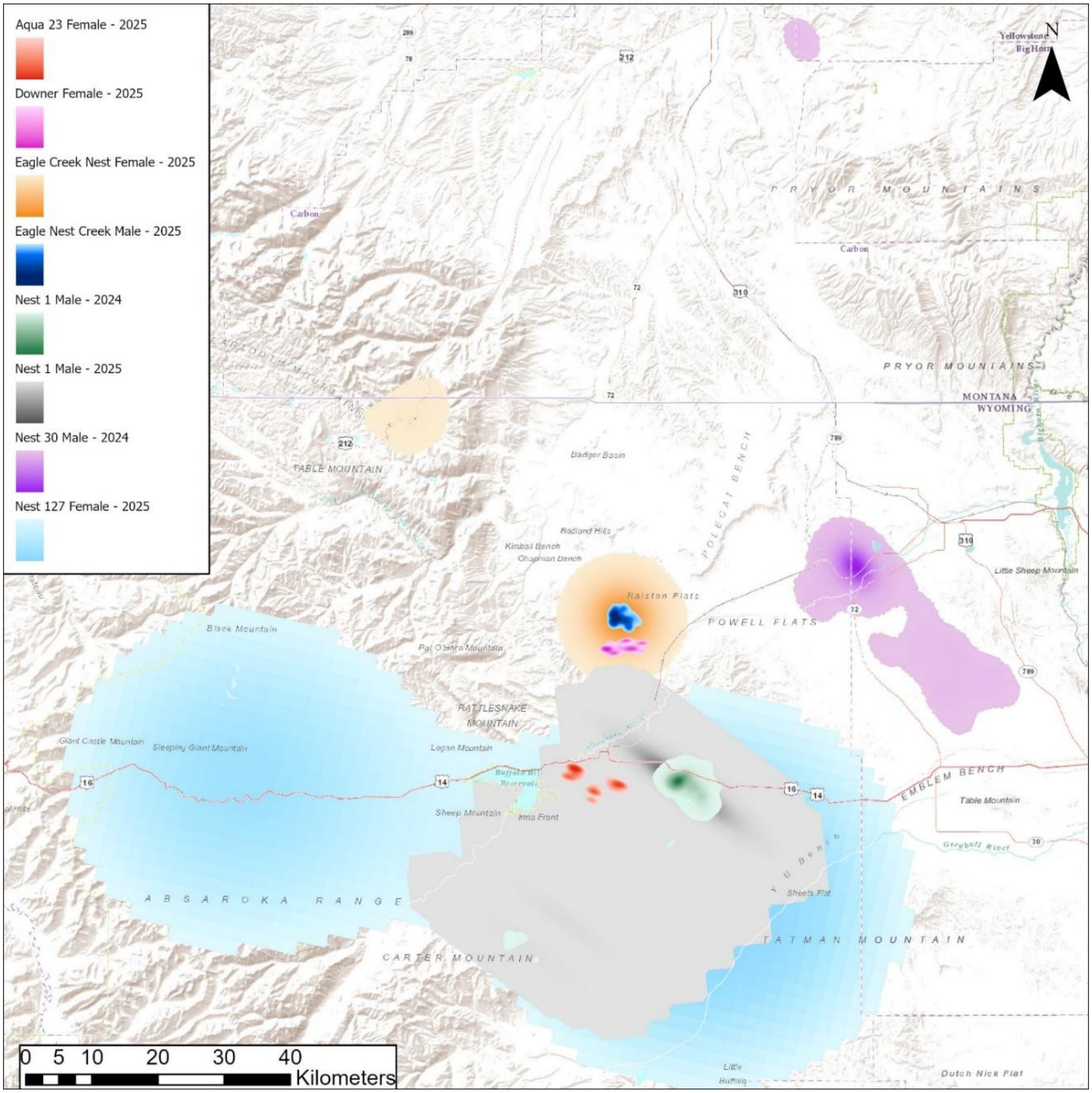


Figure 11. *Year-round home ranges of Golden Eagles for 2024 and 2025, based on 95% auto-correlated kernel density estimates (AKDEs) from January 1- December 31, where darker colors represent areas of higher use within a home range.*

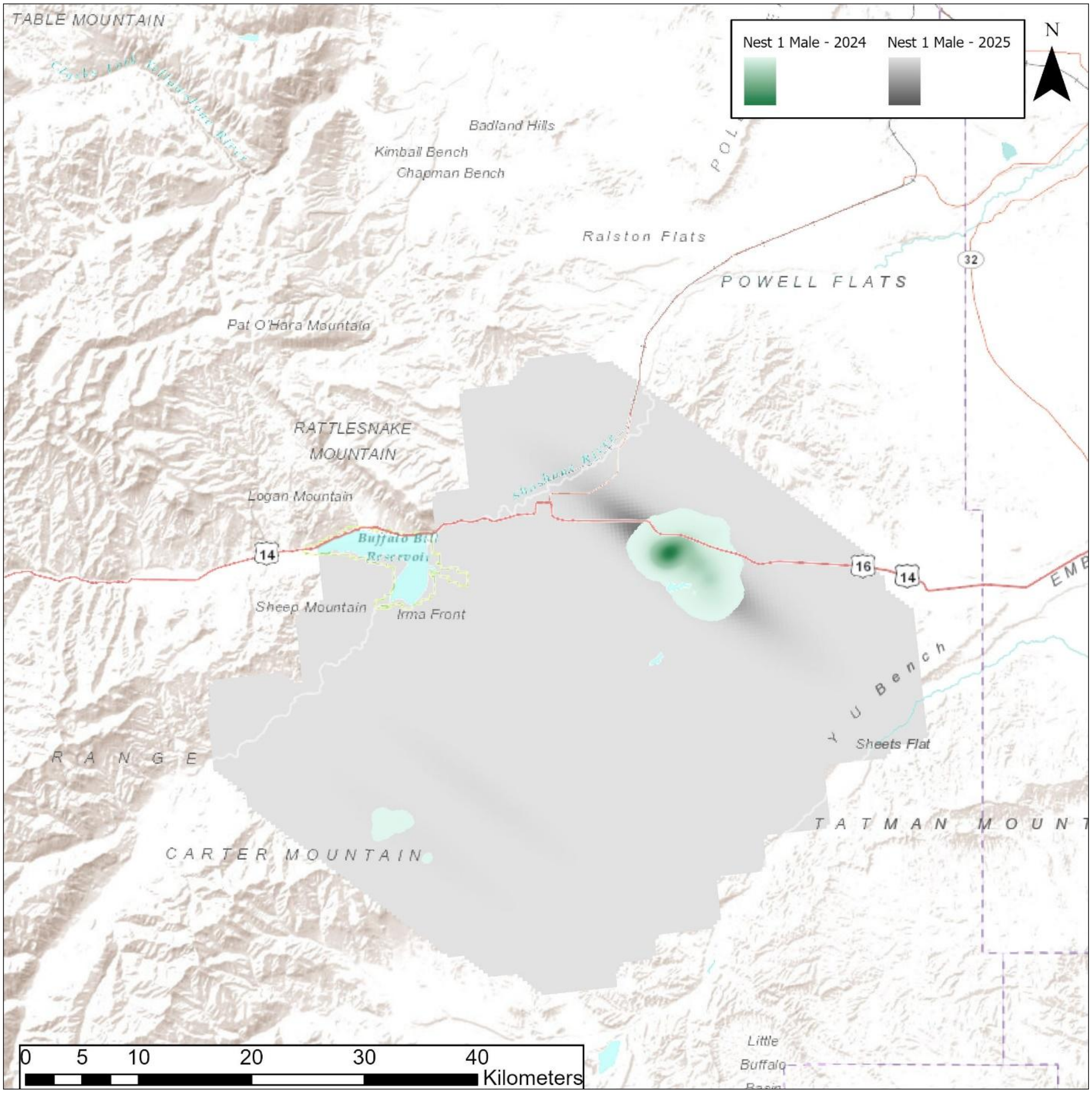


Figure 12. *Year-round home ranges of an adult male Golden Eagle from the Nest 1 territory in 2024 and 2025, based on 95% auto-correlated kernel density estimates (AKDEs) from January 1- December 31, where darker colors represent areas of higher use within a home range.*

Juvenile Trapping

We assisted the Aikens Lab at the University of Wyoming with deploying transmitters on fledgling Golden Eagles within the study area. In 2024 and 2025 we tagged 18 and 7 juveniles, respectively. During these two years we have observed a range of dispersal strategies in the young. While the majority of the tagged juveniles remained either in Bighorn Basin or elsewhere in Wyoming, a few others dispersed to Southern Canada, Idaho, Montana, Colorado, Nebraska, and even the Southwest and Mexico (Figure 8). We also plotted 1 hour locations of all juveniles while they were in Wyoming (Figure 9).

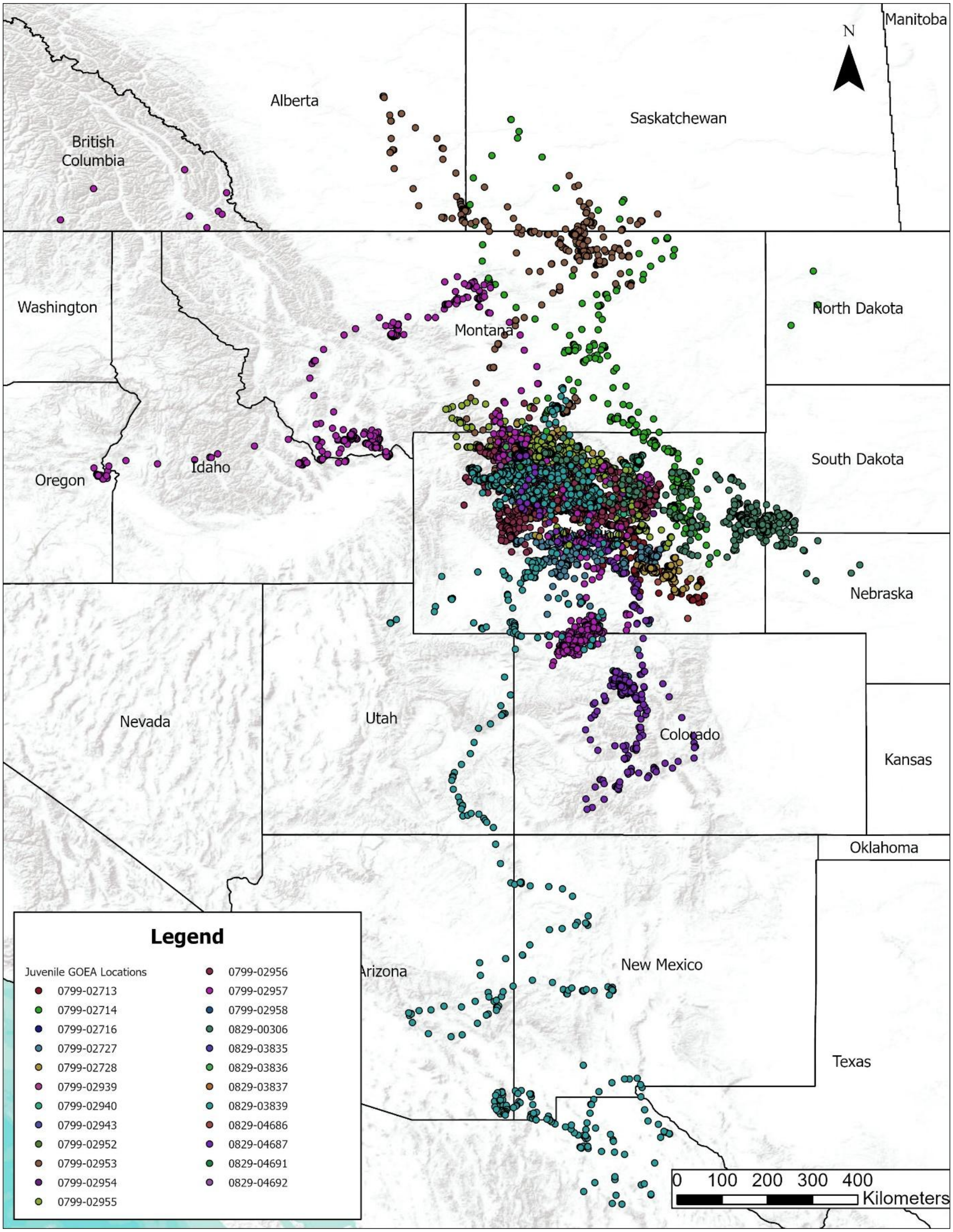


Figure 13. *2024-2025 locations of juvenile Golden Eagles tagged in collaboration with Dr. Ellen Aikens, University of Wyoming, at the local scale with locations subsampled to 1 location/hour.*

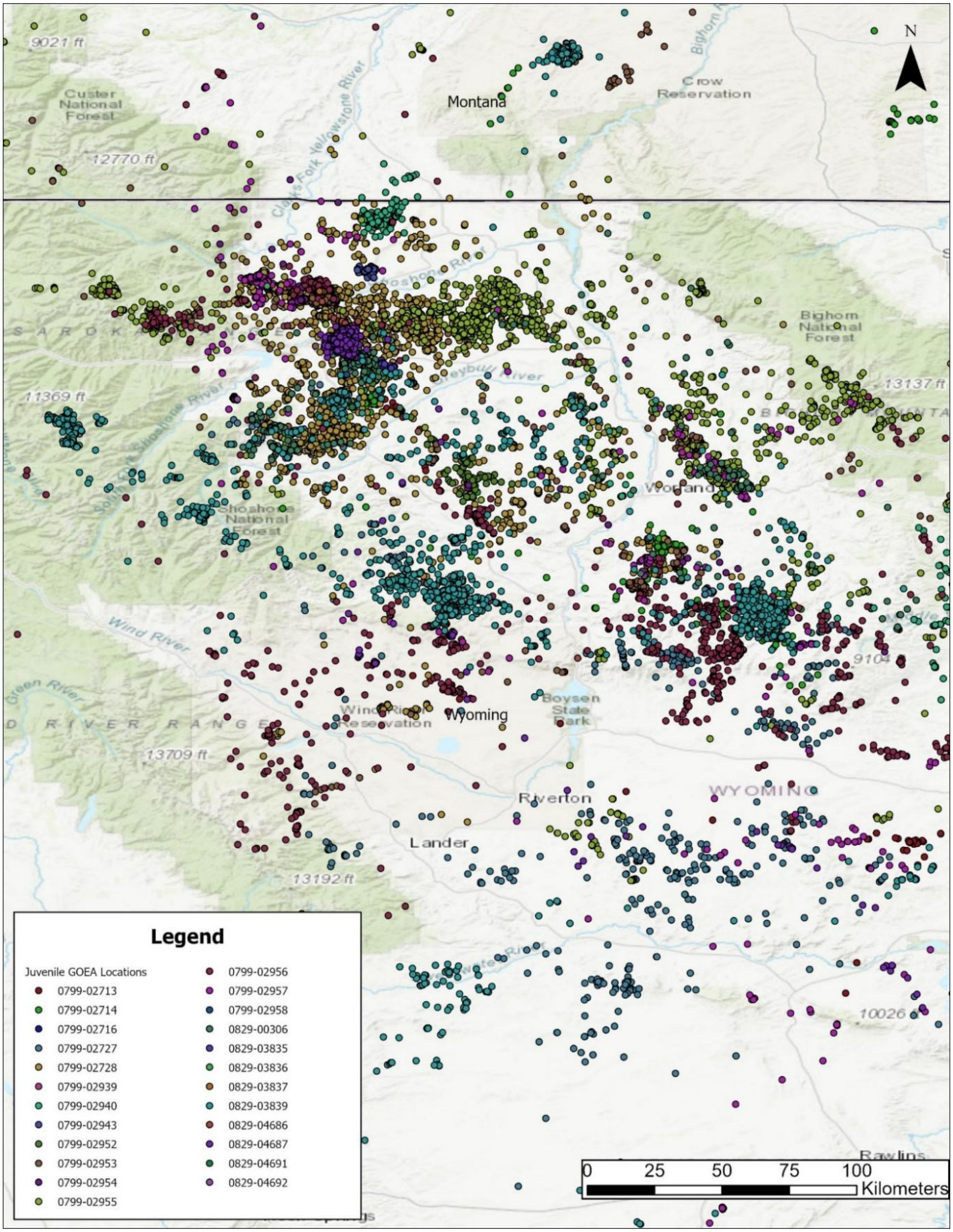


Figure 14. *2024-2025 locations of juvenile Golden Eagles tagged in collaboration with Dr. Ellen Aikens, University of Wyoming, at the local scale with locations subsampled to 1 location/hour.*

A goal of the Aikens Lab is to tag juveniles and their respective adults as part of their lifetime learning study. In 2025, we placed transmitters on seven Golden Eagle fledglings in collaboration with the University of Wyoming. We also banded one chick that was discovered to be very lethargic in the nest. Upon entry to the nest, we discovered that the chick had a pre-existing eye injury, so we did not fit this individual with a transmitter. Both the Downer female and her chick were fitted with transmitters. The chick died a few weeks after fledging but we were able to see relative movements between a chick and its parent for the first few weeks of the fledgling's life (Figure 10).

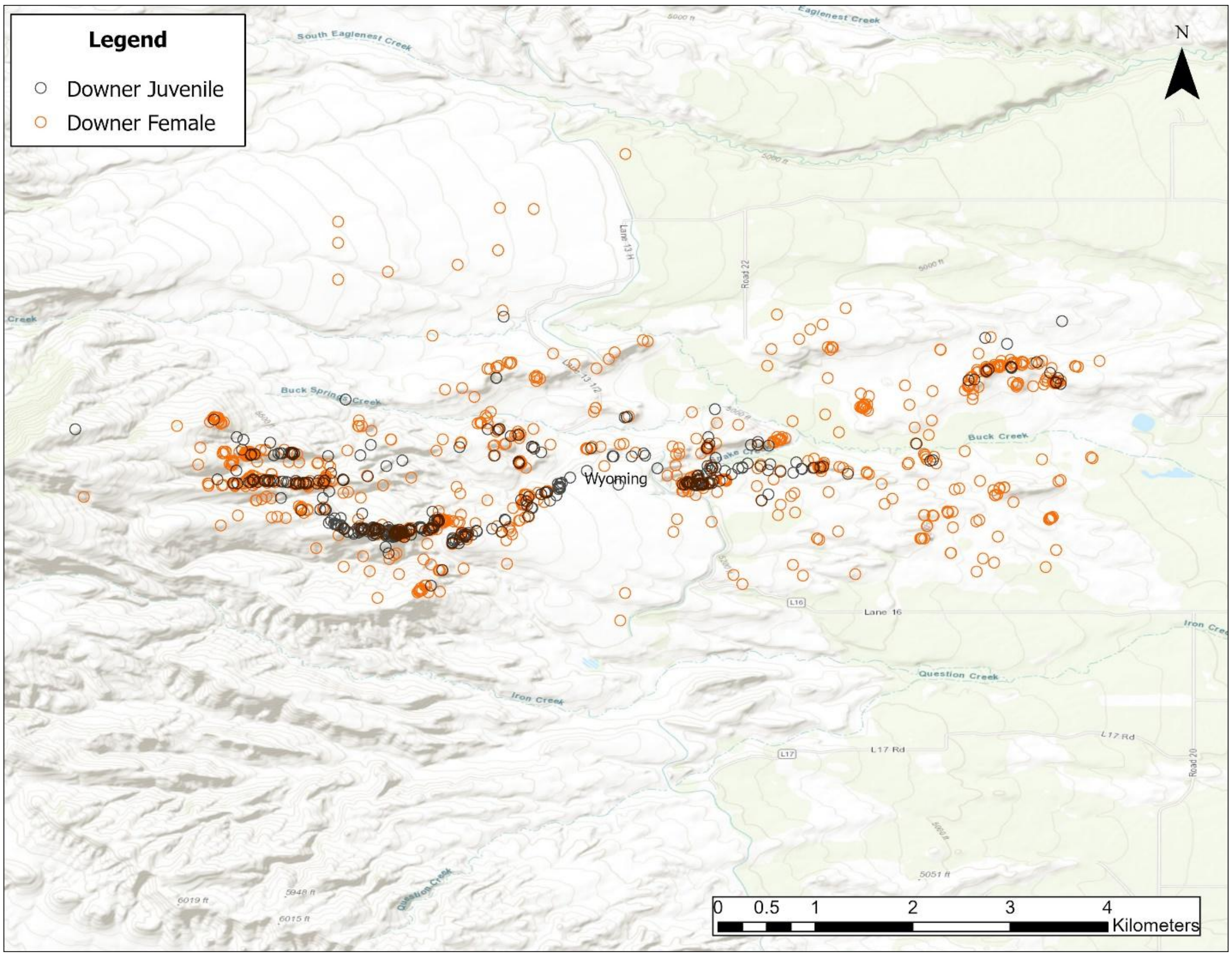


Figure 15*. Adult female and juvenile locations from the Downer Territory between late June and mid-August with locations subsampled to one location per hour.*

Trail Cameras and ARUs

We deployed two to three trail cameras and ARUs at each of the nesting territories where adults were tagged. We plan to start analyzing these data in 2026 for anthropogenic disturbance (Figure 11). We will likely use software such as BirdNET to analyze ARU data and we will use volunteers to classify our trail camera data.

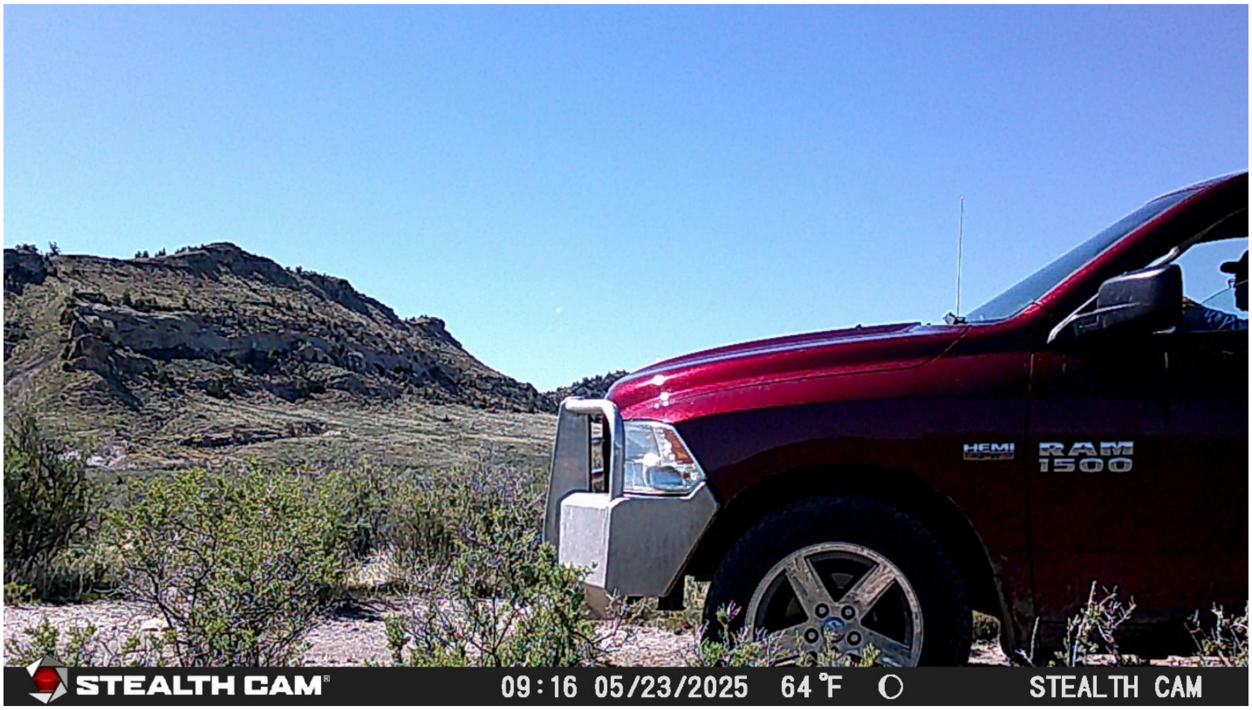


Figure 16. *A truck drives by one of our trail cameras placed to measure disturbance near Golden Eagle nests.*

Next Steps

Once again, we had hoped to deploy more transmitters during winter trapping. This year, a recent storm system in our study area caused the area to become highly affected by deep snow and sub-zero temperatures during our trapping efforts in February. Snow cover impacted our ability to access certain territories, and trap/bait maintenance had to be performed more regularly due to snow buildup and low temperatures. Maintenance included clearing launchers of snow, changing batteries, and switching out carrion. These factors, as well as the wariness of the resident eagles, caused low winter trapping success again this year. However, we were pleasantly surprised with our later success in May. In 2026, we plan to target adult males in early spring, as well as continuing to target adult females in May, with our dho-gazza and live bait set.

We will also continue to deploy and maintain ARUs and trail cameras at active nesting territories where we have tagged breeding adults. Following additional adult transmitter deployments, we will also continue to deploy ARUs and trail cameras in those territories. Our team is in the process of switching our audio analysis software from Kaleidescope to BirdNET in order to more efficiently analyze these ARU data for various types of disturbance. We will return to the study area several times/year to remotely download location data from tagged birds, while also maintaining ARUs and trail cameras. We will continue to perform aerial surveys within the Oregon Basin/Polecat study areas, while also continuing to expand into neighboring areas.

Acknowledgements

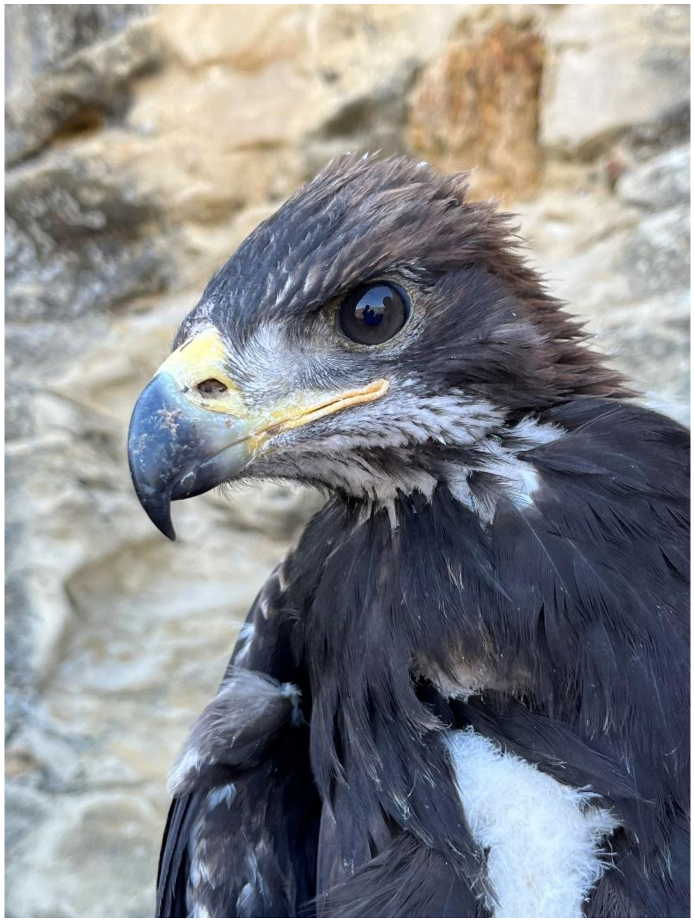
We thank The Nature Conservancy of Wyoming (Emily Buckles and staff) for field and logistical support of the project. Bruce Harrison also provided logistical support for the project. Also, many thanks to Chris

Pfister, Bruce Harrison, JD Radacovich, and other landowners for allowing access to their lands for eagle trapping and nest monitoring. Jacob Schneller of Flightline was an impeccable pilot for our flight surveys. And finally, many thanks to the Knobloch Family Foundation, Nancy-Carroll Draper Charitable Foundation, and Wyoming Governor's Big Game License Coalition for funding the project.

Bighorn Basin Golden Eagle ecology

Monitoring reproductive performance, primary prey abundance, and diet

2025 Annual Report



Cooperators

Dr. Chuck Preston and Corey Anco, Buffalo Bill Center of the West, Draper Museum of Natural History

Dr. Ellen Aikens Lab, University of Wyoming

Destin Harrell, US Fish and Wildlife Service

Study Personnel: Adrian Rouse, Hilary Turner, Anna Wolke, Addie Wichman, Zach Bordener, Ellen Ye

Summary Narrative

In 2025 we completed the seventeenth year monitoring Golden Eagle reproductive performance and nesting diet and the sixteenth year monitoring leporid abundance in northwestern Wyoming's Bighorn Basin — a regional stronghold for breeding Golden Eagles (e.g. Wallace et al. 2019). Methods in 2025 followed those outlined in Preston et al. (2017) and Preston and Anco (2021). The importance of long-term monitoring, particularly in the Bighorn Basin, is underscored by recent research showing that areas with wind energy development may be population sinks for Golden Eagles and other raptors (Watson et al. 2025). The Bighorn Basin, currently without wind energy development absent the Pryor Mountain Wind Farm distant from the study area in Montana, is thus an increasingly vital potential source of dispersing Golden Eagles for more highly impacted areas in the western U.S.

We monitored 95 territories in 2025 and found that 35 (37%) of these were occupied (please see Preston and Anco 2021 for explanation of terms). We determined the reproductive result for 33 of the occupied territories. Nine (27%) of these territories successfully produced at least one fledgling with a total of ten fledglings produced. The calculated reproductive rate was thus 0.30 fledglings per occupied territory – less than half the 0.69 value in 2024, and significantly lower than the seventeen year mean of 0.70 (Table 1).

Table 1. Golden Eagle reproductive performance 2009 - 2025.

Year	# Territories Surveyed	# and % Surveyed Territories Occupied	# and % Occupied Territories w/ Known Outcome	# and % Nest Success[a]	Reproductive Rate[b]
2009	37	34 (92%)	34	25 (74%)	1.12
2010	48	43 (90%)	41	24 (59%)	0.97
2011	50	44 (88%)	44	14 (32%)	0.43
2012	56	49 (88%)	49	16 (33%)	0.39
2013	53	43 (81%)	43	16 (37%)	0.39
2014	65	55 (85%)	55	23 (42%)	0.54
2015	55	49 (89%)	49	38 (78%)	1.24
2016	73	63 (86%)	51	45 (88%)	1.33
2017	35	25 (71%)	23	18 (78%)	1.26
2018	39	32 (82%)	32	7 (22%)	0.31
2019	36	31 (86%)	31	7 (23%)	0.29
2020	47	39 (83%)	39	20 (51%)	0.69
2021	36	29 (81%)	29	11 (38%)	0.48
2022	37	33 (89%)	33	8 (24%)	0.3
2023	42	36 (88%)	36	12 (33%)	0.44
2024	55	51 (93%)	48	28 (58%)	0.69
2025	95	35 (37%)	33	9 (27%)	0.3
Mean; SD	50.5; SD 15.4	40.6; SD 9.9 82.9%; SD 12.5	39.4; SD 8.7	18.9; SD 10.5 46.9%; SD 21.1	0.70; SD 0.4

[a] Number and Percentage of Occupied Territories with Known Outcome Producing Fledglings

[b] Number of Fledglings/Occupied Territory with Known Outcome

We've demonstrated before (see Preston and Anco 2021) that cottontails (*Sylvilagus* spp.) are typically the primary prey for nesting Golden Eagles in the Bighorn Basin, averaging 64% of nesting prey remains identified (Table 2). To assess nesting diet in 2025, we collected prey remains from a sample of seven nests. In 2025, white-tailed jackrabbits (*Lepus townsendii*) were the most frequently occurring species in prey remains (30%), followed by birds (28%) – both noticeably higher than in 2024 (24% and 22% respectively). Cottontail remains were considerably lower in 2025 (only 19%, compared to 36% in 2024). Pronghorn (*Antilocarpa Americana)* remains increased in 2025 (19%) and other mammal remains were much lower than the previous year (7% and 9% respectively; Table 2).

Table 2. Summary of prey remains frequency identified from Golden Eagle nests 2009 – 2025.

Year	Number of Prey Identified	Number of Nests Sampled	Cottontails	White-tailed Jackrabbit	Pronghorn	Other Mammals	Birds	Snakes
2009	44	3	40 (91%)	0	0	1 (2%)	2 (4%)	1 (2%)
2010	88	4	68 (77%)	3 (3%)	4 (4%)	5 (6%)	9 (10%)	0
2011	114	4	87 (76%)	2 (2%)	8 (7%)	7 (6%)	10 (9%)	0
2012	118	5	71 (60%)	18 (15%)	13 (11%)	3 (2%)	13 (11%)	0
2013	147	6	91 (62%)	15 (10%)	5 (3%)	14 (10%)	20 (14%)	2 (1%)
2014	214	13	148 (69%)	20 (9%)	9 (4%)	10 (5%)	25 (12%)	2 (<1%)
2015	235	13	182 (77%)	21 (9%)	6 (3%)	6 (3%)	18 (8%)	2 (<1%)
2016	245	14	197 (80%)	14 (6%)	1 (<1%)	23 (9%)	6 (2%)	4 (2%)
2017	198	8	140 (71%)	10 (5%)	5 (3%)	13 (7%)	24 (12%)	6 (3%)
2018	52	3	32 (62%)	7 (13%)	1 (2%)	1 (2%)	11 (21%)	0
2019	27	2	8 (30%)	3 (11%)	3 (11%)	4 (15%)	9 (33%)	0
2020	162	10	82 (52%)	12 (7%)	17 (11%)	6 (4%)	41 (25%)	2 (1%)
2021	103	7	63 (62%)	6 (6%)	8 (8%)	6 (6%)	14 (14%)	4 (4%)
2022	38	6	12 (32%)	2 (5%)	8 (21%)	3 (8%)	13 (34%)	0
2023	37	6	8 (22%)	3 (8%)	9 (24%)	11 (30%)	13 (35%)	0
2024	67	10	24 (36%)	16 (24%)	5 (7%)	6 (9%)	15 (22%)	0
2025	98	7	19 (19%)	29 (30%)	19 (19%)	4 (4%)	27 (28%)	0
Total	1987	121		181 (9%)	121 (6%)	123 (6%)		17 (1%)

			1272 (64%)				270 (14/%)	

The index to relative cottontail abundance in 2025 was 2.75 individuals per 1.6 kilometer (5 mile) route, which was slightly lower from surveys conducted in 2024 (3.5 individuals per 1.6 km; Table 3). Perhaps Rabbit Hemorrhagic Disease Virus 2 (RHDV2) played a role in this decreased count, and this decrease may account for the lower cottontail remains found in active eagle nests this year. Despite record white-tailed jackrabbit numbers counted in 2024, there was a sharp decline observed during the 2025 surveys. In 2024, 8 individuals were counted per route, versus only 1.7 in 2025 (Table 3).

Table 3. Annual indices to relative abundance of leporids in the Bighorn Basin, Wyoming 2009 -2025.

Year	Cottontail Roadside Survey[a] (Hunter Harvest[b])	White-tailed Jackrabbit Roadside Survey
2009	No survey conducted (2.5)	No Survey Conducted
2010	11.7 (2.4)	2.4
2011	3.8 (1.7)	1.8
2012	3.9 (1.3)	2.5
2013	3.1 (1.3)	2.2
2014	3.5 (1.0)	2.1
2015	12.9 (2.5)	1.7
2016	35.2 (2.7)	6.2
2017	6.1 (2.8)	1.5
2018	2.8 (1.3)	1.8
2019	2.3 (1.1)	0.8
2020	4.0 (0.8)	0.5
2021	3.8 (0.8)	2.3
2022	2.3 (0.6)	0.8
2023	1.0 (0.7)	0.7
2024	3.5 (0.6)	8
2025	2.75 (0.4)	1.7
Mean	**6.4 (1.4)**	**2.3**

[a] Average number of animals recorded per survey route in each year.

[b] Cody/Bighorn Basin regional cottontails/hunter day during September – February season (i.e., 2009 index reflects September 2008 – February 2009 season).

Interestingly, white-tailed jackrabbits still made up 30% of prey remains in nests. Additionally, the slight decrease in cottontail and jackrabbit numbers during the surveys could be responsible for the higher percentage of pronghorn and bird remains in nests during 2025.

Based on previously documented patterns, we anticipated a gradual increase in annual cottontail abundance and Golden Eagle reproduction after the cottontail decline starting in 2017. After a low point in 2019, there was a slight increase in 2020. However, in contrast to expectations, cottontail abundance declined each year until 2024. The slight cottontail decline in 2025, may be part of the cause for lower eagle productivity in the study area (Figure 1).

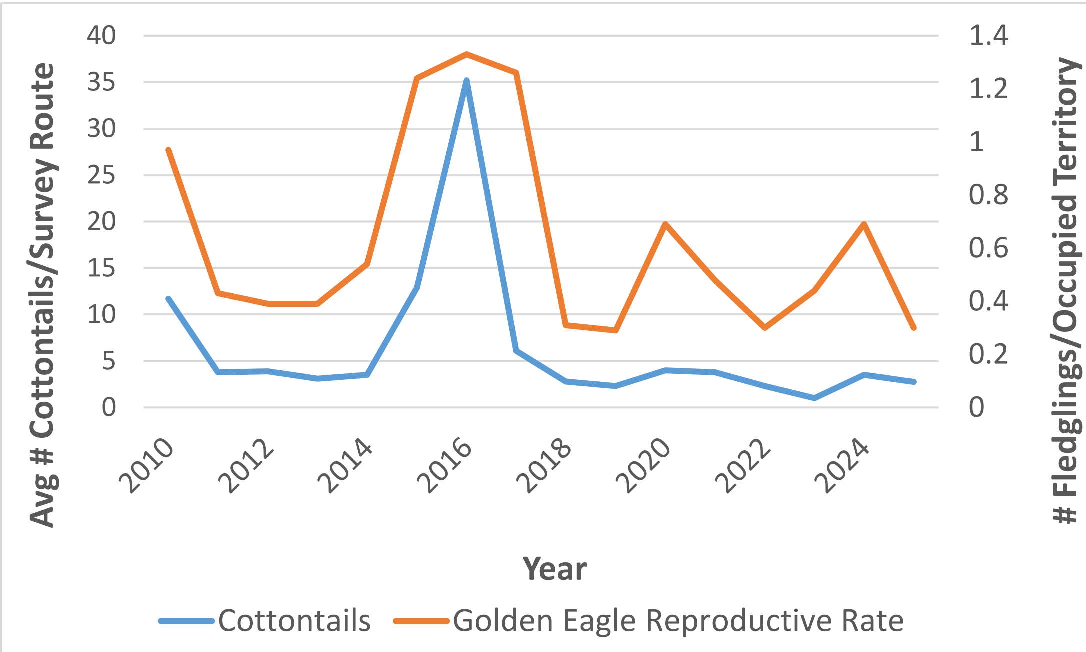


Figure 1. Relationship between annual cottontail abundance and Golden Eagle reproductive rate 2009 – 2025.

The substantial increase in jackrabbit abundance and frequency in Golden Eagle nesting diet was unanticipated. It suggests that the long decline in cottontail abundance may have contributed to a rapid rise in jackrabbit abundance, but additional research is needed to confirm or reject this hypothesis. We suspect that the dramatic and enduring decline in cottontails between 2021-2023 was due to the emergence of Rabbit Hemorrhagic Disease Virus 2 (RHDV2), first documented in Wyoming in December 2020. It is possible that RHDV2 did not impact white-tailed jackrabbits as dramatically as it did cottontails, or jackrabbits are rebounding more rapidly as the effect of RHDV2 fades from the region. If white-tailed jackrabbit abundance remains high or increases in the future, we anticipate that jackrabbits will become more frequent in the nesting diet and exert a strong positive effect on Golden Eagle reproductive importance. More information is needed on the continuing presence of RHDV2 in the region and its effect on both cottontails and jackrabbits.

Rabbit hemorrhagic disease has caused widespread ecological disturbance in some areas of Europe leading to the decline of Iberian Lynx (*Lynx pardinus*) and Spanish Imperial Eagle (*Aquila adalberti*) populations (Monterroso et al. 2016), and others (Schmidt et al. 2018) have emphasized the power of bottom-up processes to drive Golden Eagle reproductive success. The slight rebound in Golden Eagle reproductive success in 2020 suggests Golden Eagles may also be resilient to cottontail lows at least in the short-term. These developments underscore the conservation importance of long-term monitoring and research to identify reproduction trends and their drivers. Therefore, we are continuing to monitor

Golden Eagle reproductive performance and expand this project to better understand drivers of Golden Eagle reproductive performance and identify means of mitigating negative effects of RHDV2 and concomitant human-caused environmental impacts such as habitat destruction and fragmentation, wind energy development, and lead poisoning from contaminated carcasses.

Acknowledgments

We are grateful for financial support from the Nancy-Carroll Draper Charitable Foundation and Knobloch Family Foundation, and the Wyoming Governor's Big Game License Coalition. Additional financial and logistical support from U.S. Bureau of Land Management, Teton Raptor Center, and University of Wyoming. Volunteers Sally Disque, Richard Gruber, Anne Hay, Judy, Kauwell, and Lisa Marks provided valuable field assistance. Corey Anco provided access to reference collections and laboratory facilities at the Draper Natural History Museum. J. D. Radacovich, Mark McCarty, and an anonymous landowner provided access to property under their administration.

Literature Cited

Monterroso, P. et al. 2016. Disease-mediated bottom-up regulation: An emergent virus affects a keystone prey, and alters the dynamics of trophic webs. Sci. Rep. 6, 36072; doi: 10.1038/srep36072 (2016).

Preston, C. R., R. E. Jones, and N. S. Horton. 2017. Golden Eagle diet breadth and reproduction in relation to fluctuations in primary prey abundance in Wyoming's Bighorn Basin. Journal of Raptor Research 51:334-346. http://www.bioone.org/doi/full/10.3356/JRR-16-39.1

Preston, C. R. and C. Anco. 2021. The Bighorn Basin Golden Eagle Ecology Program: 2009 - 2021. Unpublished report prepared for the Draper Natural History Museum, Buffalo Bill Center of the West, Cody, Wyoming, USA.

Schmidt, J. H., C. L. McIntyre, C. A. Roland, M. C. MacCluskie, and M. J. Flamme. 2018. Bottom-up processes drive reproductive success in an apex predator. Ecol. Evol. 11:1833-1841. doi:1002/ece3.3800. eCollection 2018 Feb.

Wallace, Z., G. Bedrosian, B. Woodbridge, G. Williams, B.E. Bedrosian, and J. Dunk. 2019. Wyoming and Uinta Basins Golden Eagle Conservation Strategy. Unpublished report prepared for the U.S. Fish and Wildlife Service Western Golden Eagle Team by the Wyoming Natural Diversity Database and Eagle Environmental, Inc.

Watson, J. W., S. P. Cherry, G. J. McNassar, R. P. Gerhardt, and I. N. Keren. 2015. Long-term changes in nesting raptor communities after construction of wind power projects. J. Raptor Research 59:1–14. doi:10.3356/jrr2424 2025.

Wyoming statewide aerial Golden Eagle surveys

2025 Annual Report

Study Personnel: Zach Wallace, Julie Polasik, Hilary Turner, and Chris Bonter

Introduction

There has been increasing concern for Golden Eagle populations in the U.S. due to negative population-level impacts from human-caused sources of mortality, including shooting, lead poisoning, collisions with turbines and vehicles, disturbance at nest sites, and other sources of mortality. While Golden Eagles occur in most western states, Wyoming is a stronghold for eagles in the West, containing some of the best and most expansive Golden Eagle breeding and winter habitats. Over the past two decades, there have been suspected population declines across the U.S. for both breeding and migratory eagles.

Due to federal protections and known increases in mortality from wind turbines, the U.S. Fish and Wildlife Service (USFWS) has been conducting annual surveys of eagles across the West using aerial flight transects since 2006 to understand national population trends (Nielson et al. 2016). In 2019, the USFWS reduced the survey areas and frequency by half due to budget shortfalls. As a result, ⅔ of Wyoming was surveyed in even years and the other ⅓ in odd years (Figure 1).

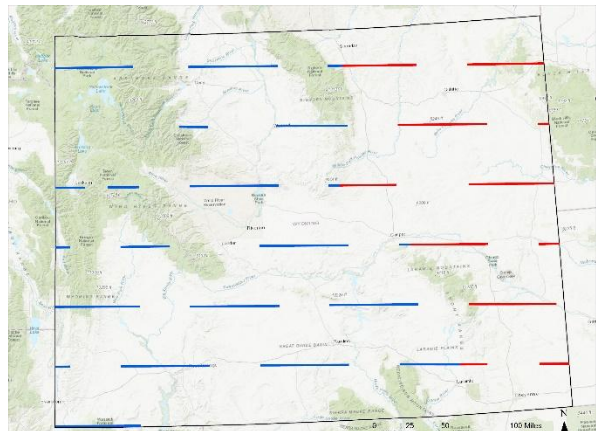


Figure 1. Aerial survey transects used by the USFWS for the Western Golden Eagle Survey to monitor population trends. In 2019, annual surveys were split into even years (red) and odd years (blue).

To help fill this data gap, we are partnering with Zach Wallace (WGFD) to provide more defensible data on eagle trends in Wyoming. Zach recently spearheaded an effort (funded by National Fish and Wildlife Foundation) to supplement the USFWS surveys in Wyoming. The TRC team helped conduct those additional aerial surveys from 2021–2024 and a formal analysis was completed of all survey data from 2006–2024. That analysis revealed a **28% decline in the population** of resident eagles in Wyoming over the past 18 years, or a cumulative loss of over 2,300 eagles (Figure 2). In 2025, we received funding to continue annual aerial surveys across the portion of Wyoming that the USFWS was not surveying, in order to monitor Golden Eagle population trends more accurately.

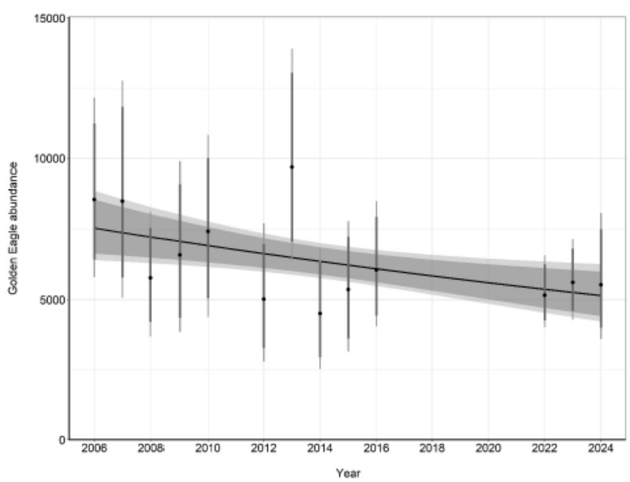


Figure 2. Golden Eagle population trend in Wyoming, 2006–2024. Wallace et al. 2025.

Methods

We surveyed ¾ of Wyoming (the western and southeast portions of the state) in 2025 to supplement surveys completed in the northeast portion of the state by the USFWS (Figure 3). Surveys were conducted in a Cessna 205, which can fit the pilot and three independent observers. The pilot maintains trajectory and altitude (either 350' or 500' AGL depending on terrain) on the survey routes (transects up to 100 km in length), while one observer seated behind the pilot locates all eagles on that side of the plane. The front and back observers on the passenger side of the plane independently locate eagles on the other side of the plane. The double observer method allows for estimates of detectability and error. Surveys are completed in late August/early September to monitor our resident population (young eagles are free-flying and migrants have not yet arrived).

Results

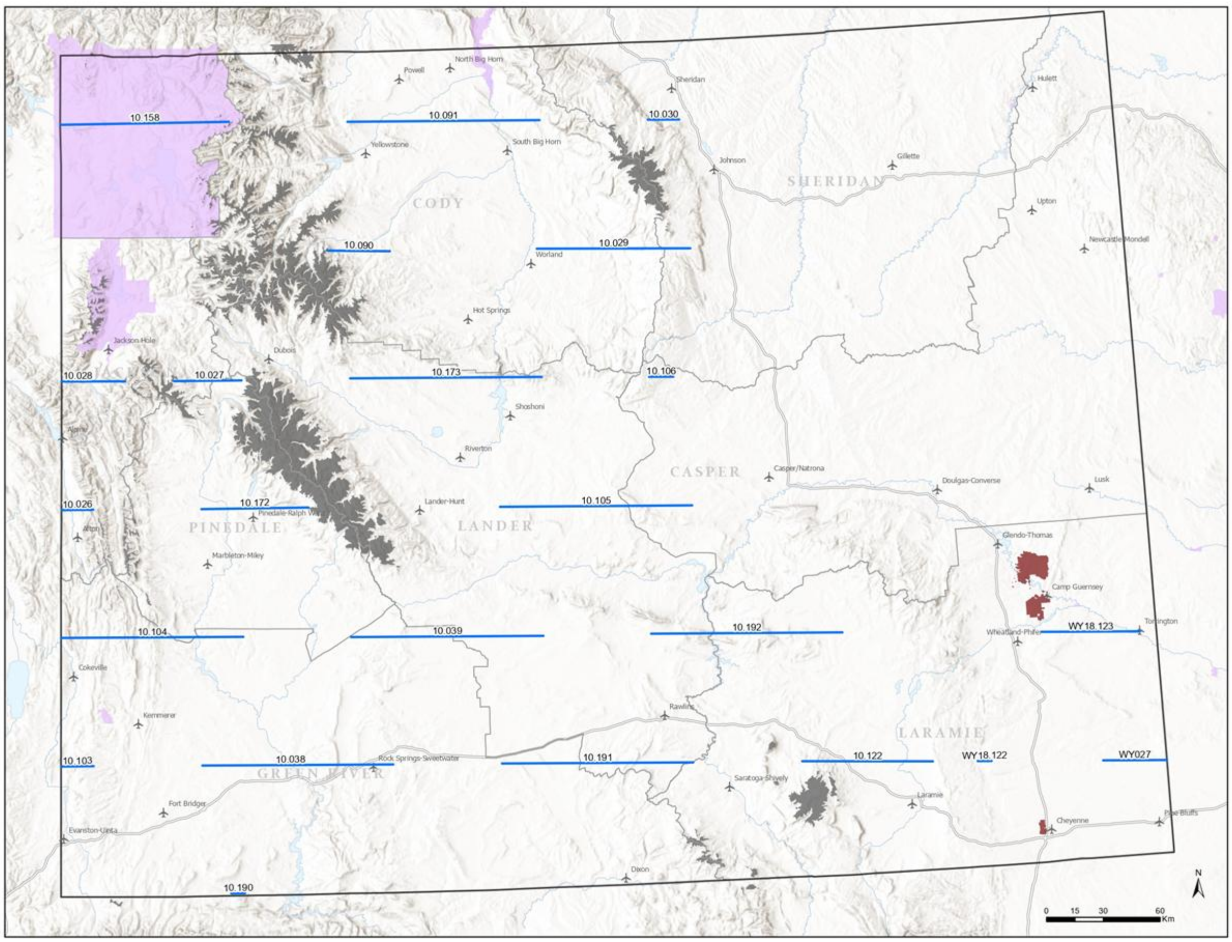


Figure 3. Map of transects survey by our crew in 2025 in Bird Conservation Regions (BCR) 10 and 18. Transect numbers begin with the BCR they are located in.

We surveyed 20 transects in 2025, encompassing approximately 1,266 km in BCR 10 and approximately 93 km in BCR 18. We detected a total of 25 groups comprising 27 Golden Eagles and 2 groups comprising 2 Bald Eagles, all within BCR 18 (Figure 4). We did not detect any eagles of either species within BCR 18. The median detection distance for visual estimates of eagles from the plane was 300m.

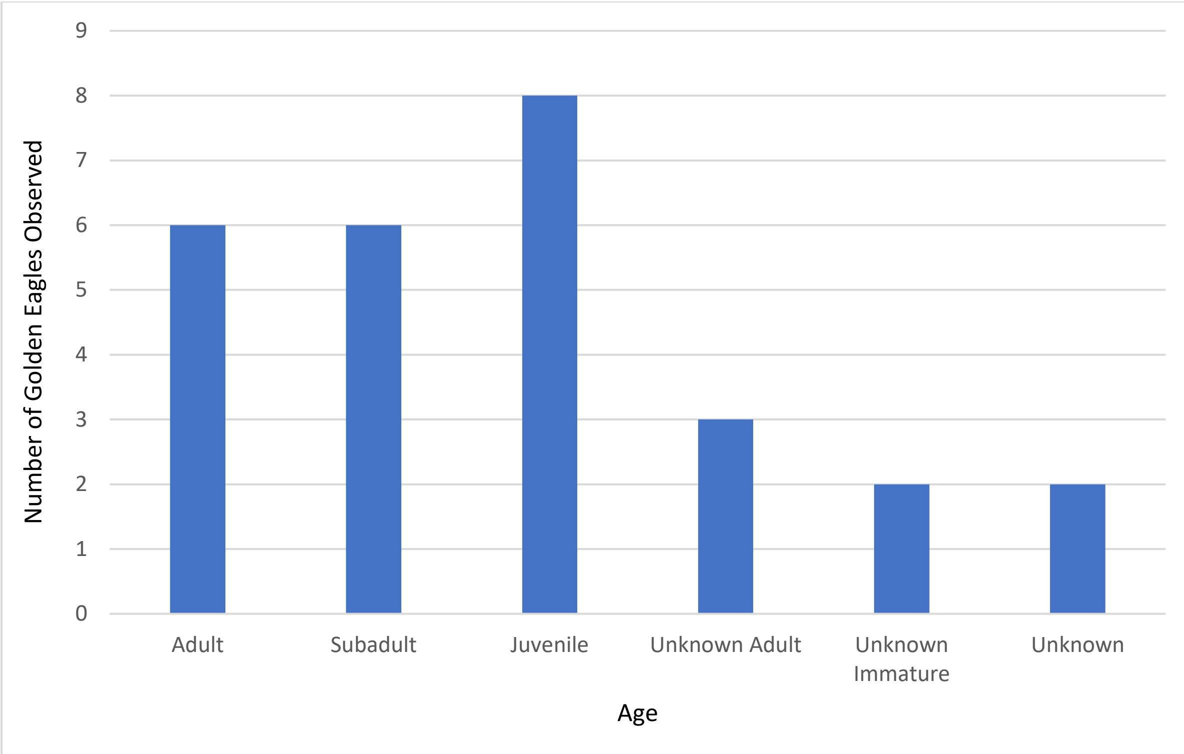


Figure 4. Total number of Golden Eagles observed by age group during 2025 aerial surveys.

Discussion

Surveys in 2025 were completed over the course of just four days as a result of good weather conditions and an experienced crew. While a formal analysis of the Golden Eagle population estimate has not yet been completed, preliminary results suggest that the number of eagles observed per km surveyed in 2025 was near average, compared to past years. Golden Eagle detectability was also similar to past years indicating our survey efforts were successful at locating eagles along survey transects. We plan to continue survey efforts in 2026 and 2027 and re-analyze the data from the three-year period to calculate population estimates of Golden Eagles in Wyoming.

Funding for this study was provided by the Knobloch Family Foundation

Literature Cited

Nielson, R.M., R.K. Murphy, B.A. Millsap, W.H. Howe, and G. Gardner. 2016. Modeling late-summer distribution of Golden Eagles (*Aquila chrysaetos*) in the western United States. PLOS One, 11(8), p.e0159271.

Wallace, Z., R. Nielson, and I. Abernathy. 2025. Wyoming Golden Eagle monitoring plan expansion. Final Report prepared for the National Fish and Wildlife Foundation.

Converse County Raptor Project

Collaborative aerial assessment of nest occupancy and productivity and prey availability

2025 Annual Report

Study Personnel: Bryan Bedrosian, Adrian Rouse, Julie Polasik, Chris Bonter, Jacob Schneller, Hilary Turner, Addie Wichman, Anna Wolke

Cooperator and Landowner Communications

In 2025, we engaged in individual conversations with operators and their consultants about fieldwork coordination to reduce the number of overflights needed as we had previously in 2023, reduce redundancy in data collection, and increase the comfort level about how our team communicates with landowners (i.e., through operators or directly). We hosted meetings with Duke, EOG, Devon, Occidental, HWA Consultants, WEST Inc., Bighorn Consultants, Continental, PacifiCorps, Northwoods (via HWA), NextEra, and Pacificorp. In general, all operators and consultants were willing to coordinate data collection and data sharing, with the exception of Northwoods Energy and NextEra. We were in regular communication with field teams actively working and surveying within the study area to avoid overlap, conflicts, and to maximize time between successive nest visits for any given nest.

Aerial Surveys

We defined the survey area largely based on the Converse County Oil and Gas Project boundary with some modifications (Figure 1). First, we removed sections where the habitat was mainly comprised of trees, due to limited raptor nest detectability from aerial surveys in this habitat type. Next, we removed sections requested by landowners and cooperators, mainly to avoid lambing areas and houses. We also removed mainly urban areas and the sections surrounding the Douglas airport for landowner and safety considerations. In 2025, we also removed sections in the southern and western edges of the study area due to weather and time constraints. In the spring of 2025, we completed our objectives of surveying the study area for all large nesting raptors in a grid-based sampling design.

Within the survey area, we conducted aerial surveys using a Cessna 172 for the entirety of the area. We had one observer in this plane locating raptor nests and also recording prairie dog occurrence and abundance within each section. This is different from 2023 when we had two observers in a Cessna 182, with one focused on prairie dog occurrence, but due to a low abundance of prairie dogs across the region we determined a single observer could both search for nests and record prairie dog abundance. Using the 172 provided consistent data across the study area that accounted for one of the two requisite raptor surveys, in addition to prey. For the second, independent surveys, we used a Husky or Cub aircraft with one observer. The observer in this aircraft has the ability to see both sides of the plane, and the airspeed is generally slower than the Cessna.

There were five areas in 2025 we considered “coordination zones” where operators/consultants were actively collecting raptor nest data within (Figure 2). We did not survey with the Husky in these coordination zones but rather relied on data collected by cooperators. Eliminating the husky flights in these areas helped keep overall project costs down due to the slower flight time of the Husky. Cooperator survey methods included ground-based surveys and aerial surveys. In total, we flew 23,389 km (14,533 mi) while actively surveying (excludes all ferry time) in both fixed-wing airplanes during the occupancy surveys (Figure 3). We conducted 109 hours of flights in the Cessna 172 and 107.4 hours in the Husky, due to coordination zones not being flown with the Husky.

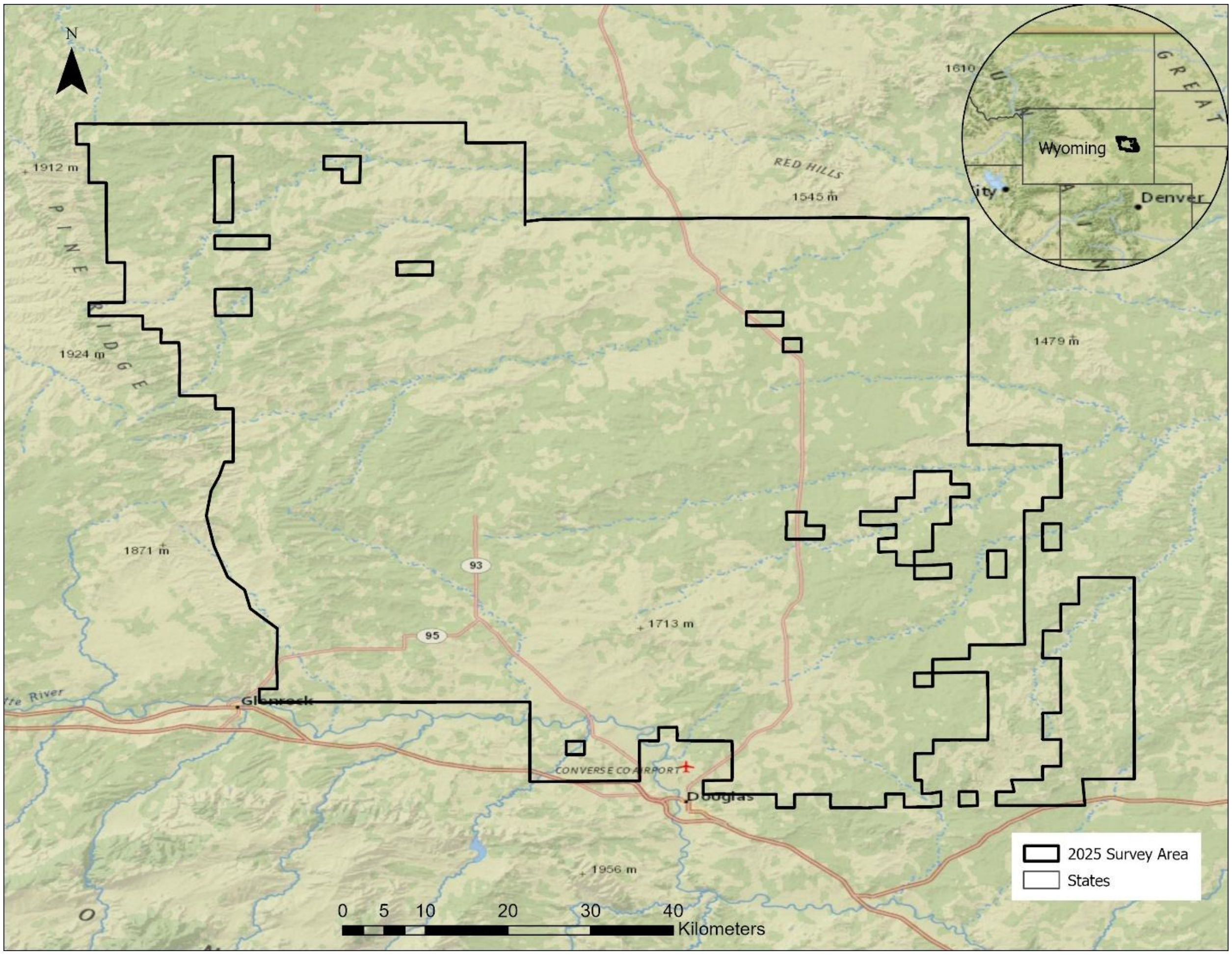


Figure 1. Areas surveyed in 2025 for the Converse County project.

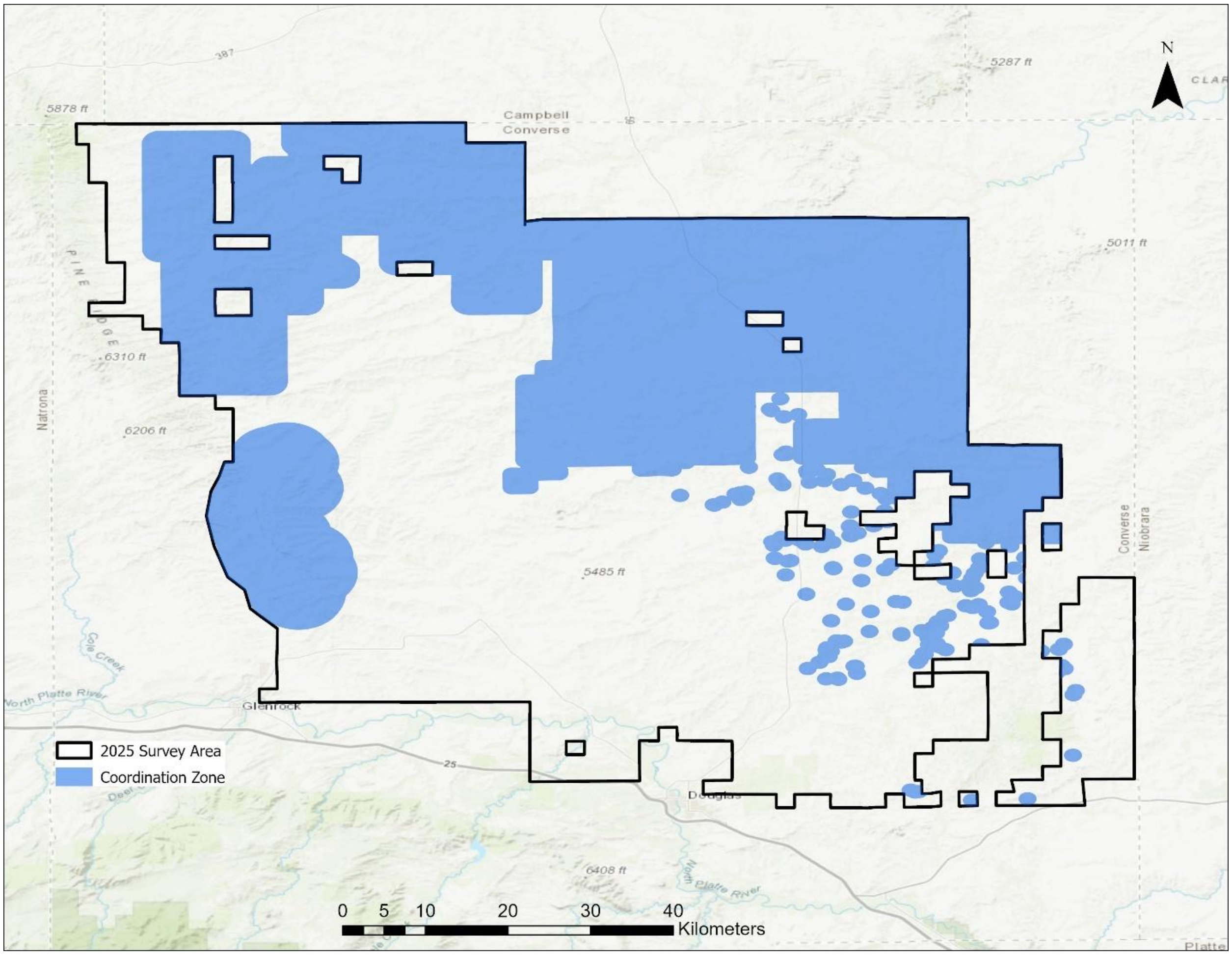


Figure 2. Areas surveyed in 2025 for the Converse County project (outlined in black) with coordination zones (shown in blue).

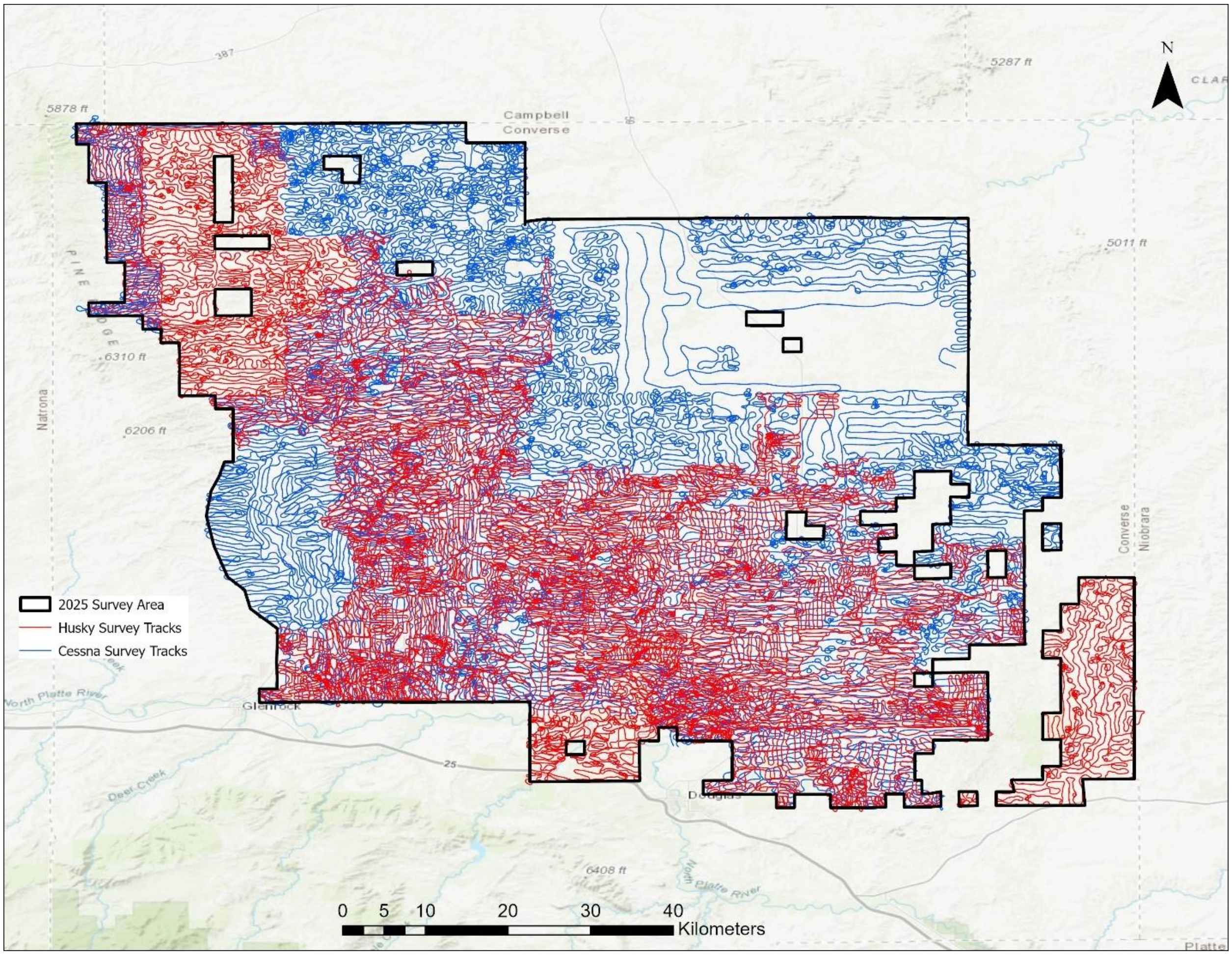


Figure 3. Tracks from aerial surveys in the Cessna 182 (blue) and Husky (red) aircraft during the spring of 2025. Tracks are only shown when actively surveying for raptor nests or prairie dogs. The large empty area in the northeast corner represents and area that was surveyed twice by collaborators.

Because several independent surveys were conducted in the same area to both assess occupancy (our two surveys) and independent objectives (coordination zones), there were many instances where the same nest was recorded multiple times. To filter duplicate records, we flagged instances where two nest records occurred within 500m. We used either the record with the estimated best point as recorded by the surveyor, or the record closest to a previously known nest location from 2023 data. Excluding duplicates, we located a total of 1,005 raptor nests during our flights. Of those, 296 nests were occupied (incubating female or pair at nest), including 109 Red-tailed Hawks, 88 Golden Eagle nests, 62 Ferruginous Hawks, 17 Bald Eagles, 2 Swainson's Hawks, 2 Great Horned Owls, 1 Osprey and 1 Turkey Vulture. We are still waiting to receive data from cooperators so the above nests only represent those located by our TRC surveys, we will update the total number of nests when we have all of the cooperator data. We also conducted follow-up productivity surveys on all active nests not surveyed by cooperators. Based on active nests checked by our team with a known nest status, 63% were successful this year.

Prey surveys

We surveyed 1,919 sections for prairie dog abundance and along 387 linear miles of roadways for lagomorph abundance. We created abundance maps of prairie dogs for the study area with five classifications of abundance based on % of a section with prairie dog mounds (0, <10, 11-25, 26-50, >50%; Figure 4). We also conducted lagomorph surveys on most public roads in the survey area (excluding urban areas) in July 2025. While we did not record a high abundance of lagomorphs, we did record cottontail and jackrabbit, with the highest abundance of cottontails in the NE section of the survey area (Figure 4).

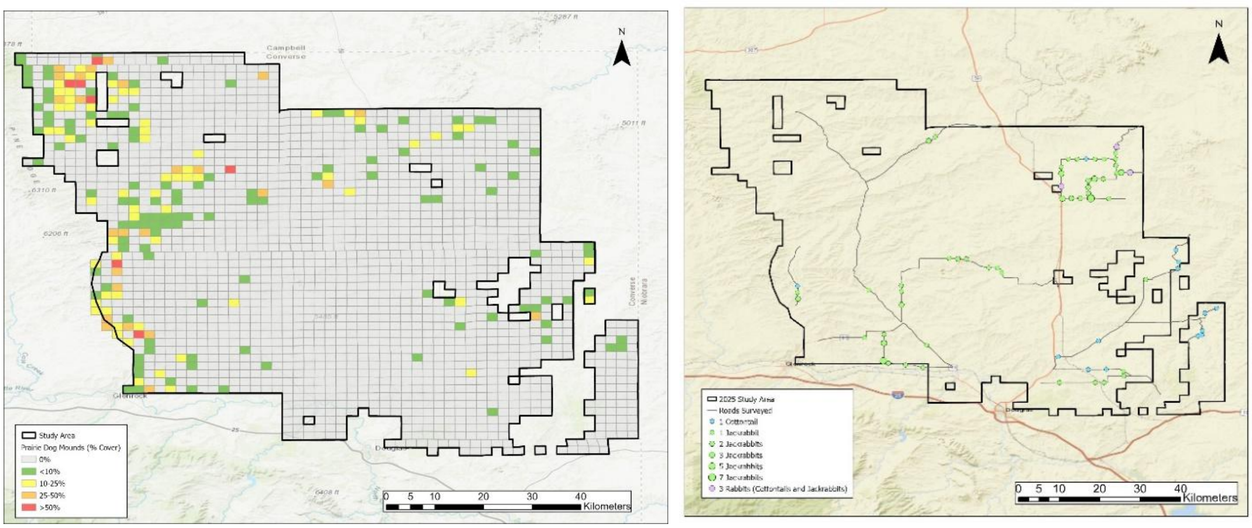


Figure 4. Prey surveys conducted during the Converse County Raptor Study. Left show the relative abundance of prairie dogs surveyed by section from the air. Right shows on-the-ground, nocturnal lagomorph survey routes on public roads and occurrence data.

Ferruginous Hawk Habitat Use and Home Ranges in Shirley Basin, Wyoming

2025 Annual Report

Principle Investigators:
Zach Wallace – Wyoming Game and Fish Department (WGFD)
Bryan Bedrosian, Julie Polasik – Teton Raptor Center (TRC)

Key Collaborators:
Mary Read, Michael Stangl, Alfred Baldenweck – Bureau of Land Management (BLM)

Funding Provided by Bureau of Land Management, Wyoming Governor's Big-game License Coalition, Wyoming Game and Fish Department, and Teton Raptor Center. We are grateful to the many landowners and operators that allowed access for this project.

Introduction

The Ferruginous Hawk (*Buteo regalis*) is a raptor of conservation concern with habitat that strongly overlaps the prime areas for development of energy resources in the Western U.S. Ferruginous Hawks are sensitive to disturbance while nesting and face disproportionate risk of mortality from human-caused factors. As such, Ferruginous Hawks are the focus of widespread conservation attention (Wyoming Game and Fish Species of Greatest Conservation Need, USFS Region 2 Sensitive Species, Wyoming BLM Sensitive Species) and substantial industrial compliance efforts. Although Golden Eagles (*Aquila chrysaetos*) have been the focus of most research and mitigation effort for wind energy development, Ferruginous Hawks have a similar life history, habitat, and behaviors that make their populations equally vulnerable. The habitat of Ferruginous Hawks in Wyoming is currently experiencing a boom in wind energy development. For example, in the Shirley Basin of central Wyoming at least 10 proposed projects would more than triple the current operating capacity within an area that has been identified as exceptionally high-quality habitat for Ferruginous Hawks and other raptors. While recent research has focused on potential negative effects of oil and gas development on Ferruginous Hawks, the two available peer-reviewed studies on the effects of wind energy development on this species found negative impacts to nest success, and survival of adults and fledglings. In the midst of a rapid expansion of wind energy development in Wyoming, researchers and managers still have time to collect data on Ferruginous Hawks to inform strategies for avoidance and minimization of negative impacts from development.

In 2025, we initiated a research project to determine the response of Ferruginous Hawks to wind energy development and inform science-based minimization measures using GPS telemetry. Our goals are to study the fine-scale movement patterns, habitat-selection, and space use of this species in southeastern Wyoming, with a focus on areas of wind energy development in the Shirley and Laramie Basins. These data are directly comparable to our study in western Wyoming located in and near conventional gas development and collaborator studies in northeastern and south-central Wyoming. Our objectives are to help gather data to inform science-based management in southern Wyoming while contributing to additional state, regional, and national studies for this species.

Analyses of fine-scale movement data for Ferruginous Hawks in areas of wind energy development will allow us to assess potential avoidance of turbines, changes in space-use and habitat-selection during and after development, define mean home range sizes to inform protection buffers, and create maps of habitat conditions associated with low-altitude flight behavior likely to place hawks in the path of turbine blades. These results will be useful to maximize conservation benefits to raptors in both broad-scale siting of wind energy developments and project-level siting of turbines within developments. In addition to these research outcomes, our study will provide basic information on space use of Ferruginous Hawks in undisturbed habitats and wind energy developments (e.g., size and shape of core areas and home ranges) that are essential for managers to evaluate currently recommended time-limiting stipulations and NSOs (i.e., nest buffers) intended to minimize disturbance to nesting raptors. Additionally, we will share data with collaborators working on a decision support mapping tool for raptors (raptormapper.com, TRC) and a graduate student working on a range-wide analysis of Ferruginous Hawk movements (Libby Mojica, Colorado State University).

Methods

Ferruginous Hawk nest location and status information was collected on the ground by Rawlins BLM field office biologists, WGFD databases, and during one aerial, fixed-wing survey by Z. Wallace in the spring of 2025. Active nests were mapped and assessed for ownership and potential access. Project PIs and collaborators worked with private landowners for access to active nests for capture attempts.

We captured adult hawks to outfit them with a backpack-style GPS-GSM, solar-powered transmitter when the chicks were at least 10d old. In 2025, we attempted captures between 4 June – 12 June. We targeted nests in close proximity to wind energy facilities. Captures were completed by using an elevated, remote-controlled Great Horned Owl mount with elevated dho-gaza nets. Traps were continually monitored from a blind ~20m away and captured hawks were extracted from nets immediately and hooded to reduce stress.

We banded all captured hawks, drew blood for DNA storage, measured morphometric data, and outfitted them with transmitters. Transmitters were affixed with a Teflon ribbon harness with elastic in the straps and breakaway stitching where the four harness straps connect in the front. Transmitters were manufactured by Ornitella (Lithuania) and were either a 20g model with elevated solar panel or a 15g model with flush solar panel. Transmitters had variable GPS collection cycles, largely depending on solar charging and season, but typically collected location data at 15-minute intervals during daylight hours, during the breeding season.

Movement data were collated in Movebank and we monitored movements and survival of hawks daily. Breeding season timing was determined by verifying location data visually and ending the season when regular continuous movements away from the nesting area occurred. We calculated breeding season home ranges as 95% Autocorrelated Kernel Density Estimates (AKDEs) using the ctmm package in R.

Results

We captured and tagged 10 adult, Ferruginous Hawks in May 2025, including five male and five female hawks, all from different breeding territories (Table 1). Since deployment, we have collected >239,000 GPS locations from tagged individuals, with an average of 23,897 locations/individual (range 14,189 – 31,263). Due to the large number of locations collected, we resampled locations to 1 per hour for estimating home ranges (Figure 1). The average breeding season 95% AKDE home range size across the 10 individuals in 2025 was 12.04 km^2 (SD ±13.68 km^2) and ranged from 1.77 km^2 – 40.77 km^2 (Table 2, Figure 2). The average male home range size of 14.44 km^2 (± 17.06 km^2) was larger than the average female home range size of 9.65 km^2 (± 10.76 km^2). The percent of each 95% AKDE home range that fell within a 1-mile radius buffer of the nest locations ranged from 19% to 99% by individual (Table 2).

Typical for this species, some individuals exhibited widespread post-breeding nomadic movements to the west, north, and east (Figure 3). Hawks moved to winter ranges as early as August but most began migrations in September (Figure 4). Individuals showed variation in winter ranges, with two hawks winters in Colorado, two in California, one in Utah, two in New Mexico and one on the New Mexico/Texas border. Winter ranges varied from extremely small (e.g., 2187-24125) to very wide-ranging (e.g., 1218-08028; Fig. 4). Of the 2025 sample, males did tend to migrate to more distant winter ranges.

As of the end of 2025, 8 of 10 hawks were confirmed alive, while one was dead and one was unknown. A male died in the central valley of California in November, approximately two weeks after completing its fall migration. A local agency biologist went to investigate localized movements and found an agricultural field with dozens of raptors hunting and perching but did not locate our marked Ferruginous Hawk. After another week, we concluded the hawk must be dead based on lack of movements and the local biologist was able to obtain permission to retrieve the bird about 1.5 weeks later. The hawk was sent in for necropsy but was too desiccated for any diagnosis about cause-of-death. The transmitter was recovered for re-deployment in 2026. The transmitter of a female that went to Canada in late August has failed to send any points shortly after entering Canada. It is unknown at this time if there are issues with GSM connectivity in Canada, the transmitter failed, or the hawk is dead.

Table 3. Information on 10 Ferruginous Hawks tagged in Wyoming, 2025. Table shows individual ID, sex, start and end dates and number of days used to calculate breeding season home ranges (Table 2).

Individual	Sex	Start Date	End Date	Number of Days
2187-24124	Male	10-Jun	11-Aug	62
2187-01100	Male	12-Jun	29-Aug	79
2187-24123	Male	5-Jun	27-Aug	83
1218-08028	Female	4-Jun	3-Aug	60
1218-08031	Female	12-Jun	16-Aug	65
2187-24122	Male	5-Jun	25-Aug	82
1218-08027	Female	11-Jun	7-Aug	58
2187-24125	Male	10-Jun	28-Jul	48
1218-08029	Female	11-Jun	31-Jul	50
1218-08030	Female	12-Jun	19-Aug	68

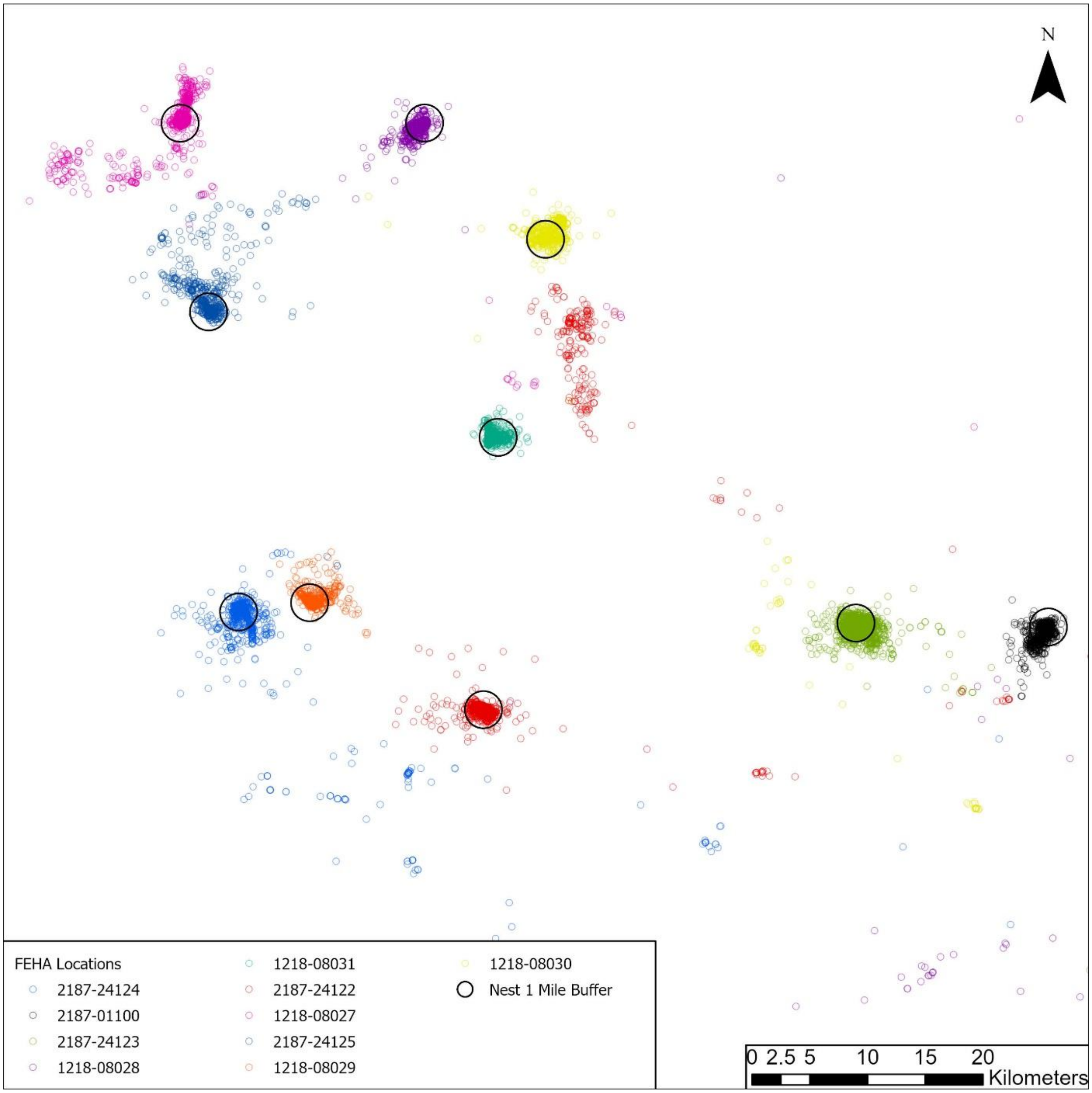


Figure 17. Ferruginous Hawk locations from GPS telemetry for 10 individuals during the 2025 breeding season in Wyoming, resampled to 1 location per hour. One mile radius nest buffers are shown as black circles.

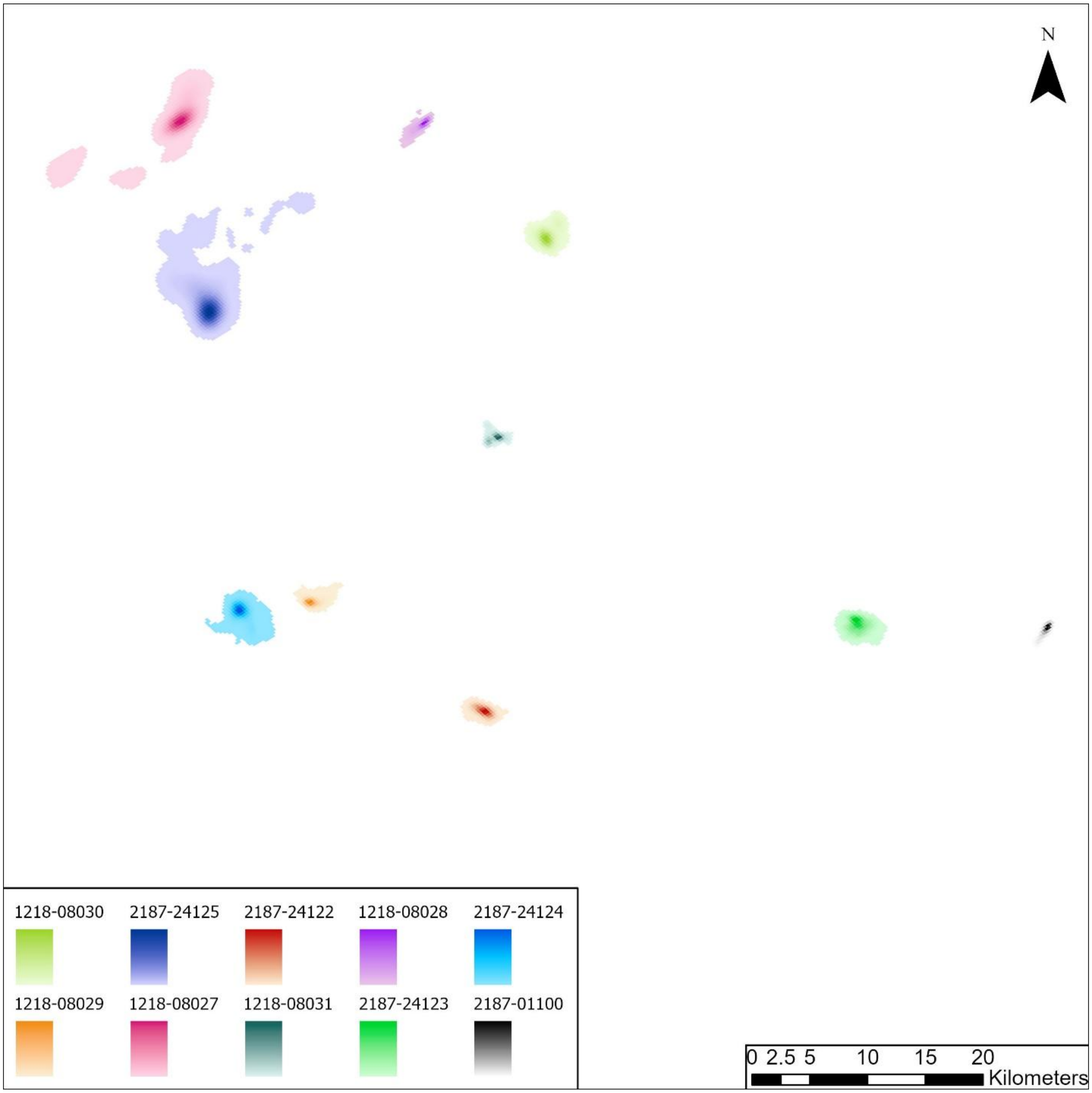


Figure 2. Breeding season 95% Autocorrelated Kernal Density (AKDE) Home Range estimates for 10 Ferruginous Hawks in Wyoming, 2025.

Table 4. Breeding season home range Autocorrelated Kernal Density Estimates (AKDEs) in km^2 for 10 Ferruginous Hawks with 95% AKDEs and Confidence Intervals (CIs), percent of 95% AKDE within 1 mile nest buffer, 75% AKDEs, 50% AKDEs, and area Degrees of Freedom (DOF).

Individual	Sex	95% AKDE (km^2)	95% CI	Percent of 95% AKDE within 1 mile nest buffer	75% AKDE (km^2)	50% AKDE (km^2)	areaDOF
2187-24124	M	12.91	(11.97, 13.88)	56%	2.56	0.88	697
2187-01100	M	2.08	(1.77, 2.40)	84%	0.65	0.24	164
2187-24123	M	8.06	(7.60, 8.54)	82%	2.90	1.34	1128
1218-08028	F	3.41	(2.81, 4.07)	80%	1.08	0.39	113
1218-08031	F	2.94	(2.72, 3.18)	98%	0.98	0.39	641
2187-24122	M	5.06	(4.80, 5.33)	99%	1.27	0.57	1371
1218-08027	F	28.55	(25.15, 32.16)	27%	5.97	2.25	255
2187-24125	M	44.11	(40.77, 47.58)	19%	7.71	2.71	644
1218-08029	F	5.14	(4.78, 5.52)	85%	1.22	0.42	744
1218-08030	F	8.20	(7.26, 9.21)	83%	3.36	1.25	271

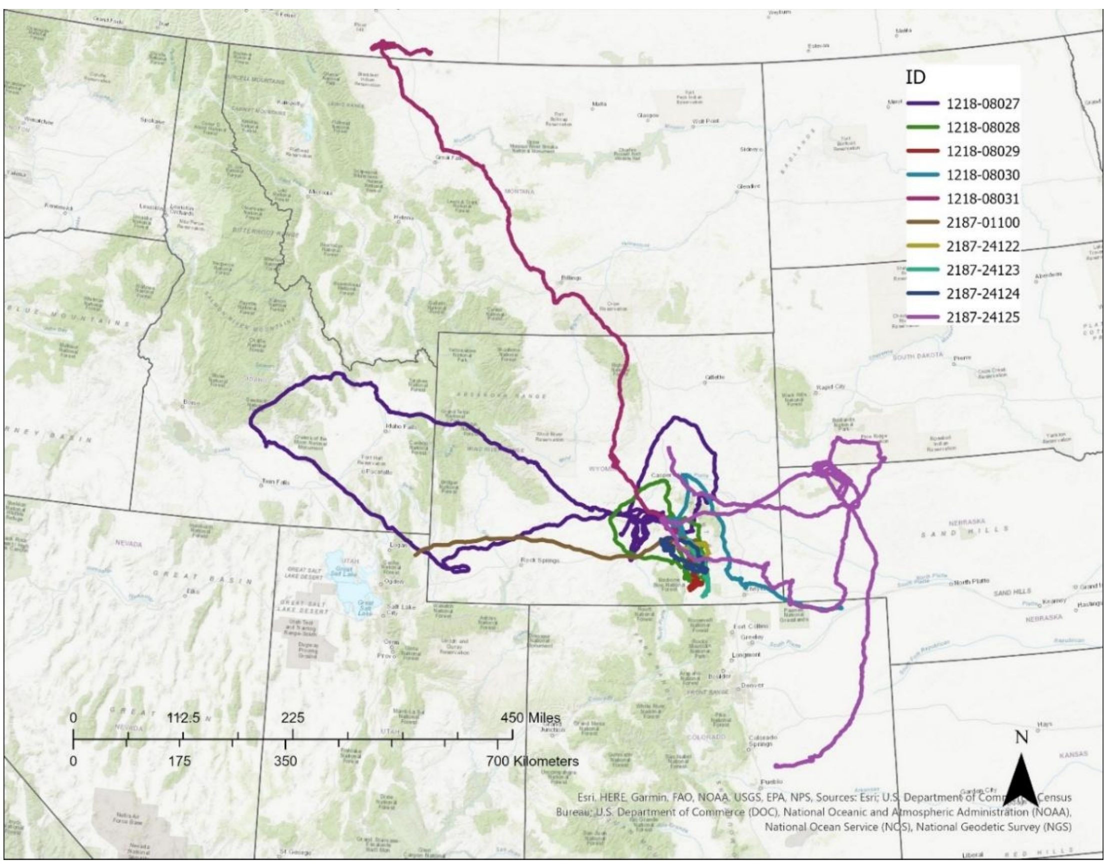


Figure 3. 2025 post-breeding movements (August) of Ferruginous Hawks breeding in southeastern Wyoming. Female IDs begin with 1218 and male IDs begin with 2187.

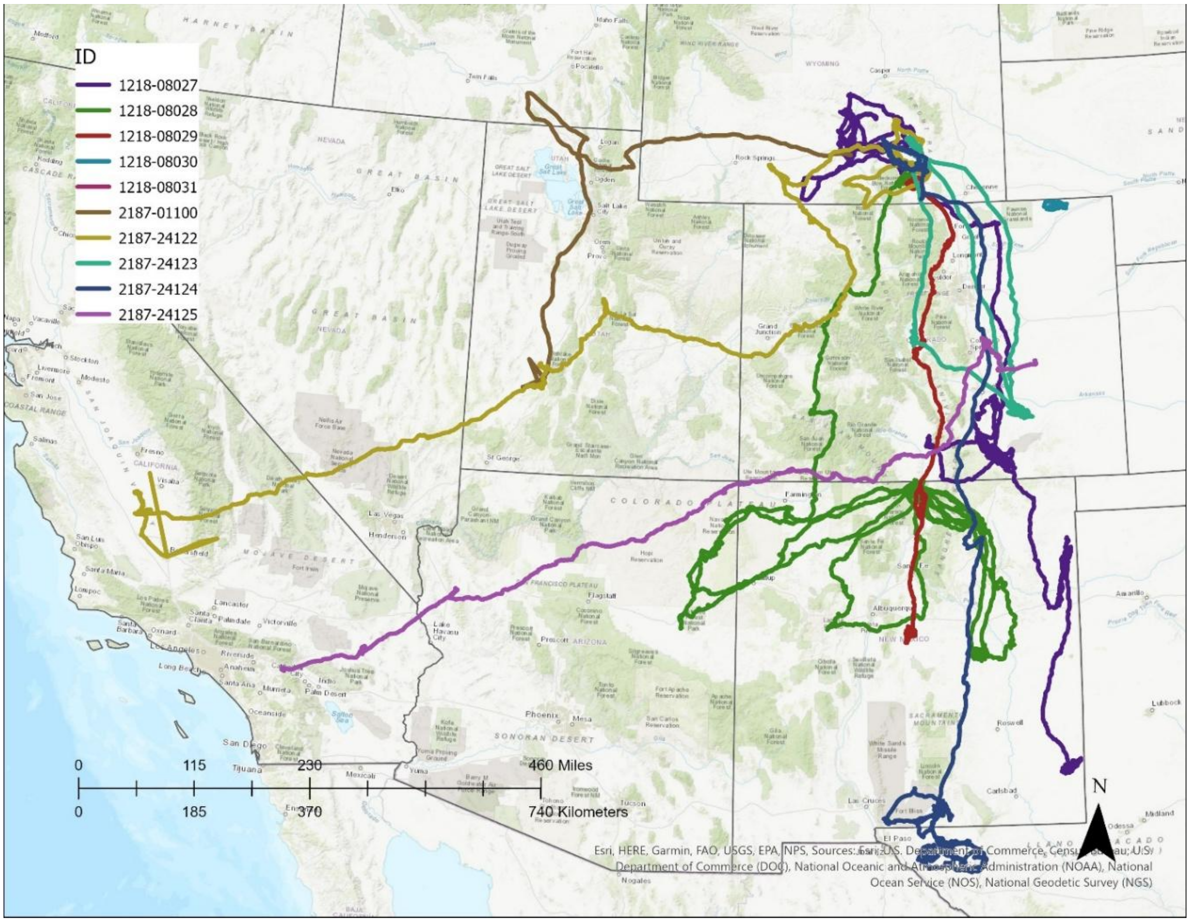


Figure 4. 2025 Migration and winter movements (Sept - Dec) of Ferruginous Hawks breeding in southeastern Wyoming. Female IDs begin with 1218 and male IDs begin with 2187.

Discussion

Breeding home range sizes across the tagged Ferruginous Hawks varied from less than 2 km^2 up to 40 km^2, with 7 out of 10 individuals having home ranges less than 10 km^2. Only one female hawk had a home range size over 10 km^2, while two of the male hawks had home ranges over 10 km^2. A recent study in western Wyoming (Ramirez et al. in review) found mean AKDE home ranges for nesting Ferruginous Hawks that were slightly larger, but similar home ranges compared to what we estimated in Shirley Basin this year. They found a mean 95% ADKE home range during the breeding season of 11.36 km^2 for nesting females (n = 11) and 25.67 km^2 for males (n = 10) and males. They also found patterns of increasing home range size for non-breeding hawks, particularly in males whose mean increased to 58.09 km^2. Their study was focused adjacent to large natural gas development (Jonah Field) and found that larger home range sizes were positively correlated with the number of producing gas wells and negatively correlated with barren ground cover within the 95% AKDE. Conversely, nearly all hawks had core areas (50% AKDEs) that contained no producing wells.

Our mean 50% AKDE was 3.02 km^2 and 2.52 km^2 for males and females, respectively. Opposite the 95% AKDE, our 50% AKDEs were slightly larger than hawks in western Wyoming (2.75 and 1.03 km^2). The most notable limitation to any of our estimates of home range is that we only tracked hawks for a limited amount of time after chicks were ca. 3 weeks old. This likely inflates home range estimates because male and female foraging generally increases with chick age and fledging.

We did track one male with an exceptionally large home range for a hawk with an active nest. This male was nesting in what appeared to be a previous Golden Eagle nest. The nest was located in a Douglas Fir at the top of an area with rough terrain and not adjacent to typical Ferruginous Hawk foraging habitat. While it is currently unclear if this association was a driver of the large home range, this male likely had to travel greater distances to access prairie dog colonies at lower elevations. The other hawk with a large home range was also on the northern end of our study area (BLM North Female). It is notable that these two hawks were the only birds tagged in areas devoid of current development. We plan to address these and other questions related to development in home ranges in planned data analyses.

Recommendations by the U.S. Fish and Wildlife Service Wyoming Ecological Services Field Office and WGFD for Ferruginous Hawk nest protections are 1-mile no surface occupancy (NSO) between March 15 – July 31. Bureau of Land Management NSO buffers apply to year-round permanent disturbance. A 1-mile buffer around a nest equates to an 8.14-km^2 circle. While data in this report are not complete nor conclusive, the preliminary data indicate that the circular equivalent of the mean 95% AKDE in the Shirley Basin would equal 1.24 miles (up to 2.33 miles). The radius of a circular equivalent of the mean 75% and 50% AKDE would be 0.58 and 0.36 miles, respectively. Based on our preliminary data, an average of 71% (range = 19 – 99%) of the 95% AKDE home ranges for Ferruginous Hawks occurred within 1-mile nest radius buffers. Most hawks (n = 7) had their full home ranges encompassed within the 1-mile buffer, but there was a wide range from a few individuals (described above). We expect the breeding home ranges from this first year of our study to underestimate average sizes because all of our data were from hawks captured and tagged at successful nests with hatched chicks, and thus did not include any individuals that did not initiate nesting or had failed nesting attempts, both of which are known to result in larger home ranges. We will continue to update home range sizes annually as we collect more data.

As is typical with Ferruginous Hawks, breeding adults left territories in August and started late-summer movements that are often directed northward. Several hawks engaged in these wide-ranging late summer movements before beginning their typical fall migration to discrete winter ranges (Figure 3). One individual moved into Canada, which has been seen by other hawks from Wyoming (B. Bedrosian, TRC, unpubl. data) but this individual's tag stopped reporting shortly after entering Canada and the ultimate status and wintering range of this bird is unknown. Ferruginous Hawks from Shirley Basin wintered in a variety of locales across the southwestern US, ranging from Colorado to California (Figure 4). Some individuals used a single winter range, while others used a series of discrete winter ranges. Although winter movements and home ranges are not the focus of this study, we will investigate these aspects as part of a separate and later analysis.

In 2026, we plan to continue monitoring the movements of these individuals in the future as well as tagging approximately 15 additional Ferruginous Hawks in the Shirley Basin region and other areas of Wyoming to understand how their home ranges and movements are influenced by wind energy development.

Ferruginous Hawk habitat use and nest productivity in the NPL Natural Gas Development Field

2025 Annual Report

WGFD Permit 33-1232

Cooperators:

Sarah Ramirez, USGS

Dale Woolwine, Theresa Gulbrandson, Mark Thonoff; BLM-Pinedale Field Office

Study personnel: Bryan Bedrosian, Hilary Turner, Adrian Rouse, Anna Wolke, and Addie Wichman

Background and Introduction

Ferruginous Hawks are a Wyoming state sensitive species that can react negatively to ground-related disturbance, experiencing lowered reproduction rates or abandoning their nests. However, there is some evidence to suggest that by providing tall nesting platforms correctly placed within existing territories, the hawks will increase chances of nest success through nesting on the elevated platforms, creating a vertical buffer between the nest and disturbance. To date, only one study has investigated the potential success of using nesting platforms as a mitigation tool. The study noted that incorrectly placed platforms may significantly hinder hawk populations through increased adult mortality or lower long-term occupancy if platforms were not maintained. The study urged caution about using this technique as a mitigation tool until more data are gathered on correct placement and post-fledging survival. To maximize the success of platform use, we have modeled the home range and habitat of currently nesting Ferruginous Hawks to inform correct placement of these platforms.

The Normally Pressured Lance (NPL) natural gas development field is in the beginning phases of development in western Wyoming where an existing population of Ferruginous Hawks nest. From 2020-2023, Sarah Ramirez was utilizing this study to develop her MS thesis with Colorado State University, under the direction of Dr. Liba Pejchar. Sarah successfully defended her thesis in 2024 and has developed several manuscripts, including one that was published in 2025 (Ramirez et al. 2025) and others that are currently in review. As part of this collaboration, we collectively monitored nests across the study area from 2018-2021 and installed nesting platforms in existing territories in 2022. Utilizing nesting and habitat use data from tagged birds, we developed a Resource Selection Function (RSF) model for nesting Ferruginous Hawks in the region to inform correct platform placement that maximizes nest distance to future disturbance in currently selected-for habitat.

We have been continuing the project and data collection under TRC since 2023, with plans to continue and expand this project as development happens across NPL in the coming years.

Results

In 2025, we surveyed nests from the ground to monitor nest productivity in the NPL Natural Gas Development Field. Ground surveys were conducted on May 12 and 13, 2025. We monitored fifty-eight nests in May, and we followed up by conducting a second ground check of active nests late in the season (June 19, 2025) to determine productivity (Table 1).

We observed 12 occupied Ferruginous Hawk territories during our May 2025 ground survey (Figure 1). Of those 12 territories, 10 were confirmed to be successful with follow-up ground monitoring in June. Active nests produced an average of 2.9 young per nest in 2025 (Table 1). We banded 12 nestlings in platform nests on June 19, 2025 for future identification.

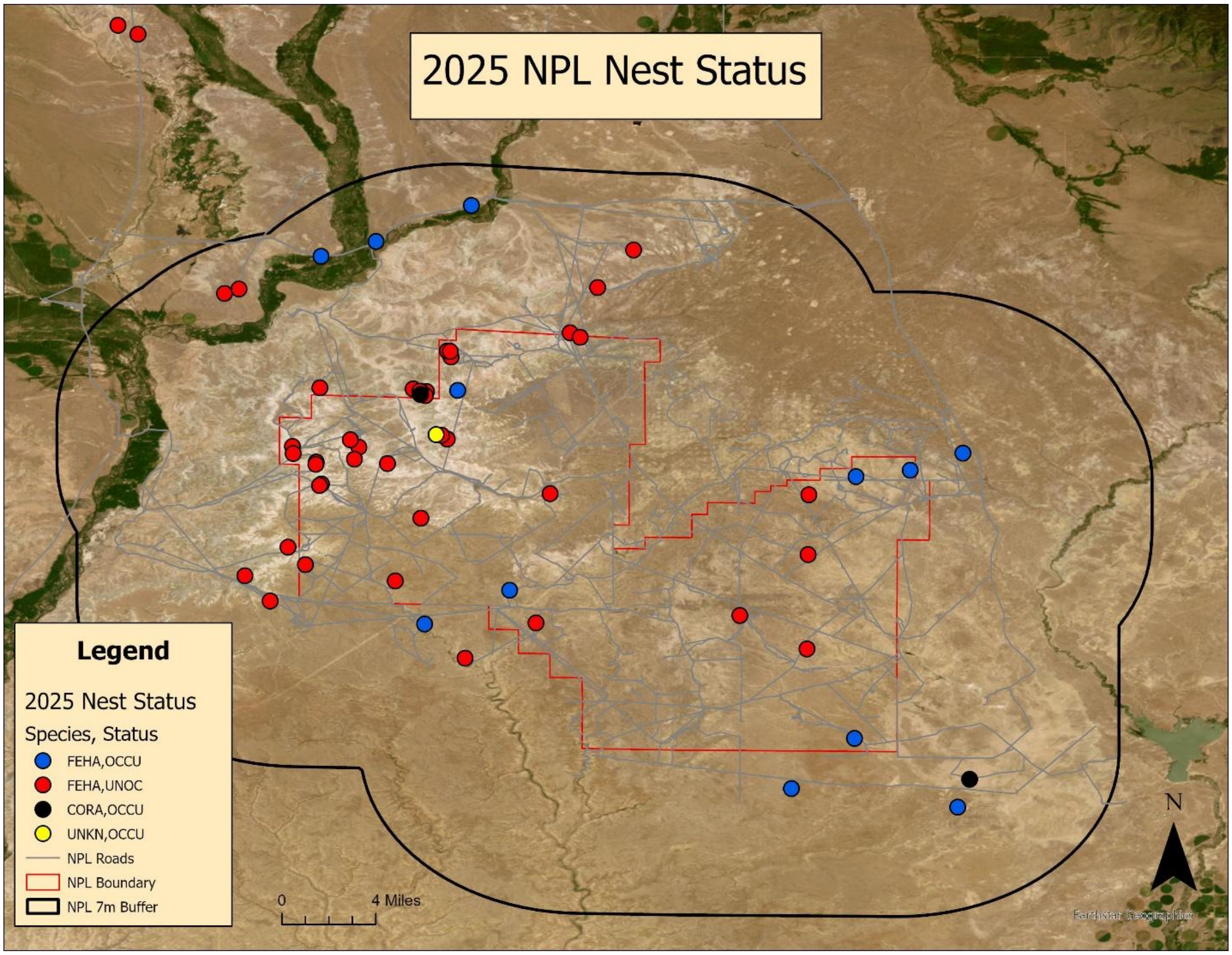


Figure 18. Nest status for all known nests in the NPL study area in 2025.

Table 5. Active Ferruginous Hawk nests in the NPL study area and their outcomes in 2025.

Territory	Status	Outcome	Number of Young	Lat	Long
Powerline Platform	Active	Successful	3	42.34305	-109.899
Oregon Trail	Active	Successful	4	42.2419	-109.673
Puerto Rico 2024	Active	Successful	2	42.23052	-109.571
Water Well	Active	Successful	4	42.27271	-109.634
Platform A	Active	Successful	4	42.43371	-109.633
Platform B	Active	Successful	3	42.43761	-109.6
Platform C	Active	Successful	1	42.44812	-109.568
Hwy 351 Platform North	Active	Successful	3	42.60061	-109.87
Hwy 351 Platform	Active	Successful	3	42.56938	-109.963
Nowhere Platform	Active	Successful	2	42.48671	-109.879
Pipeline Platform	Occupied			42.36383	-109.847
FEHA 47 Platform	Active	Unknown		42.5785	-109.929

2018 – 2025 Summary

Nest productivity information on active Ferruginous Hawk nests in and near the NPL study area was gathered from 2018 – 2025 (Figure 2); however, the amount of effort spent monitoring nests varied by year. We have observed as many as 20 occupied territories when enough ground surveys were being conducted to locate territorial pairs that did not have an active nest (aerial surveys cannot accurately assess occupied, inactive territories). The number of active Ferruginous Hawk nests documented from 2018 to 2025 ranged from 7 - 15 (mean = 11.1; Figure 3). Study years 2020-21 and 2023-24 had a high number of active nests. It is notable that lagomorph numbers have been notably increasing in the past two years. We gathered productivity data on 11 occupied Ferruginous Hawk nests in 2025. Of these, all nests were successful except one, in which the hawks never laid eggs, but they did build a robust new nest. Interestingly, all active nests in and around the NPL study area were on platforms or manmade structures. All natural nests we monitored from the ground were empty and no birds were seen on those territories. More details on productivity and habitat selection can be found in Ramirez (2024).

Location data was obtained from a total of 15 Ferruginous Hawks that we deployed transmitters on between 2019 and 2022. Two of these transmitters are still online as of 2025 (Dump male and Platform A female; Figure 4). The location data from the original 15 birds were used in creating an RSF model to predict high quality habitat for Ferruginous Hawks in the NPL Study Area (see Ramirez 2024). Movement data from tagged birds indicated that seasonal movements often involved a north and eastward movement early in the fall before they later move south of their breeding season range (Figure 5). We are sharing those data with USFS Rocky Mountain Research Station for a broader migration and staging area analysis.

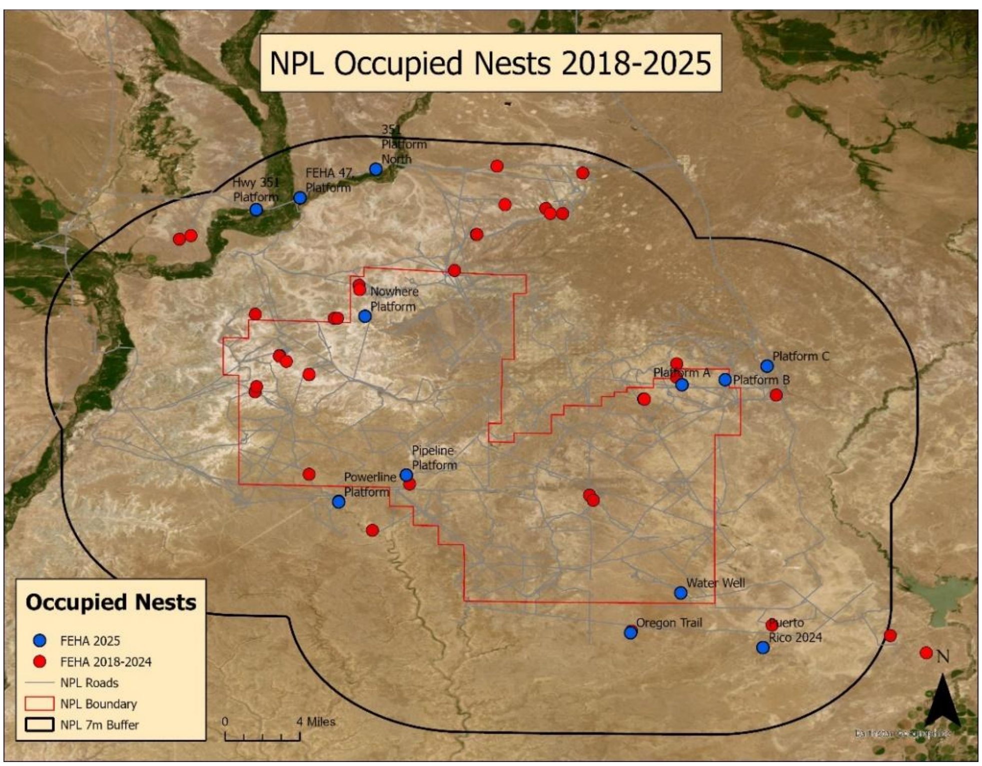


Figure 19. All active Ferruginous Hawk nest locations in the vicinity of the NPL Study Area from 2018-2025.

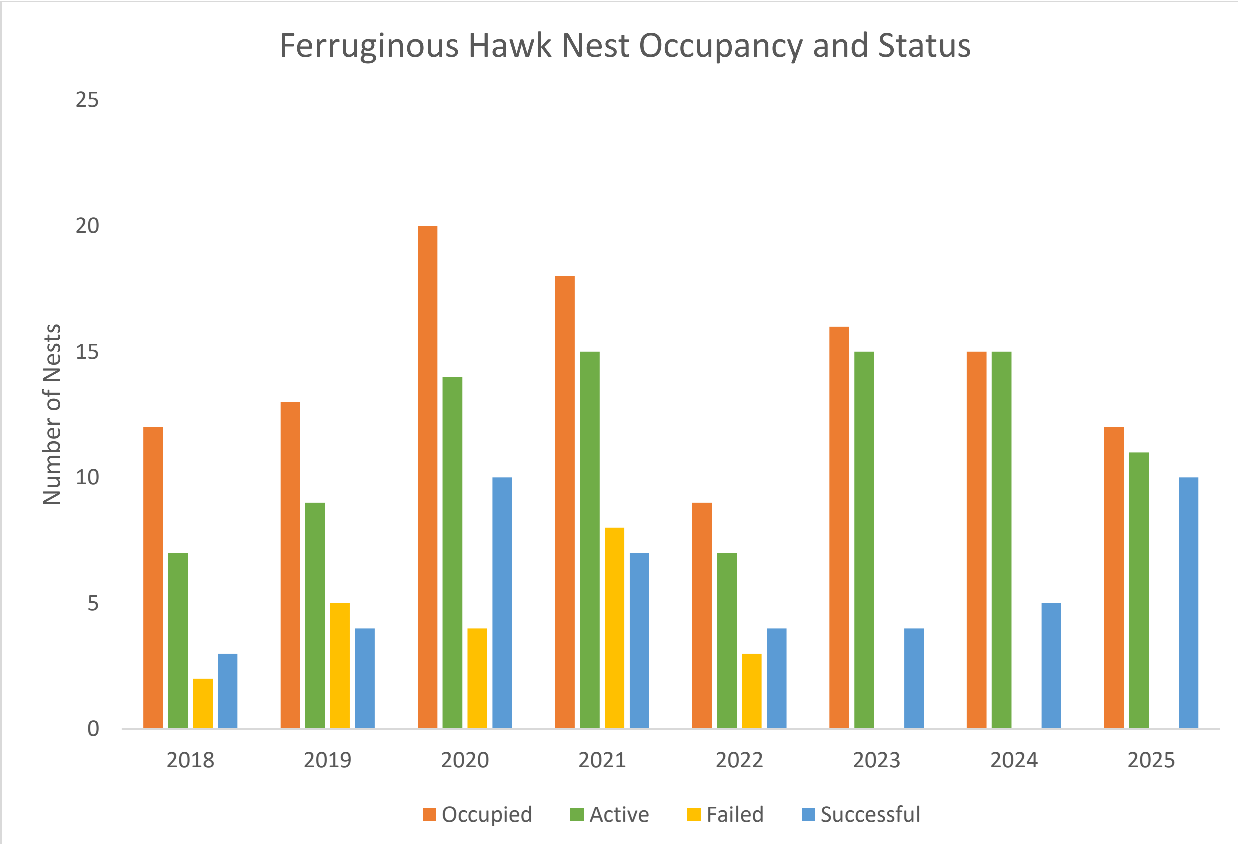


Figure 20. Number of occupied Ferruginous Hawk territories and active nests by year from 2018-2025 with nest success for active nests. Note: ground surveys were not conducted in 2022-24 and occupied territories with inactive nests are likely underrepresented. Productivity is only reported for years with sufficient ground surveys to assess success/failures.

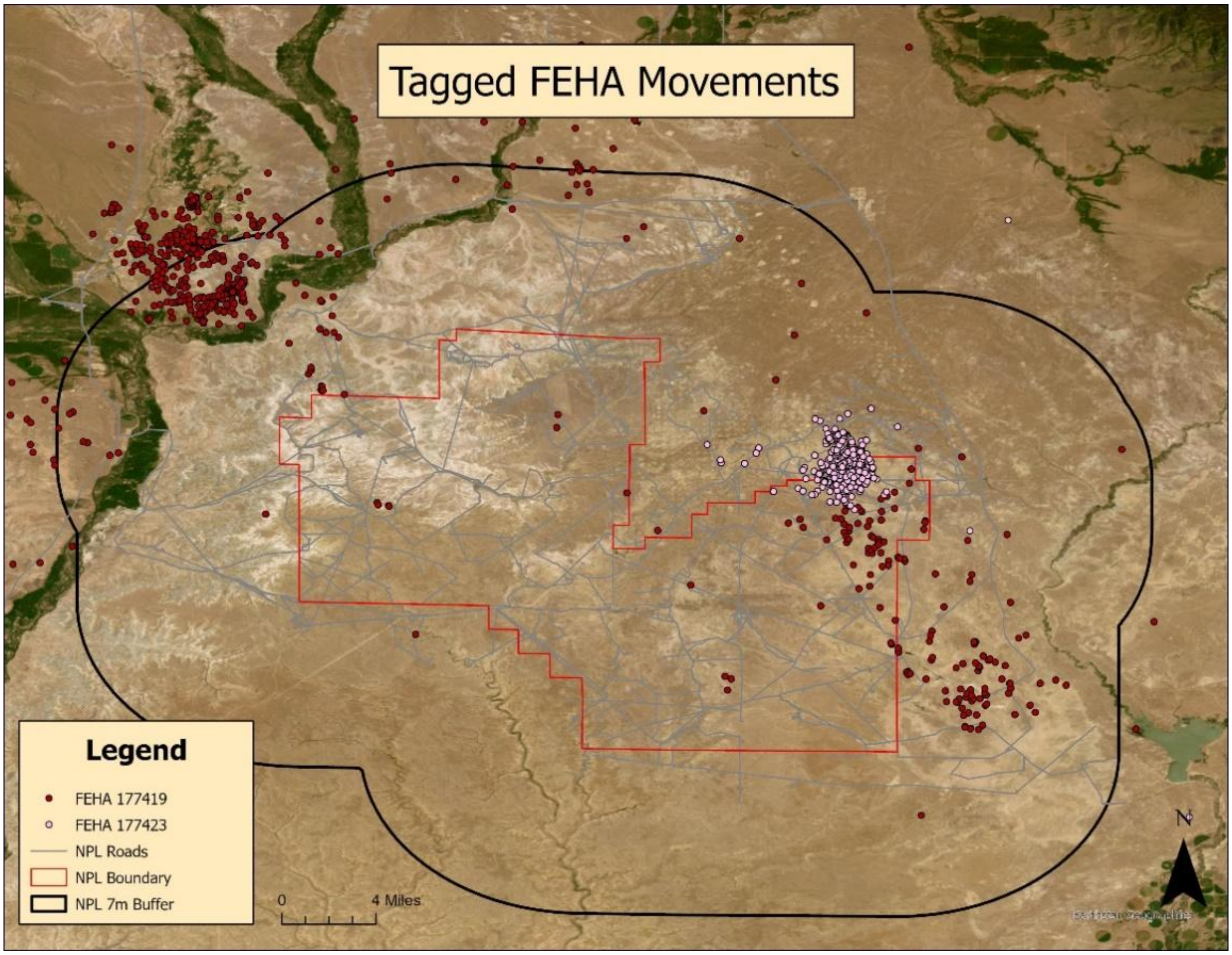


Figure 21. Location data for two tagged Ferruginous Hawks in the NPL Study Area from September 1, 2024 – August 31, 2025.

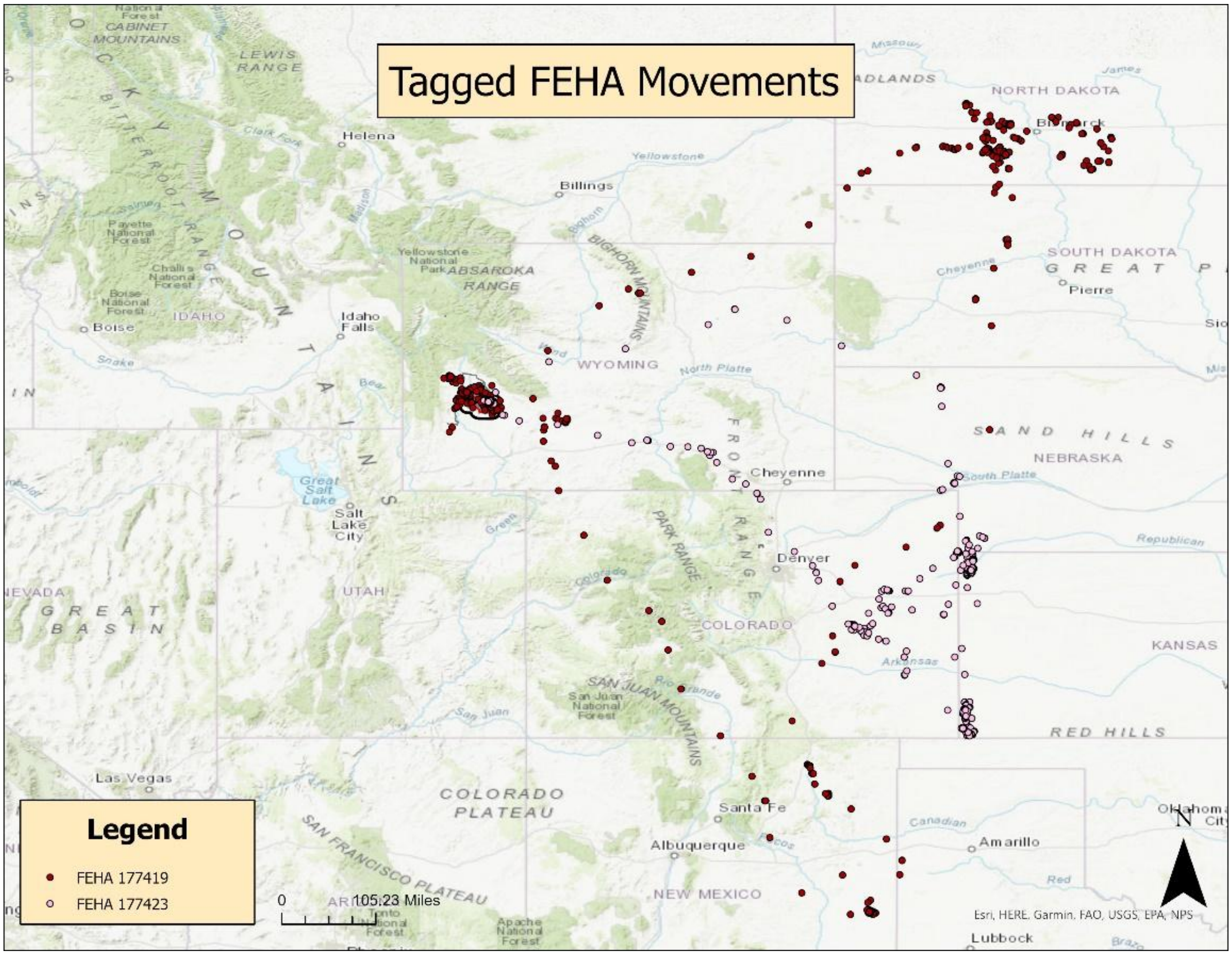


Figure 22. Movement data for two tagged Ferruginous Hawks on a continental scale from September 1, 2024 – August 31, 2025. These Ferrigunous Hawks show an interesting pattern of moving north and east before eventually migrating south in the fall.

Artificial Nesting Platforms

In the fall of 2022, we installed 13 platforms in the NPL study area to provide nesting structures for Ferruginous Hawks (Figure 6). We located nesting platforms within the boundaries of known, occupied territories during the study and were predicted as the best habitat in the RSF model (Figure 7). Specifically, locations were chosen based on buffering nests by half of the nearest neighbor distance (1.9 km) and then placing them closest to the nest but outside of the buffer and within the highest predictive category in the RSF model. Platform locations took into consideration access to the sites for installation while also reducing visual disturbance. All nesting platforms were located outside of Greater Sage-grouse Core and Winter Concentration Areas. We also installed a remote camera at each nesting platform to determine if they become discovered and used by nesting hawks in future years.

In 2023, the spring year following installation, we documented an active nest on one platform. This was a new platform installed adjacent to three platforms that had been installed several decades ago. Based on previous ground survey efforts, we had documented an active territory in this area while the adjacent old platform was also active. In 2023, the pair previously nesting at Platform A (both tagged with transmitters) moved and built a nest on the new platform. The pair was captured on camera and laid an egg (that we observed from our aerial survey), but abandoned that effort and moved back to Platform A. BLM biologists informed us that the camera we have previously placed on Platform A was shot off the platform with many rounds of ammunition sometime in late 2022. We speculate that this and/or other disturbances may have been the impetus for the pair to move, but we do not know why the pair failed after egg laying.

In 2024, we documented use of three additional new platforms. Powerlines Platform was active and that pair produced two fledglings. We did not have a camera placed on that nest in 2024. We did capture use of the Pipelines Platform by a pair of Common Ravens. They built a new nest, which was also investigated by a Ferruginous Hawk. However, the new nest blew off the platform in a windstorm before egg laying and a re-nest was not attempted. Finally, we observed a new nest built on the Alkali platform while conducting aerial surveys, but no hawks were observed incubating.

In 2025, all active Ferruginous Hawk nests on and around the NPL study area were on manmade structures, including nine platforms. Three of the platforms we installed in 2022 were occupied by Ferruginous Hawks this year, although the Pipeline Platform did not produce chicks. A Ferruginous Hawk pair arrived on the territory on March 10 this year and built a robust nest on the platform. The birds were still bringing material to the nest on June 19, 2025, when our team removed the SD card from the camera on that nest (Figure 8). Powerlines and Nowhere Platforms produced 3 and 2 chicks, respectively, and six other platforms throughout the project area were active this year and produced at least one chick. In this low productivity year for natural nests, we find it remarkable that so many platforms were occupied and produced young. Of the active nests this year, we had a 91% nest success rate for fledglings.

To gain a better understanding of long-term nesting and productivity trends and the impact of future development within the NPL study area, we plan to continue to monitor nests within the NPL study area on a yearly basis through annual surveys and remote camera installation at nesting platforms. We will also continue to track the movements of individuals tagged with transmitters, as well as band nestling Ferruginous Hawks for our long-term understanding of the population.

Acknowledgements

2025 funding was provided by Meg and Bert Raynes Wildlife Fund and Teton Raptor Center. Funding for previous years included BLM, Meg and Bert Raynes Wildlife Fund, Colorado State University, The Nature Conservancy, and others.

Literature Cited

Ramirez, S., B. Bedrosian, D. Wooline, and L. Pejchar. 2025. Ferruginous Hawk nest site selection, success, and productivity: Implications for mitigating the effects of natural gas development. Biological Conservation 310:111314 https://doi.org/10.1016/j.biocon.2025.111314

Ramirez, S.K., 2024. Home range estimates, habitat selection, and nesting behavior of Ferruginous Hawks (Buteo regalis) in western Wyoming. Master's Thesis, Colorado State University.

Figure 6. Examples of artificial nesting structures built for Ferruginous Hawks in the NPL area in 2022.

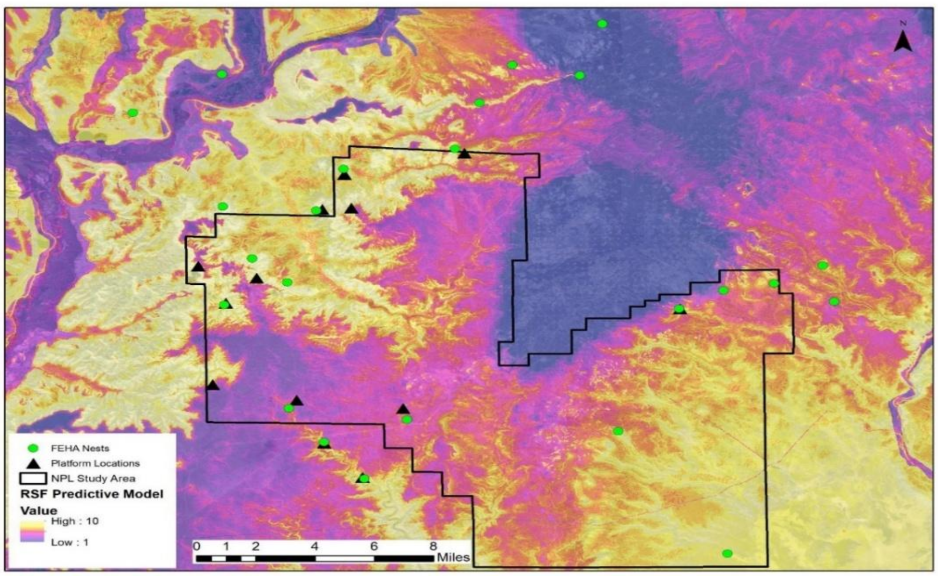


Figure 7. Platform locations based on the RSF model and active Ferruginous Hawk territories.

Figure 8. Our trail camera captured a Ferruginous Hawk arrival at the Pipeline Platform on March 10, 2025. The pair was still adding material to the nest on June 19, 2025, when we replaced the SD card in that camera.

American Goshawk habitat use in the Greater Yellowstone Ecosystem

Territory monitoring via audio recording units and home range analysis

2025 Annual Report

Wyoming Permit 33-1286
GTRE Permit SCI-006
BTNF Permit JAC225202

Study personnel: Bryan Bedrosian, Julie Polasik, Adrian Rouse, Hilary Turner, Anna Wolke, and Addie Wichman

Introduction

Many animal populations are at risk across Wyoming and in the Greater Yellowstone Ecosystem. While agencies are tasked with managing sensitive species, they often lack the resources to adequately understand and manage these animals. American Goshawks (previously known as Northern Goshawks) are an uncommon forest-dwelling raptor currently classified as a Species of Greatest Conservation Need in Wyoming and a sensitive species by the US Forest Service (USFS) because of their reliance on mature, older contiguous forest stands. These habitats are increasingly at risk due to issues such as logging, burning, insect infestations, and climate change. Since the early 1990's, several studies have documented goshawk occupancy declines across the intermountain West (Bechard et al. 2006, Patla 2005). Many factors may be driving these declines including geographical shifts of nesting pairs, weather and climate, prey availability, and changes in forest structure and age.

In and around the Jackson Hole valley, we have been investigating the density and occurrence of breeding goshawks for the past five years with the support of organizations such as the Meg and Bert Raynes Wildlife Fund, the US Forest Service, Teton Conservation District, and private donors. Through these initial efforts, we identified 15 occupied territories within and adjacent to the valley and determined more effective survey techniques to monitor breeding birds (more territories have been located since). Still, we know very little about the population trends, habitat needs, sensitivity to disturbance, and aspects of population dynamics in northwestern Wyoming. For example, we still lack basic knowledge about if this population is migratory or occurs on territories year-round.

Many management actions rely on site visits to document animals, spatial occurrence data, and predictions of occurrence. Following a pilot study tracking one breeding male goshawk in 2019, we developed this movement-based project with the objective of gathering critical movement data from breeding goshawks to understand habitat use, movement patterns, and to create predictive maps of critical habitat. Understanding and being able to predict seasonal habitats in the Greater Yellowstone Ecosystem will help state, federal, and local agency managers sustain these sensitive raptors in Jackson Hole by having a habitat model to help assess current and future changes to critical goshawk habitat.

Methods

We first surveyed previously known territories using Autonomous Recording Units (ARUs) with methodologies we previously developed to determine occupancy (TRC, manuscript in prep) in 2019. This involved placing multiple ARUs within existing territories for ≥6 consecutive days with continuous recording. Following deployment, each territory was searched on the ground several times until a nest was located or we determined that birds were not present (typically with ≥ 3 territory visits). We processed recordings through Kaleidoscope acoustic software with a custom detector we built for goshawks. We considered the territory as "occupied" when at least one goshawk was documented during either site visits or with multiple detections (or pairs) from the ARUs. In 2025 we focused on determining territory occupancy using only the data from ARU deployments and did not follow up with nest searching efforts.

From 2019 – 2024, when an active nest was located, we monitored the nest weekly to document nesting success and timing. In 2020, we started capturing a subset of breeding goshawks once nests had nestlings that were at least 50% of fledging age using a stuffed, mechanical Great Horned Owl lure and dho-gaza nets placed near the nest. We were targeting males to receive transmitters because they are more likely to delineate home ranges and habitat use. In 2021, we also added a method of capturing nesting hawks prior to incubation using a live pigeon and bow-net. We set up a small, mobile blind near (but out-of-sight of) the suspected or known nest when the male was not present, typically pre-dawn.

We then waited to lure the goshawk until the male returned to the nest site. If the female was unintentionally captured, we rapidly banded her and released her without a transmitter and reset for the male. All birds were banded, measured, and extracted a blood sample for DNA banking. For this study, we have used several types of GPS transmitters, including GPS/GSM units from Ecotone and Ornitella and GPS/PTTs from Microwave Telemetry.

Home Range Analysis

To determine breeding season home ranges, we used GPS location data collected on goshawks with transmitters from two different time periods each year, the nesting season (15 April – 10 July) and the post-fledging season (11 July – 15 September). These time frames were chosen based on observations of breeding season activity and average fledging dates observed in our study area. We estimated nesting season home ranges and post-fledging season home ranges for each bird-year using Autocorrelated Kernel Density Estimates ($AKDE_c$) and the ctmm package (R Core Team 2025, Fleming et al. 2015, Calabrese et al. 2016, Fleming and Calabrese 2017). Home ranges were only calculated for instances where variograms of location data indicated enough data were collected for accurately estimating AKDEs (Fleming et al. 2014). We calculated 95% and 50% confidence intervals around AKDE estimates to assess core areas of home ranges. We used an ANOVA test to determine if there were significant differences in home range size by sex and nest outcome, when differences were present, we followed up with a Tukey's HSD post-hoc test.

To model the probability of use for both nesting and post-fledging seasons we used eight covariates: aspect, slope, elevation, distance to water, distance to roads, forest cover 10-49%, forest cover ≥ 50%, and landcover, in a generalized linear model (GLM) to create a resource selection function (RSF; Manley et al. 1993). Elevation, slope and aspect were all derived from 30m Digital Elevation Models (DEMs), while forest cover and landcover covariates were derived from LANDFIRE data (LANDFIRE 2016, USGS 2024). We determined the best model fit for the RSFs using Akaike's Information Criterion (AIC; Burnham and Anderson 2002). For RSF development, goshawk locations were considered used, while random locations within the study area were available locations. We extracted covariate values for used and available locations using the R package terra (Hijmans et al. 2022). We mapped RSF predicative surfaces using the best fit model and for ease of interpretation we binned values based on a probability of habitat use from 0 to 1, with 1 being highest probability of habitat use. We used cross validation to verify the accuracy of the model. Known goshawk nest locations in our study area were also used to verify the results of the RSF nesting model.

We calculated the median 95% AKDE home range estimate size for nesting and post-fledging areas of bird-years where birds nested. We used those median home range size estimates for determining the size of a moving window analysis of RSF predictions. Within each moving window we calculated the average RSF value for nesting and post-fledging habitats. This provided information on surrounding cell values to determine the highest probability habitat within a median home range size for a goshawk in our study area. To determine the overall probability of use across a combination of nesting and post-fledging time periods we added the probability of use values for each that we had generated using the moving window approach and mapped a predictive surface representing overall breeding season probability of use.

Results

From 2019-2025, we have been monitoring goshawk territories for occupancy (Figure 1), and from 2019-2024 for nesting activity (Figure 2). We have monitored between 14 – 23 territories each year, depending on snow conditions, previously known territories and access. Occupancy appears to have dropped from 2022-2024 but increased again in 2025. However, this apparent trend may be more related to the percentage of new territories located each year and limited resources to monitor all the previously known territories. A newly identified territory is inherently occupied, but the movement of birds between territories or distance between alternate nests between years may affect our ability to detect territorial birds.

In 2025 we detected two new goshawk territories, one in a new region of our study area and one found based on the movements of a female tagged with a transmitter that formerly nested on a different territory. We did not actively search for nests or check nests in 2025 therefore we do not provide updated numbers on nest activity and success. In 2025, we also obtained breeding season locations for three previously tagged goshawks and had one transmitter that went down (Table 1). Of the three goshawks we were able to obtain breeding season data for, two of them were females (Beaver Creek, Red Top) and one was a male (Red Top) (Figure 3). The transmitter that went down was a male goshawk (Mosquito) whose remains were recovered. The Beaver Creek female goshawk did not appear to nest in 2025, nor did the Red Top male. However, the Red Top Female moved territories and nested in the Caribou-Targhee Forest of Idaho in 2025.

Similar to previous years, the Beaver Creek female was the only true migrant and moved to her typical wintering area near Salt Lake City, while other tagged goshawks either stayed on territory year-round, or conducted westward movements into Idaho (Figure 4).

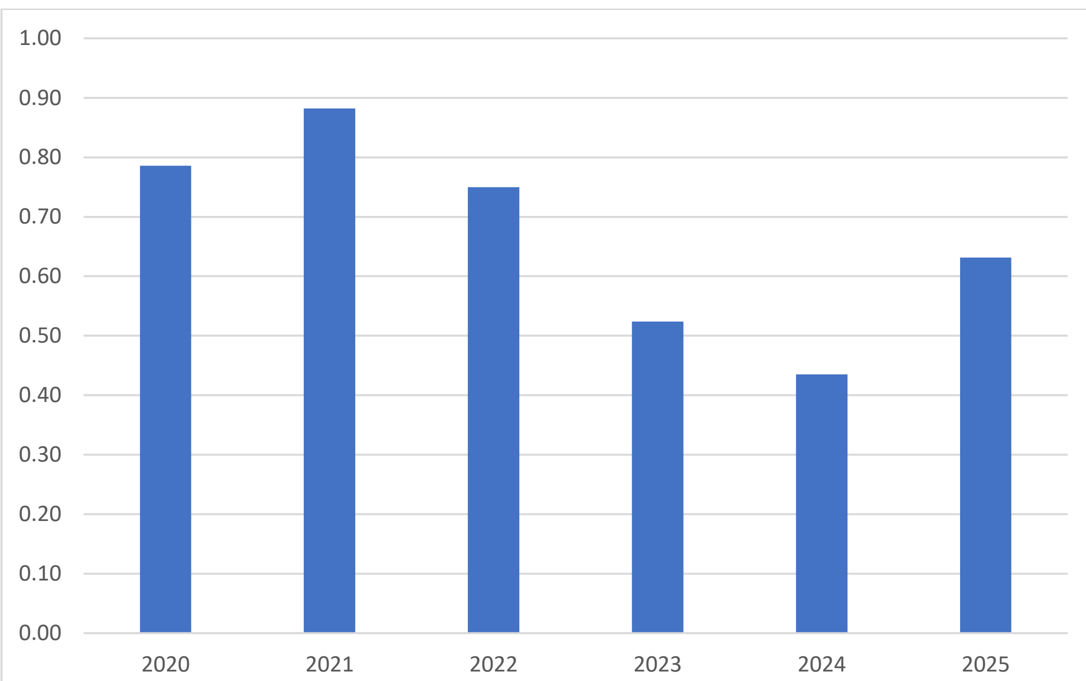


Figure 1. The percent of goshawk territories that were occupied from 2020-2025.

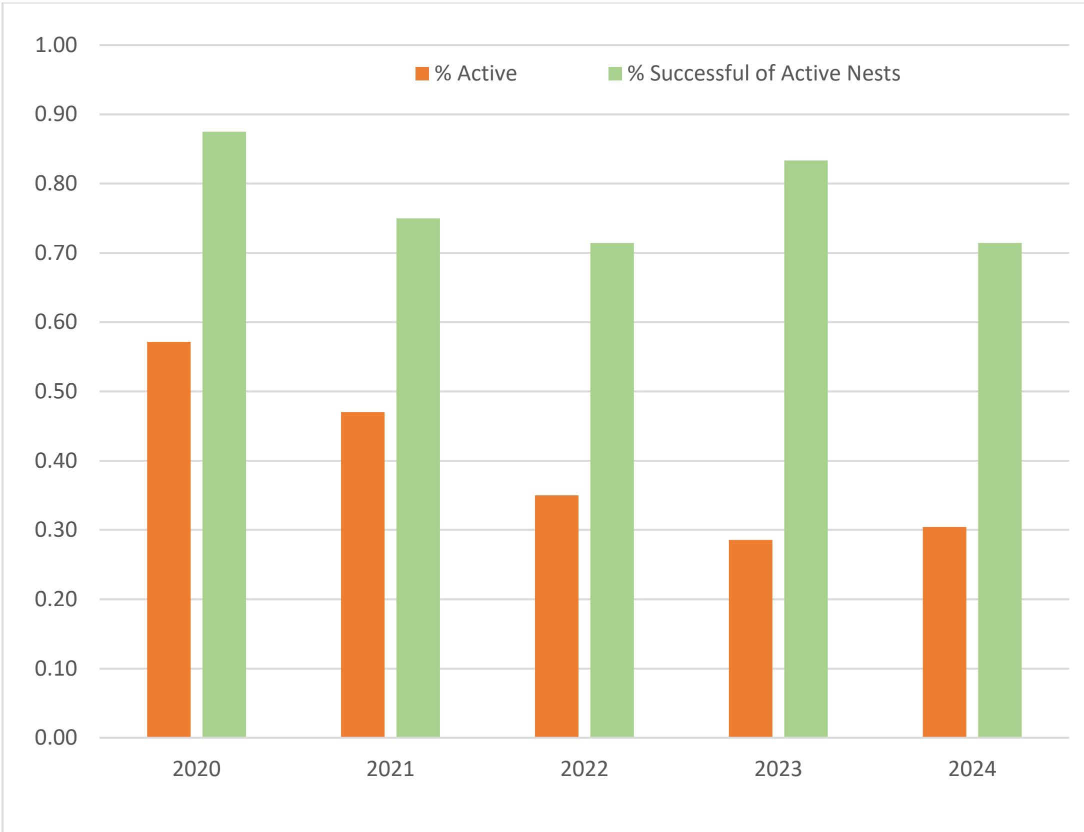


Figure 2. The percent of territories that were active, and the percent of successful nests out of active nests from 2020-2024.

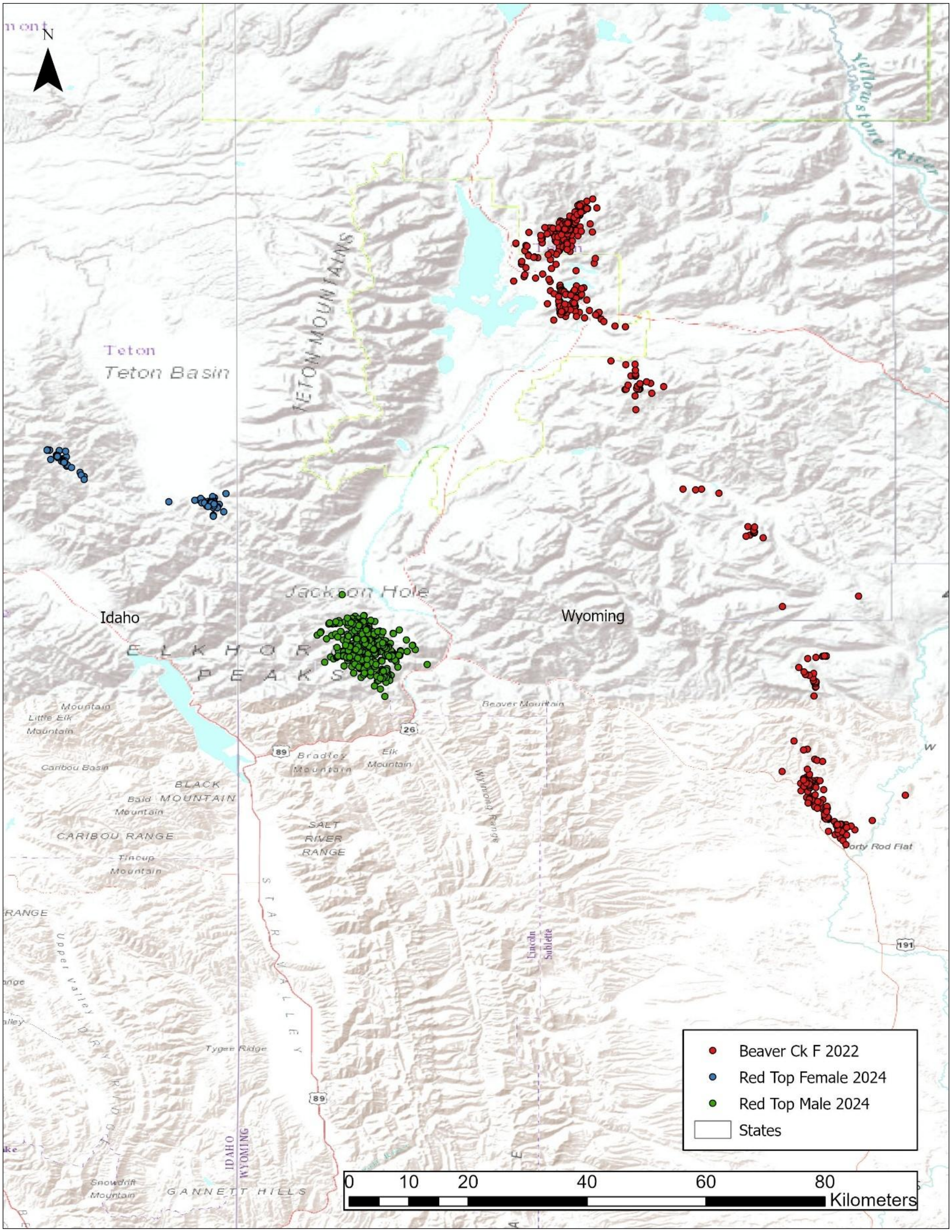


Figure 3. Goshawk locations in the vicinity of Jackson Hole for three individuals with breeding season location data (Late April-early September) in 2025.

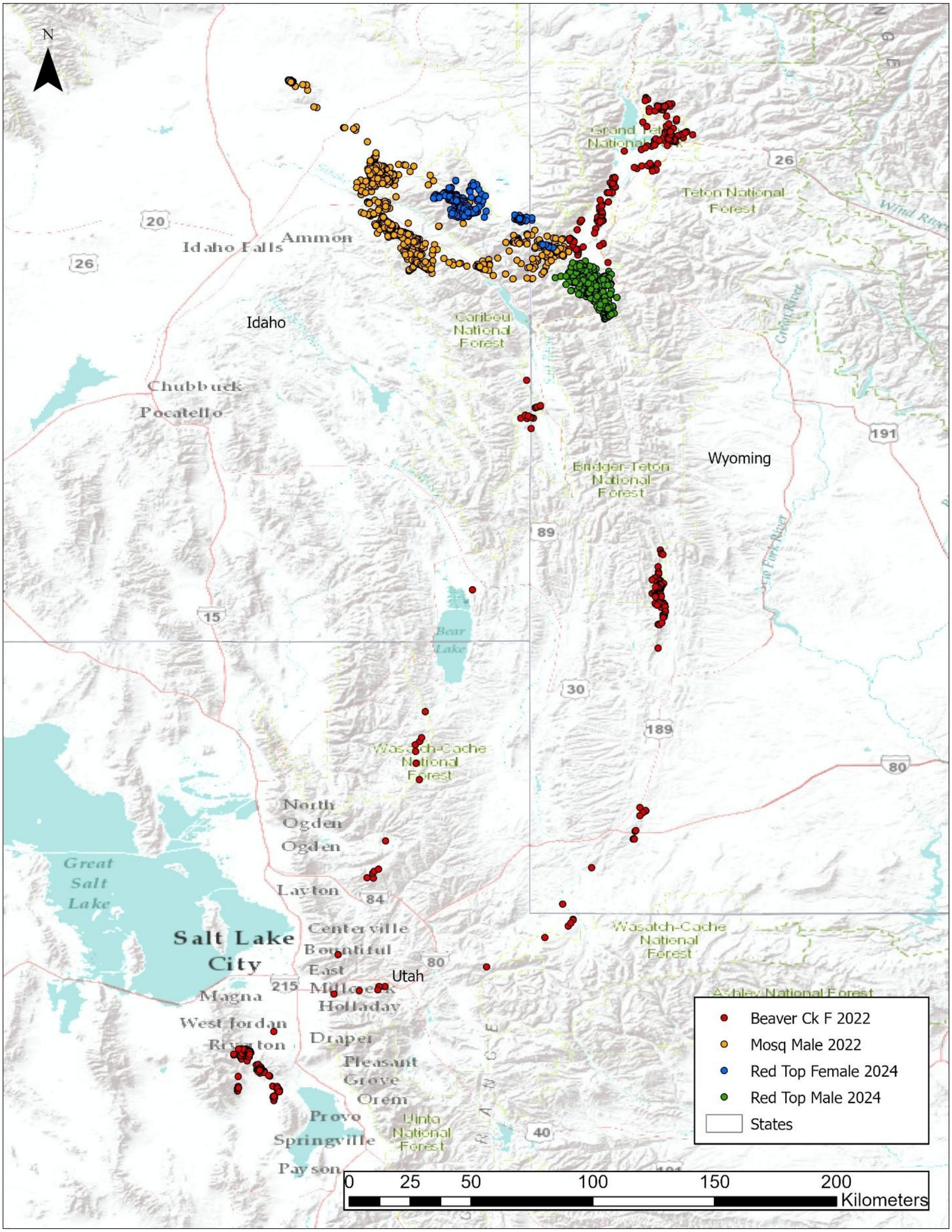


Figure 4. 2024-2025 winter movements of four goshawks tagged in Jackson Hole, Wyoming.

Table 1. Details for goshawks tagged with transmitters in Jackson Hole, Wyoming 2019 – 2025.

Ind	Location	Sex	Year	Nest Status	Migrant Status	Number of Points	Fate	Transmitter Dates
1	Snow King	Male	2019	Successful				
1	Snow King	Male	2020	Successful	Local	1341	Unk	7/11/2019 – 9/2/2020
2	Murie	Male	2020	Successful	Unk	77	Failed Trans	7/1/2020 – 7/10/2020
3	Grandview	Female	2020	Successful	Unk	132	Failed Trans	7/2/2020 – 7/7/2020
4	Beaver Creek	Female	2020	Successful	Local	217	Failed Trans	7/3/2020 – 11/14/2020
5	Beaver Creek	Male	2020	Successful	Long Distance	541	Unk	7/13/2020 – 5/10/2021
18	Beaver Creek	Female	2022	Successful				
18	Beaver Creek	Female	2023	Successful				
18	Beaver Creek (now Signal Mtn)	Female	2024	Successful	Long Distance	7360	Active	6/30/2022 – Current
18	Beaver Creek	Female	2025	Did not nest		1790		
6	Poison	Male	2020	Successful	Unk	49	Failed Trans	6/7/2020 – 6/8/2020
9	Poison	Male	2021	Successful				
9	Poison	Male	2022	Unsuccessful	Local	1573	Predation	4/14/2021 – 4/6/2023
7	Taylor	Male	2020	Successful	Local	510	Unknown	7/9/2020 – 3/5/2021
12	Taylor	Male	2021	Successful				
12	Taylor - Granite	Male	2022	Unknown	Long Distance			
12	Taylor - Granite	Male	2023	Unknown		606	Dropped Trans	6/17/2021 – 6/11/2023
8	Mosquito	Male	2020	Successful	Short Distance	321	Unknown	7/9/2020 – 11/17/2020
17	Mosquito	Male	2022	Successful				
17	Mosquito	Male	2023	Did not nest				
17	Mosquito	Male	2024	Did not nest	Short Distance	9422	Died, possible starvation	6/23/2022 – 3/20/2025
10	South Fall Creek	Male	2021	Unsuccessful	Long Distance	520	Unk	4/20/2021 – 4/19/2022
11	Coal Creek	Male	2021	Successful	Short Distance	193	Car Collision	6/8/2021 – 10/19/2021
20	Coal Creek	Female	2022	Successful	Local	1205	Dropped Trans	7/14/2022 – 11/14/2022
13	Turpin	Male	2021	Successful	Unk	175	Unk	6/22/2021 – 9/30/2021
14	Jackson Peak	Female	2021	Successful	Unk	2	Dropped Trans	7/22/2021 – 7/22/2021
15	Trails End	Female	2022	Unsuccessful	Local	3216	Dropped Trans	4/25/2022 – 1/26/2023
16	Trails End	Male	2022	Unsuccessful				
16	Trails End	Male	2023	Did not nest				
16	Trails End	Male	2024	Unknown	Short Distance	945	Unknown	4/25/2022 – 6/12/2024
19	Mill Creek	Male	2022	Successful	Unk	405	Window Strike	6/30/2022 – 8/15/2022
21	N Fork Fall Creek	Female	2023	Successful				
21	N Fork Fall Creek	Female	2024	Successful	Unk	56	Faulty Trans	8/1/2023 – 8/15/2024
22	Red Top	Male	2024	Unsuccessful	Local	409		
22	Red Top	Male	2025	Unknown		1697	Alive	6/15/2024 – Current
23	Red Top	Female	2024	Unsuccessful	Short Distance	660	Alive	6/15/2024 – Current
23	Red Top - Mike Harris	Female	2025	Successful		1863		

We had sufficient data from 17 American Goshawks (13 males and 4 females), from 2019 – 2024, across 11 different territories, to calculate nesting and post-fledging home ranges. We calculated nesting home ranges across 14 bird-years and post-fledging home ranges across 21 bird-years. Home ranges were calculated across an average of 68 days (range 55-87 days) during the nesting season, and an average of 64 days (range 35-67) days during the post-fledging season based on available data. The average AKDE home range estimate during the nesting season was 94.2 ± 25.9 km^2, with larger home ranges for males (n = 11, 98.8 ± 32.9 km^2) than females (n = 3, 77.0 ± 17.9 km^2; Fig. 5). The average AKDE home range estimate during the post-fledging season was 169.6 ± 66.8 km^2, but in this case male (n = 15, 81.6 ± 16.4 km^2) home ranges were significantly smaller than females (n = 6, 389.6 ± 216.9 km^2, $P < 0.05$; Fig. 6).

Across the 14 bird-years for which we estimated nesting home ranges, four had nests that were successful, four were unsuccessful, three did not nest, and three were of unknown nesting status. Nesting home range estimates were smaller on average ($P = 0.17$) for birds with successful nest territories (58.9 km^2) compared to territories that did not nest (207 km^2) but were not different between territories that were successful and initiated vs. not successful (61.9 km^2). For the 21 bird-year post-fledging home range estimates, 14 birds had successful nests, five were unsuccessful, and two did not nest. Post-fledging home range sizes were not significantly different by nest outcome.

Resource selection functions (RSF) for both nesting habitat and post-fledging areas were based on the global model that included all eight covariates with elevation as a polynomial in order to utilize the largest amount of data for creating predictive surfaces of probability of use. For the nesting habitat RSF, covariates most influential on probability of use by American Goshawks were forest cover ≥ 50% which increased the odds of use by over six times and forest cover 10-49% which increased the odds of use by three times (Fig. 7). The probability of use also increased with less steep slopes, and mid-elevations were preferred. Cross-validation indicated 0.98 accuracy of the nesting RSF model. Verification of the nesting model with 22 known American Goshawk nest locations in the study area predicted those areas to be a high probability of use (0.8-1 on a 0-1 scale). In the post-fledging habitat RSF, forest cover ≥ 50% increased the odds of use by almost five times, forest cover 10-49% increased the odds by three times, steeper slopes had a reduced probability of use, and mid-elevations had higher probability of use (Fig. 7). Cross-validation indicated an accuracy of 1.0 for the post-fledging RSF model.

The median AKDE home range estimate size of goshawks that nested was 52.6 km^2 during the nesting period and 70.9 km^2 during the post fledging period. We used moving window sizes of 7.25 km x 7.25 km for the nesting period and 8.42 km x 8.42 km for the post-fledging period to represent the median home range sizes. Within each moving window we calculated the average probability of use value for nesting and post-fledging RSFs and mapped those results to show the highest probability of use accounting for median home range sizes (Fig. 8, Fig. 9). For bird-years in which goshawks nested, the average probability of use within home ranges during the nesting period was 0.80 (range 0.70 – 0.94) and during the post-fledging period was 0.76 (range 0.63 – 0.87). We also combined nesting and post-fledging RSF values to create an overall probability of use map during the goshawk breeding season and found that there was a large degree of overlap in high probability of use areas between nesting and post-fledging periods (Fig. 10).

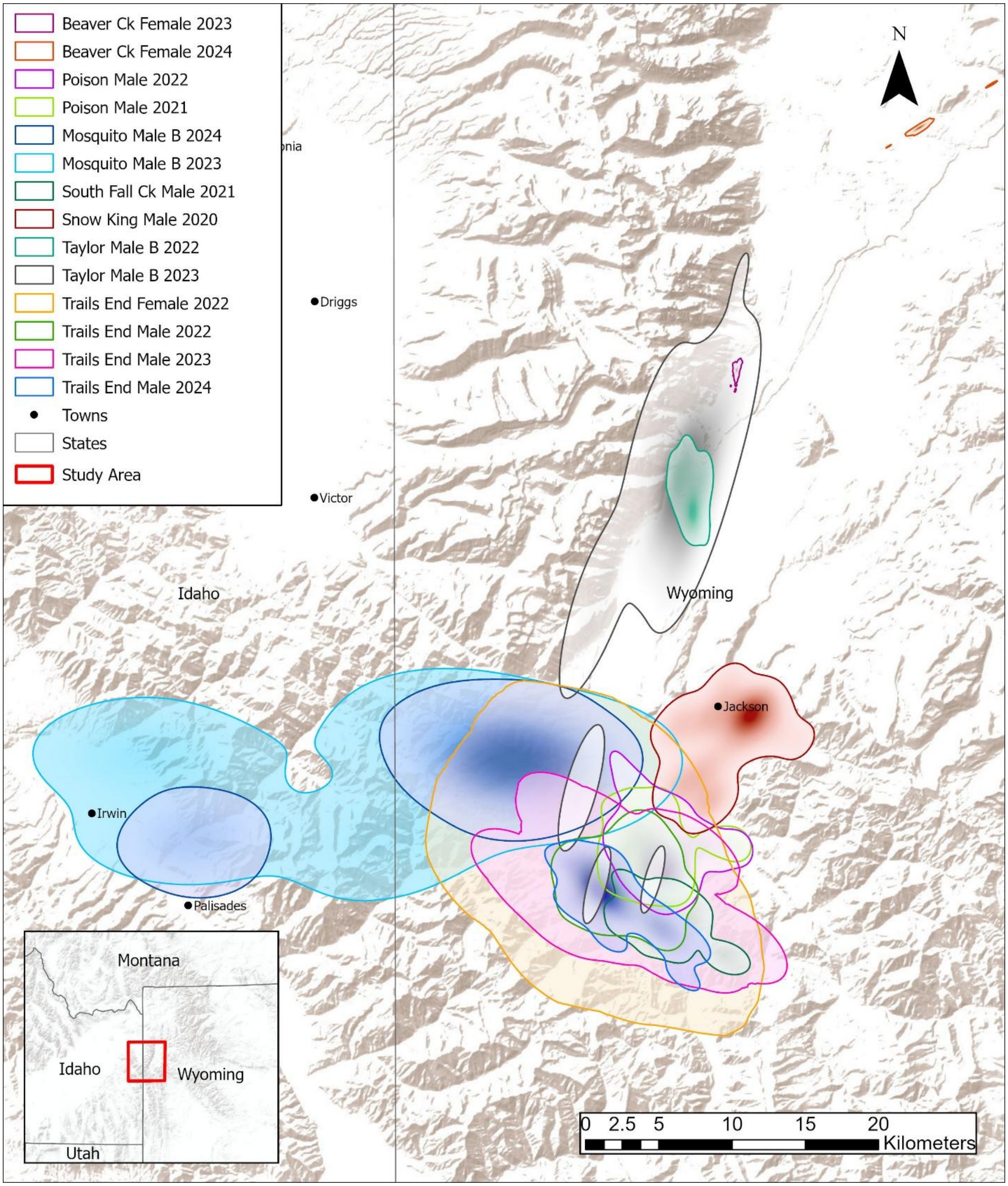


Figure 5. American Goshawk nesting season home ranges in northwest Wyoming and eastern Idaho based on Autocorrelated Kernel Density Estimates (AKDE). Outlines indicate 95% home range estimates while darker colors within each home range indicate areas of higher use.

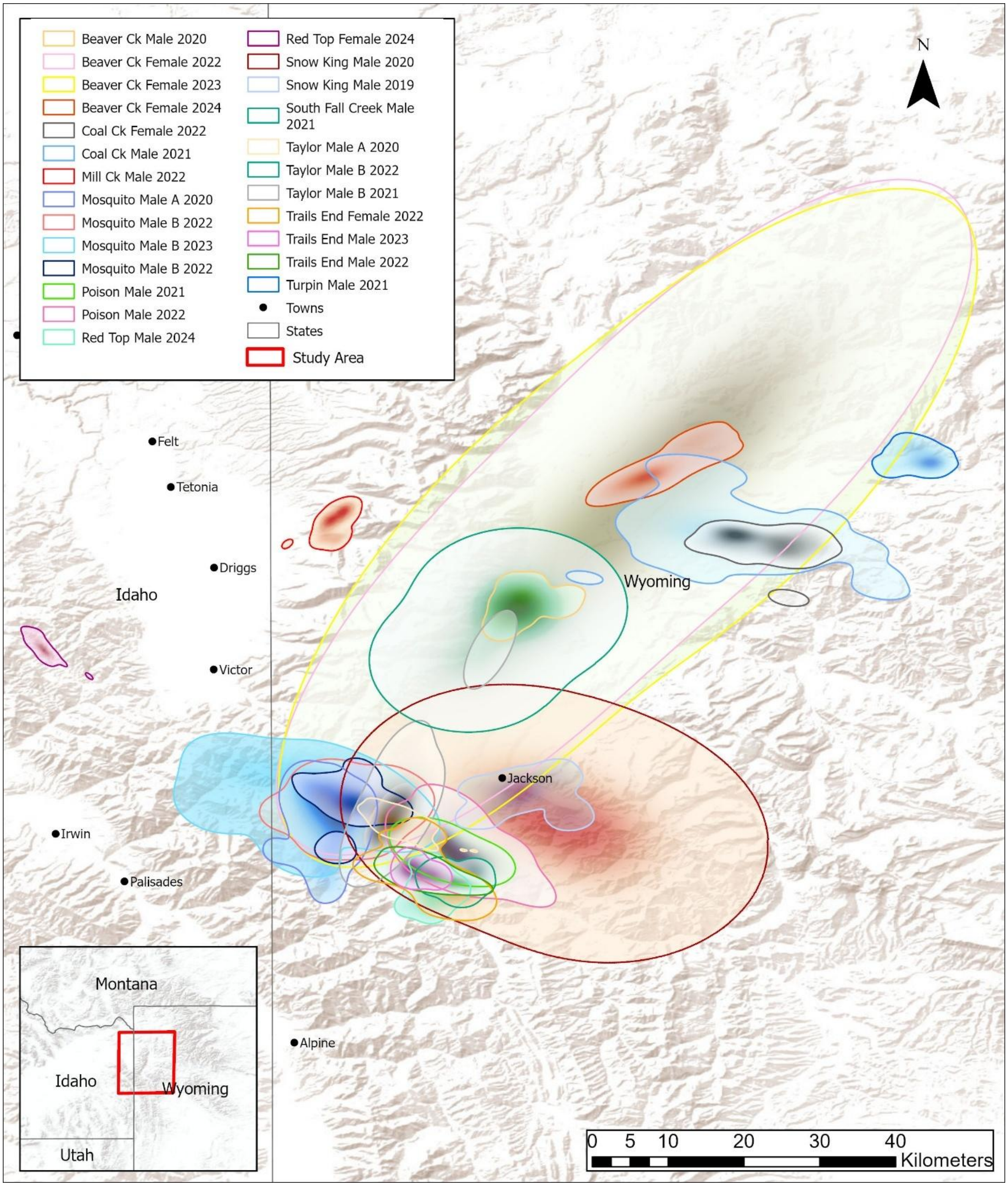


Figure 6. American Goshawk post-fledging home ranges in northwest Wyoming and eastern Idaho based on Autocorrelated Kernel Density Estimates (AKDE). Outlines indicate 95% home range estimates while darker colors within each home range indicate areas of higher use.

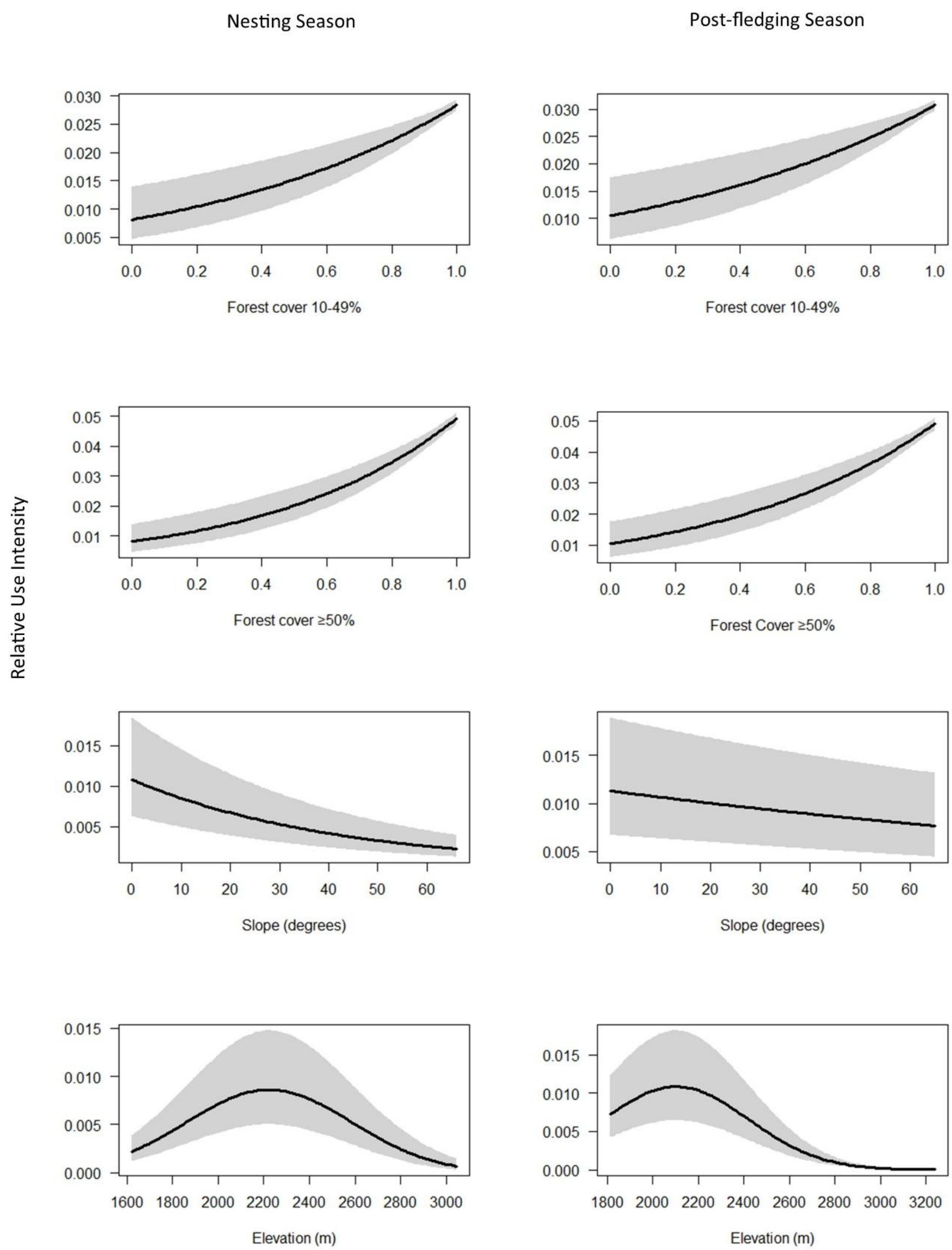


Figure 7. Relative use intensity by covariate for nesting and post-fledging season models.

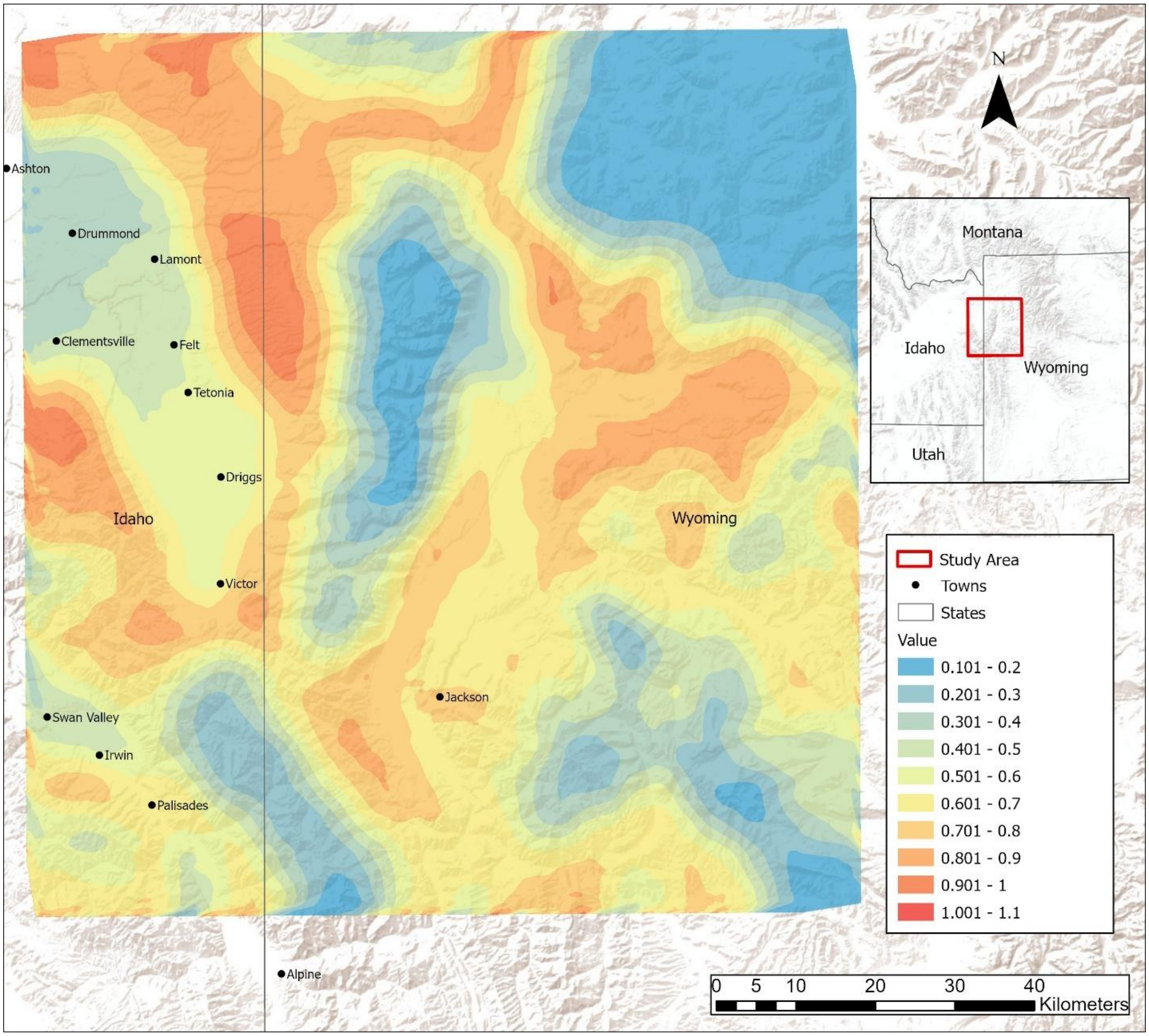


Figure 8. Resource selection function (RSF) values of predicted American Goshawk nesting habitat in northwest Wyoming and eastern Idaho where 1 (red/orange) represents higher probability of use and 0.1 (blue) represents low probability of use. Values were calculated across a 7.25 km x 7.25 km moving window to represent the median size of the nesting goshawk home ranges.

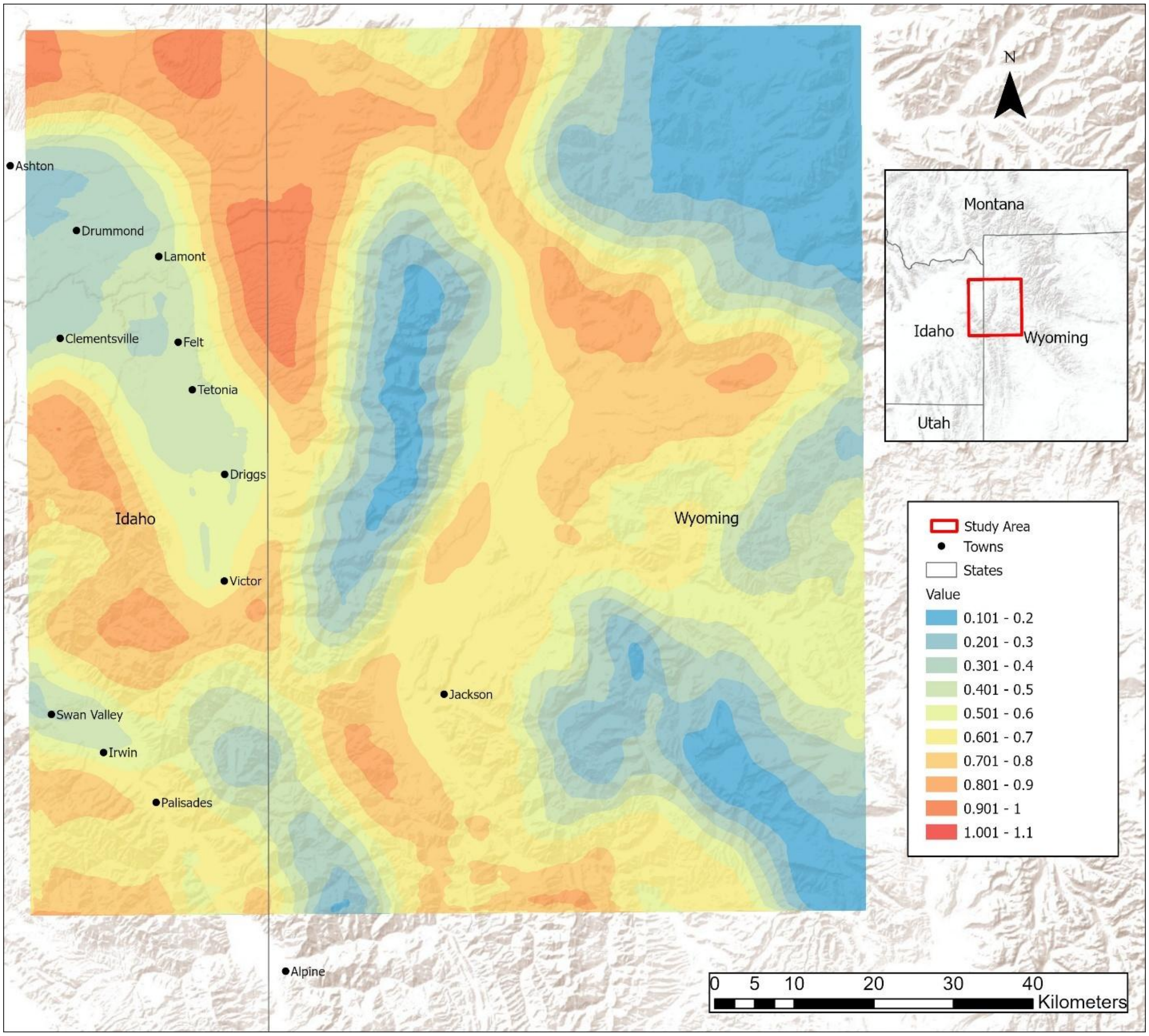


Figure 9. Resource selection function (RSF) values of predicted American Goshawk post-fledging habitat in northwest Wyoming and eastern Idaho where 1 (red/orange) represents higher probability of use and 0.1 (blue) represents low probability of use. Values were calculated across an 8.42 km x 8.42 km moving window to represent the median size of post-fledging goshawk home ranges.

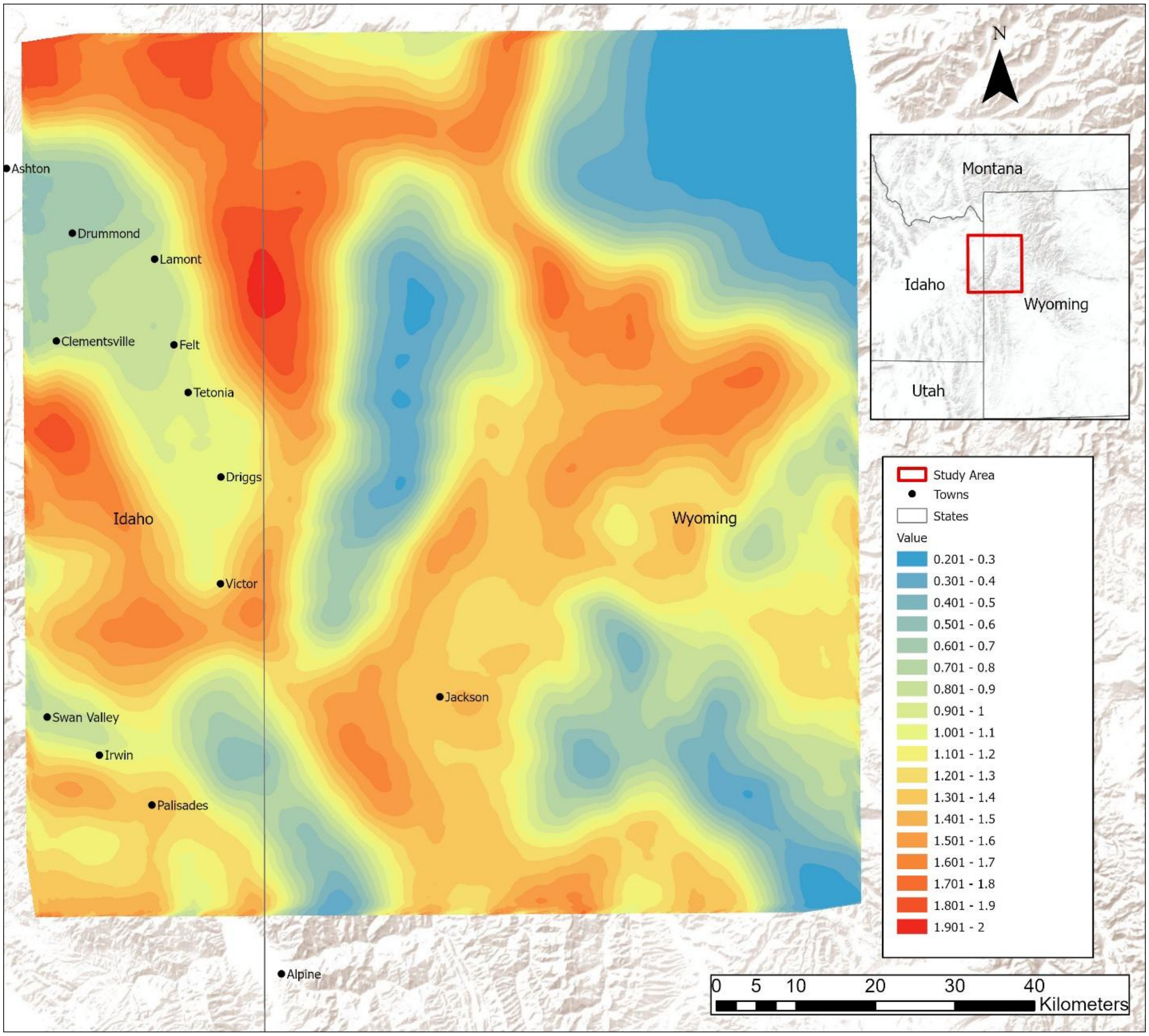


Figure 10. Resource selection function (RSF) values of combined predicted American Goshawk nesting and post-fledging habitat in northwest Wyoming and eastern Idaho where 2 (red/orange) represents highest probability of use and 0.2 (blue) represents lowest probability of use. Values were calculated by adding average nesting and post-fledging moving window RSF values based on the size of the median nesting and post-fledging goshawk home ranges.

Discussion

Goshawk territories in the study area appear to have relatively high nest success from active territories across years. However, territory occupancy and nest initiation rates appeared to be declining across the years of observation with a small increase in territory occupancy rates in 2025. All of this can be difficult to interpret though given different rates of territory and nest monitoring across the years. It is challenging to compare occupancy and percentage of active nests to the current literature due to differences in the definition of occupancy. Here, we refer to occupancy as the number of territories that have goshawks present during the courtship period. Whereas, the literature generally refers to occupied territories as those with active nests (pairs that either built a nest and/or laid eggs). The key difference is that breeding adults can (and do) occur in historic territories where they do not build nests or lay eggs in a given year. This cannot be determined with traditional call-back surveys or territory visits but can be determined with ARUs or multiple pre-dawn surveys during the courtship period. If we assume that our measure of active territories (those with new nests and/or eggs laid) is equivalent to previous measures of "occupancy" in the literature, then our estimates fall within the range of normal for the species.

The proportion of occupied territories to active nests appears to be relatively consistent over the past five years up to 2024, although the occupancy rate appeared to be declining overall until this year when we only monitored occupancy and did not follow up on checking nest activity. Goshawks are known to move active nests sites up to 1km from previously active nests and we cannot deploy enough ARUs in large enough areas to account for this scale of nest movement. Further, over the last several years we have documented three goshawks completely moving territories across the valley or beyond (Beaver Creek to Signal Mtn, Taylor to Granite, and Red Top to Mike Harris). These are very large movements and could help explain the variation in territory occupancy rates we measured using "small" areas around previously known nests to calculate this statistic.

Over the course of this study, we have collected movement information from 19 breeding goshawks. We have experienced multiple transmitter failures and/or unknown fates of hawks. Unknown fates are all situations in which the transmitter was operating normally (at least several points/day) and stopped reporting in suddenly. There were no instances with multiple locations at the last known spot, which would indicate a dropped transmitter or mortality. We were able to recover four transmitters in which our breakaway harness system successfully worked. It is likely that at least a few of the unknown fates are dropped transmitters that failed to charge or lost signal on the ground. However, it is also possible that predation occurred and damaged the transmitter in such a way that it could no longer function.

Home Range Analysis

Using the transmitters with sufficient data for a statistically sound home range analysis, we found that goshawk home ranges averaged (94.2 ± 25.9 km^2) larger than reported by other studies in North America but ranged in size from 14.8 km^2 to 392 km^2 with males (98.8 ± 32.9 km^2) having larger nesting ranges than females (77.0 ± 17.9 km^2). The largest difference in nesting home range sizes based on nesting status was found between goshawks in years of successful nests vs. those that did not nest, with those that did not nest having larger home ranges. Post-fledging home range estimates averaged 169.6 ± 66.8 km^2, were larger than nesting home ranges and were also larger for females than males in our study. Forest cover, especially ≥ 50%, was significantly important for predicting both nesting and post-fledging habitat as were less steep slopes and mid-elevations.

The large variability in nesting home ranges of goshawks in our study is consistent with what others have found although our overall average home range sizes were larger. Moser and Garton (2019) found that male goshawks had average breeding home ranges of 51 km^2 and that females were 39 km^2 in northern Idaho. Blakey et al. (2020) found median home range sizes of 39 km^2 for males and 16 km^2 for females. Differences in our home ranges could be due to inclusion of bird-years for cases where goshawks did not nest, or when the nesting status was unknown, as the average nesting home range estimate is lower (60.4 ± 8.3 km^2) with inclusion of only bird-years with known active territories where birds nested, regardless of successful or unsuccessful status.

Post-fledging home ranges in our study were larger than nesting home ranges on average, but post-fledging areas (PFAs) could not be accurately compared to other studies that were primarily based on tracking fledglings rather than tracking adults. Our average post-fledging home range size of 179.6 km^2 across all bird-years and 217.1 km^2 for goshawks in years with successful nests indicates that goshawks are using large areas in the post-fledging season. Our results are consistent with others in terms of observed larger home ranges on average for adults during the post-fledging season with movements of up > 15 km (Hargis et al. 1994, Blakey et al. 2020).

Nest site fidelity is common across goshawks, with fidelity as high as 95% for males and 92% for females observed in Arizona across a 20-year time period (Reynolds et al. 2025). Of the 17 goshawks we tagged in this study, only six had sufficient location data for at least two breeding seasons for home range analysis to assess territory fidelity. Of those six we observed two (33%) shifting territories, one male and one female, while the other four exhibited territory fidelity. The Beaver Creek Female was present on one territory for the first two seasons (2022, 2023) after she was tagged but shifted to a new nesting territory 20 km to the north in 2024 (Fig. 5). Her nests were successful during all three seasons, but she had the largest post-fledging area use of all goshawks in 2022 and 2023, which encompassed a large area to the north (Fig. 6). The Taylor B Male also switched territories during our study, occupying one territory in 2021 with a successful nest, and then moving to a new territory approximately 25 km to the north during 2022 and 2023 with an unknown nesting status. While these data suggest changes in nesting territories, our 10+ year nest monitoring dataset associated with both tagged and untagged birds suggests goshawks in the region are often returning to territories year after year. In the future we hope to further assess territory fidelity within our study area as part of a long-term goshawk occupancy monitoring effort utilizing a combination of tagged birds and passive acoustic recordings of breeding season calls.

In assessing resource selection, we found that nesting and post-fledging probability of use were both highly associated with forest cover ≥50%, and increased with forest cover 10-49%, less steep slopes, and moderate elevations (Fig. 7). Our mapped nesting and post-fledging RSFs across moving windows of median home range sizes provide local land managers with a predictive surface of high probability of use habitat for American Goshawks during nesting and post-fledging periods (Fig. 8, Fig. 9). Furthermore, the combined predictive surface that encompasses RSF values from both nesting and post-fledging habitats provides one overall map to represent highest probability of use areas for goshawks during the breeding season (Fig. 10). These maps will provide important information for conservation planning and for targeting pre-project monitoring efforts for goshawks to improve our overall understanding of the species in the Greater Yellowstone Ecosystem.

American Goshawks are a U.S Forest Service sensitive species and Management Indicator species that can have variable home range sizes and breeding habitat often associated with mature and contiguous forest stands. In our study, we observed variable but typically large home range sizes in goshawks in the Greater Yellowstone Ecosystem, much like other regions of North America. Our information on nesting and post-fledging home ranges reiterates the importance that forest management decisions for goshawk habitat occur not just in the immediate vicinity of known nest locations, but across entire forests, for goshawk conservation and management. We encourage land managers to consider these findings and to utilize our predictive surfaces of high probability of use areas during nesting and post-fledging periods when determining impacts of proposed projects and forest management efforts.

In 2026, we plan to continue to monitor territories solely through ARU deployments and review of audio data collected at territories early in the breeding season. We do not plan to deploy additional transmitters on goshawks unless they are on a new territory for which we want additional information on home ranges and habitat use. We plan to publish the thorough breeding home range analysis we provided in this report as a summary of our findings on goshawk home ranges and habitat use for the Greater Yellowstone Ecosystem.

Acknowledgments

We thank A. Rouse, H. Turner, A. Wichman, A. Wolke, J. Constable, A. Swan, K. Li, A. Faticoni-Manolas, S. Bol, K. Gura, N. Hough, B. Boyton, R. White, and S. Poole for their assistance with territory monitoring and American Goshawk capture and transmitter deployment. Funding for the project was provided by the Bridger-Teton National Forest, Teton Raptor Center, Community Foundation of Jackson Hole, Meg and Bert Raynes Wildlife Foundation, Teton Conservation District and private donors. All animals were tagged and handled following the Guidelines to the Use of Wildlife Birds in Research (Fair et al. 2023). All birds were banded under the following permits: Bird Banding Lab Permit #24140, Wyoming Game and Fish Department Permit #33-1286, Bridger-Teton National Forest Permit #JAC225202, and Grand Teton National Park Permit #GRTE-year-SCI-0016.

Literature Cited

Bechard, M. J., G. D. Fairhurst, and G. S. Kaltenecker. (2006). Occupancy, productivity, turnover, and dispersal of Northern Goshawks in portions of the northeastern Great Basin. Studies in Avian Biology 31:100-108.

Blakey, R. V., R. B. Siegel, E. B. Webb, C. P. Dillingham, M. Johnson, and D. C. Kesler. (2020). Northern Goshawk (*Accipiter gentilis*) home ranges, movements, and forays revealed by GPS-tracking. Journal of Raptor Research 54:388-401. doi: https://doi.org/10.3356/0892-1016-54.4.388

Burnham, K. P., and D. C. Anderson. (2002). Model selection and inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

Calabrese, J. M., C. H. Fleming, and E. Gurarie. (2016). ctmm: an R package for analyzing animal relocation data as a continuous-time stochastic process. Methods in Ecology and Evolution 7:1124-1132.

Fleming, C. H. and J. M. Calabrese. (2017). A new kernel density estimator for accurate home-range and species-range area estimation. Methods in Ecology and Evolution 8:571-579. doi: https://doi.org/10.1111/2041-210X.12673

Fleming, C. H., W. F. Fagan, T. Mueller, K. A. Olson, P. Leimgruber, and J. M. Calabrese. (2015). Rigorous home range estimation with movement data: a new autocorrelated kernel density estimator. Ecology 96:1182-1188. doi: https://doi.org/10.1890/14-2010.1

Hargis, C. D., C. McCarthy, and R. D. Perloff. (1994). Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16:66-74.

Hijmans, R. J., R. Bivand, K. Forner, J. Ooms, E. Pebesma, and M. D. Sumner. (2022). Vignette terra: Spatial data analysis. The comprehensive R archive network.

LANDFIRE. (2016). Existing Vegetation Type Layer and Existing Vegetation Cover Layer, LANDFIRE 2.0.0, U.S. Department of the Interior, Geological Survey, and U.S. Department of Agriculture. Accessed 10 April 2025 at http://www.landfire/viewer.

Manly, B. F., L. L. McDonald, and D. A. Thomas. (1993). Resource selection by animals. Chapman and Hall, London, United Kingdom.

Moser, B. W. and E. O. Garton. (2019). Northern Goshawk space use and resource selection. Journal of Wildlife Management 83:705-713. doi: https://doi.org/10.1002/jwmg.21624

Patla, S. (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.

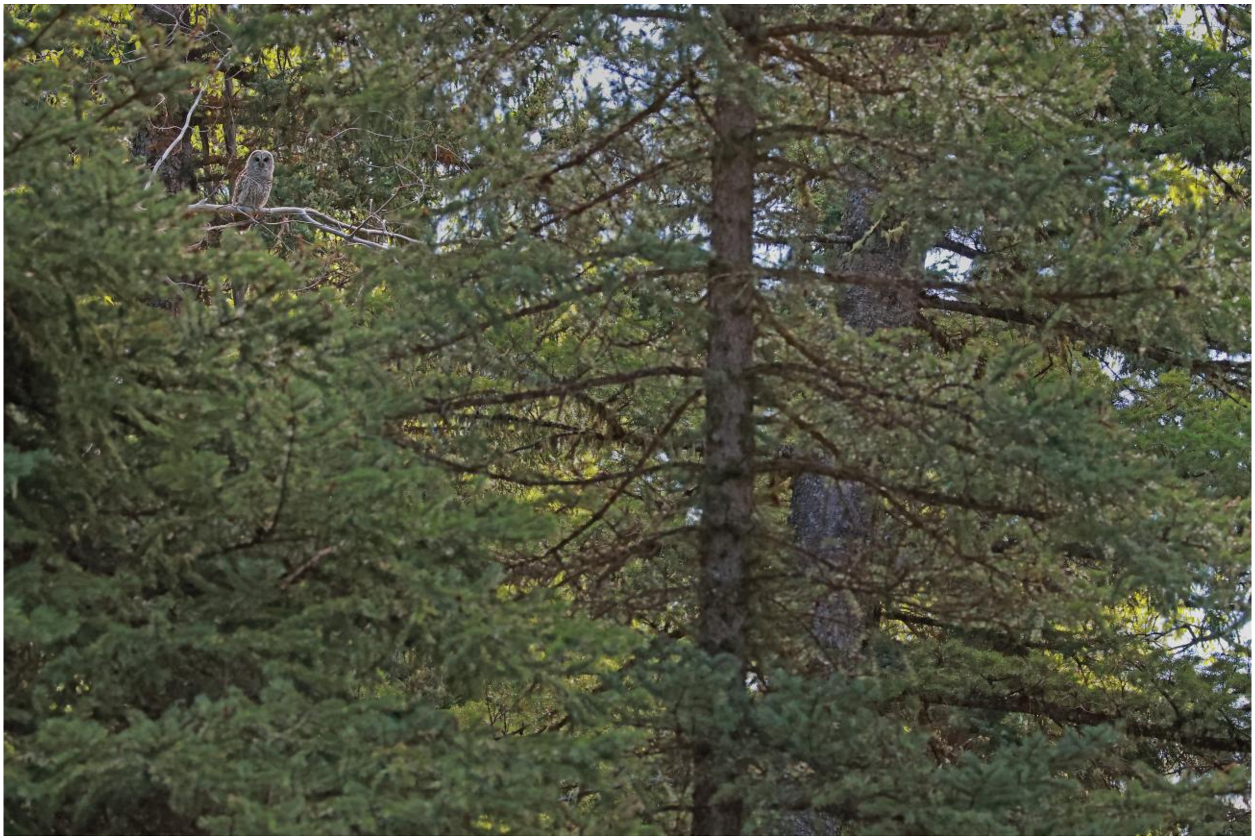
R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. http://www.r-project.org/

Reynolds, R. T., S. T. Kay, J. S. Lambert, and M. Ellis. (2025). Fidelity to territory and mate and the causes and consequences of breeding dispersal in American goshawk (*Astur atricapillus*). PLoS One 20: e0323805. https://doi.org/10.1371/journal.pone.0323805

U.S. Geological Survey. (2024). 1 arc-second Digital Elevation Model (DEM), accessed March 23, 2025 at URL https://www.usgs.gov/the-national-map-data-delivery.

Monitoring Barred Owl expansion in the Greater Yellowstone Ecosystem

2025 Annual Report



Study Personnel: Bryan Bedrosian, Julie Polasik, Hilary Turner, Adrian Rouse, Addie Wichman, and Anna Wolke

Introduction

We have been experiencing significant climatological and biodiversity changes in the Greater Yellowstone Ecosystem (GYE) over the past two decades. For example, changing climate has already altered habitats and allowed for some significant shifts in species distributions. This has been particularly evident in some of our avian communities. Species like American Crows, Turkey Vultures, and Eurasian Collared-Doves are now thriving in the GYE, while they were previously absent or at extremely low densities just 15 years ago. Similarly, meso-carnivores that are typically associated with anthropogenic activities and habitats are significantly increasing. Species like red fox, racoons, and skunk have all been widely increasing across the southern GYE in the past 20 years. There are complex ecological associations and interactions between climate, land management, ecological processes, and species interactions that determine which species will benefit from these changes and those who will not (Wilkin et al. 2016).

Many recent studies have focused on the interaction between the changing climate and wildlife in the GYE. For specialist species, such as the Great Gray Owl, changing snowpack due to climate change is affecting their movements and distribution. Recent data indicate owls need to leave the GYE and travel larger distances due to increasing freeze/thaw and rain-on-snow events, which cause stronger snow crust layers that the owls cannot penetrate to access prey (Gura et al. 2025). Notably, recent models predict full extirpation of this species in the GYE and across the coterminous US if temperatures rise by even 1.5° C (Audubon 2025). Similarly, other specialist species, like American pika, are considered at considerable risk of extirpation due to declining snowpack and reduced dispersal capabilities (Smith 2020). In general, most specialist species in the GYE are expected to experience significant decreases in range and abundance as temperatures increase, while generalist species are expected to expand their ranges and increase population sizes (Audubon 2025). Current observations across the GYE are already starting to show these trends.

Understanding the juxtaposition of both climate change and species competition on biodiversity is key to understanding the changing ecosystems and determining effective management strategies. For example, in the Pacific Northwest, this juxtaposition of changing habitats, expansion of invasive species, and competition are currently leading to the likely extirpation of Northern Spotted Owls in Canada, Washington, and Oregon (Franklin et al. 2021). Barred Owls have expanded their distribution and population size, moving from the eastern US, across the lower boreal Canadian forests and into the West (Potts 2024). As Barred Owls colonized forests in the Pacific Northwest, they began to co-occur with an already declining population of Northern Spotted Owls due to habitat loss and fragmentation (Long and Wolfe 2019). Territory occupancy for Northern Spotted Owls in Washington has declined from 80% to <20% from 1993-2018, while the inverse occurred for Barred Owls (Franklin 2021). It has become clear that Northern Spotted Owls "will face extirpations if competition from Barred Owls is not ameliorated in the short term" (Franklin et al. 2021). This has led the USFWS to approving the removal of up to 40,000 individual Barred Owls to limit their further invasion and improve the survival and recovery of spotted owls (USFWS 2024).

While Great Gray Owls are experiencing habitat changes and projected habitat loss in the GYE for different reasons than their *Strix* cousin (Spotted Owls), they may soon face a similar additional threat of direct competition from their other *Strix* cousin, Barred Owls. Some historic records of Barred Owls in the GYE exist (Livezey 2009, unpubl. data from Grand Teton National Park, Wyoming Game Fish

Department, Teton Raptor Center), but no nests have ever been documented. Potts (2024) recently completed breeding surveys for Barred Owls across Montana and located breeding owls in central Montana and individuals during the breeding season as far south as Deer Lodge, highlighting their range expansion south towards the GYE.

As part of our ongoing studies, we have located and annually monitored 38 Great Gray Owl territories with ARUs and worked to understand population demographics (TRC 2025), habitat use (Bedrosian et al. 2017, Gura et al. 2025), genetic health and connectivity (Mendelsohn et al. 2020), and climate-induced movements (Gura et al. 2025) using a variety of field techniques and individual GPS tracking. We documented lack of occupancy in a Great Gray Owl territory in Grand Teton National Park that was historically occupancy every year, while other territories did not indicate a population-level decline in occupancy. While conducting annual prey surveys in this territory in early August 2023, our team found fledgling Barred Owls. This was clear evidence of the first breeding pair of Barred Owls in Wyoming and the GYE.

As a preliminary assessment of nesting Barred Owls last year, we documented a second nesting attempt by this same Barred Owl pair, deployed ARUs near historic Barred Owl records, and began reviewing the past decade of our ARU recordings. We documented at least two other likely nesting territories; one pair on a newly deployed ARU and a second in a recording from 2019. With encouragement from Grand Teton National Park and Wyoming Game and Fish, we have developed a new study design to better understand the range expansion of Barred Owls in the GYE, habitat use, movements, and impacts to other raptors.

Project Objectives

- Use automated recording units to locate breeding owls, nest sites, and document the expansion and current population size of Barred Owls in the GYE
- Model and map nesting and seasonal habitat selection of Barred Owls expanding into the GYE
    - Use these models to inform future surveys
- Document and model dispersal of young produced in the GYE to understand
- Predict areas and timing of future expansion using habitat and dispersal models
- Create and widely distribute engaging content for the general public to understand and appreciate the complex relationship of invasive and native species in the delicate Greater Yellowstone Ecosystem

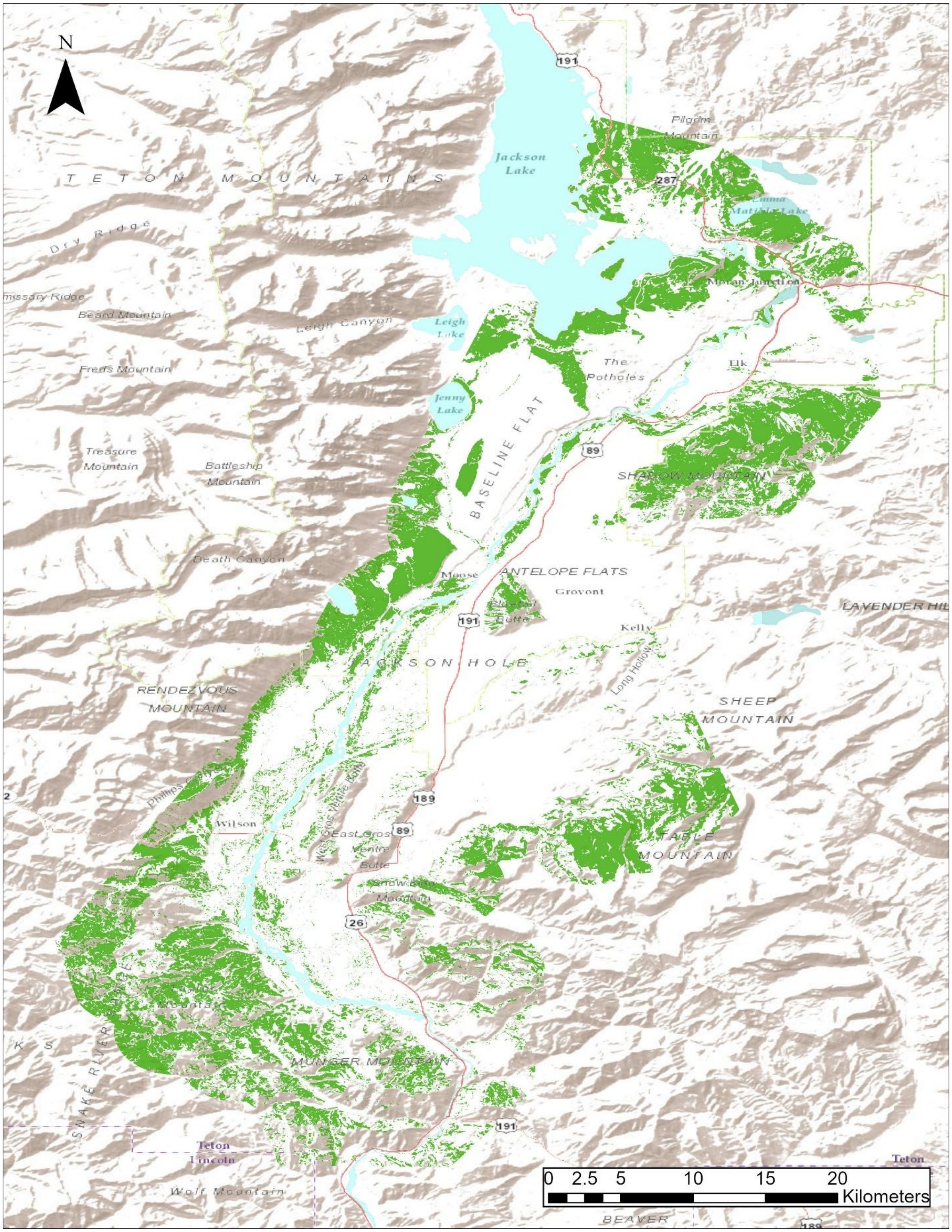


Figure 23. Map of modeled potential Barred Owl habitat (shown in green) within our study area in the Greater Yellowstone Ecosystem (GYE) based on slope, terrain ruggedness, and forest cover.

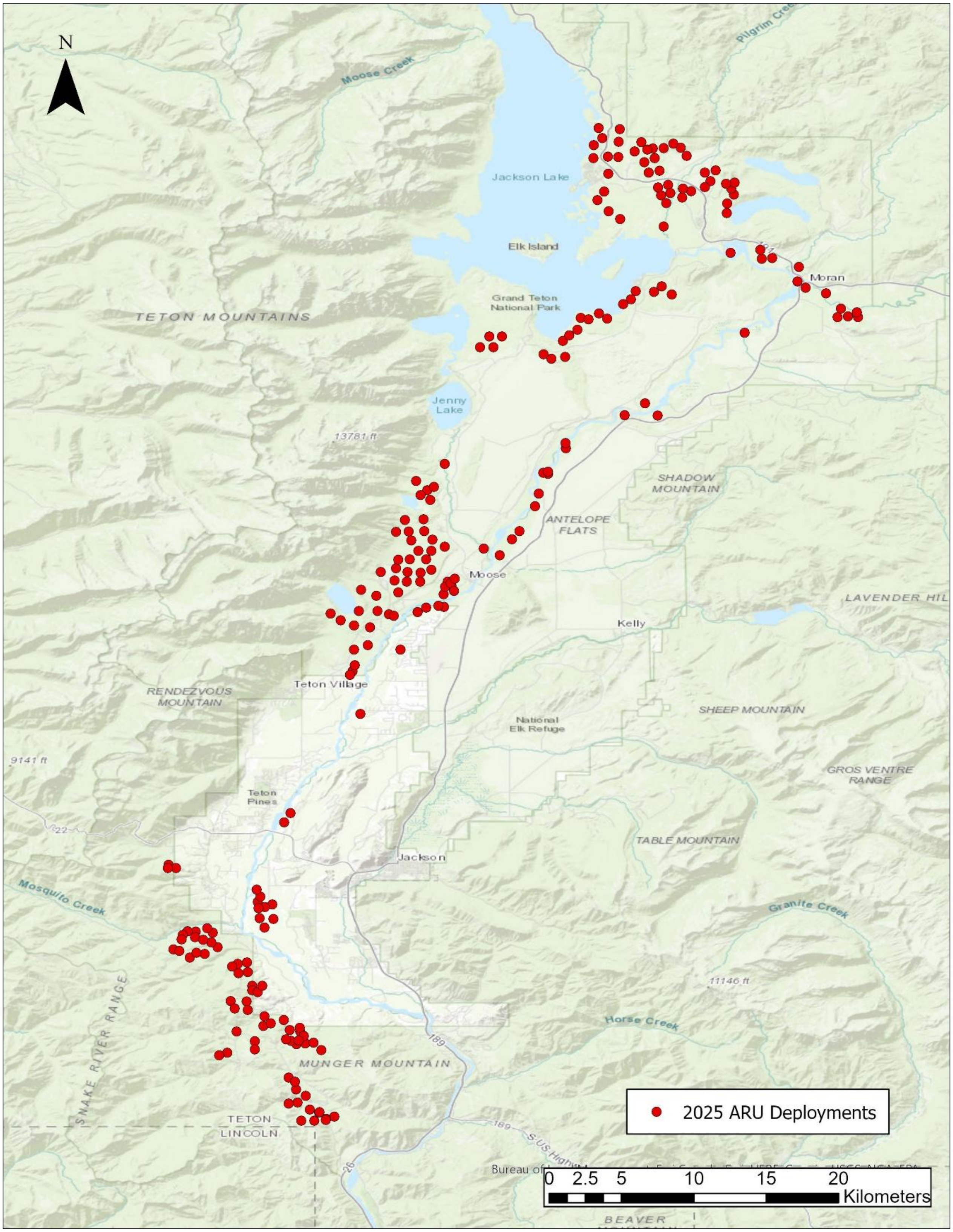


Figure 2. Location of 2025 Automated Recording Unit (ARU) deployments for Barred Owls.

Methods

To document the occurrence and density of breeding Barred Owls, we deployed 214 automated recording units (ARUs) in 2025 to determine if Barred Owls were present in the area. We deployed Automated Recording Units for a minimum of 6 nights, typically during the early breeding season (mid-March to early May) to detect territorial calls of Barred Owls. The ARUs we deployed recorded from 2 hours before sunset to 2 hours after sunrise if we were using Wildlife Acoustics Song Meter Minis or 24 hours a day if we were using SoundScout Units. We used a species-specific classifier that we developed to review audio data in Kaleidoscope for Barred Owl calls.

We deployed ARUs in areas near historic records, areas of recent activity, and suspected Barred Owl habitat (derived and modeled from habitat characteristics measured in Montana; Potts 2024). Suspected habitat was modeled based on slopes of ≤25°, terrain ruggedness within a 3 x 3 cell window of <0.25, forest cover ≥35%, and limited the model to areas within 3km of roads for feasibility of ARU deployments (Figure 1). Deployments within these regions were often typically using a minimum detection radius of 300m as arrays to cover larger regions of suitable habitat, historic records, or recent activity (Figure 2). ARUs were also deployed in areas of known American Goshawk and Great Gray Owl territories to overlap with existing long-term monitoring efforts for sensitive raptor species.

In areas where we detected regular Barred Owl activity, as determined by ≥50 calls within a 6-night period, we followed up with daytime nest searching efforts or nighttime call-playback surveys depending on if detections indicated the presence of a pair (duets) or individual (lone individual giving territorial calls). If a Barred Owl was found, we attempted to trap the individual and deploy a Lotek transmitter fitted with a backpack harness. We used a few different methods to attempt to capture Barred Owls including a Bal-chatri trap, a pan-trap, and a dho-ghaza net setup using live prey (mice). Having individuals outfitted with transmitters will allow us to track movements of the Barred Owl by providing daily locations over the course of a 3-year period.

Additionally, since 2016, we have deployed 2,117 ARUs on National Forest, National Park and private lands to survey sensitive forest raptors for several ongoing studies. In 2025, we prioritized reviewing audio data from these historical deployments based on the habitat suitability criteria above, as well as areas with known current Barred Owl presence, and began reviewing historical audio data for Barred Owl presence.

Results

We detected Barred Owl vocalizations on 16% of the ARUs (n = 33) that we deployed and reviewed using the species-specific classifier in 2025. Only 7% of the ARUs had ≥50 Barred Owl detections, indicating regular calling activity. The ARUs with ≥50 Barred Owl detections represented one previously known nesting territory that was active in 2025, and one lone individual male that was recorded across multiple ARUs regularly within a separate region of our study area. Additional detections with <50 calls occurred in the same region with the lone individual male, as well as a separate region of the study area. We did not detect the Barred Owls in those two regions with follow-up surveys but suspect that the later timing of the search efforts coupled with the Barred Owl being a lone individual may have limited our success.

The one active Barred Owl nesting territory that we monitored in 2025 had a pair that nested, but the nest failed during the breeding season. We were able to capture and tag the female of this pair with a

Figure 3. Female Barred Owl with a Lotek transmitter fitted with a backpack harness.

transmitter in early May 2025 (Figure 3). During the first five months after transmitter deployment (May-early October), her movements indicated that she was staying within a ~200 ha area surrounding her nest location. However, in mid-October she began moving up in elevation into the foothills and mountains and has been staying up at the higher elevations from late October through mid-November. We plan to continue to monitor her movements by downloading the transmitter data every 1-2 months through the next 2-3 years.

We ran 357 current and historical audio deployments through our species-specific classifier in Kaleidoscope for Barred Owls and utilized volunteers to manually verify any Barred Owl calls. This process is ongoing, but so far, six volunteers participated in audio verification after receiving training on the data review protocol and learning the target sounds. In 2025, volunteers analyzed 270 ARU deployments and of those, 17 had positive Barred Owl detections (Figure 4). All of the Barred Owl detections found in historical data were at previously known to have Barred Owls. We still have approximately 1,500 historical audio deployments that could be run through our classifier and verified for Barred Owls.

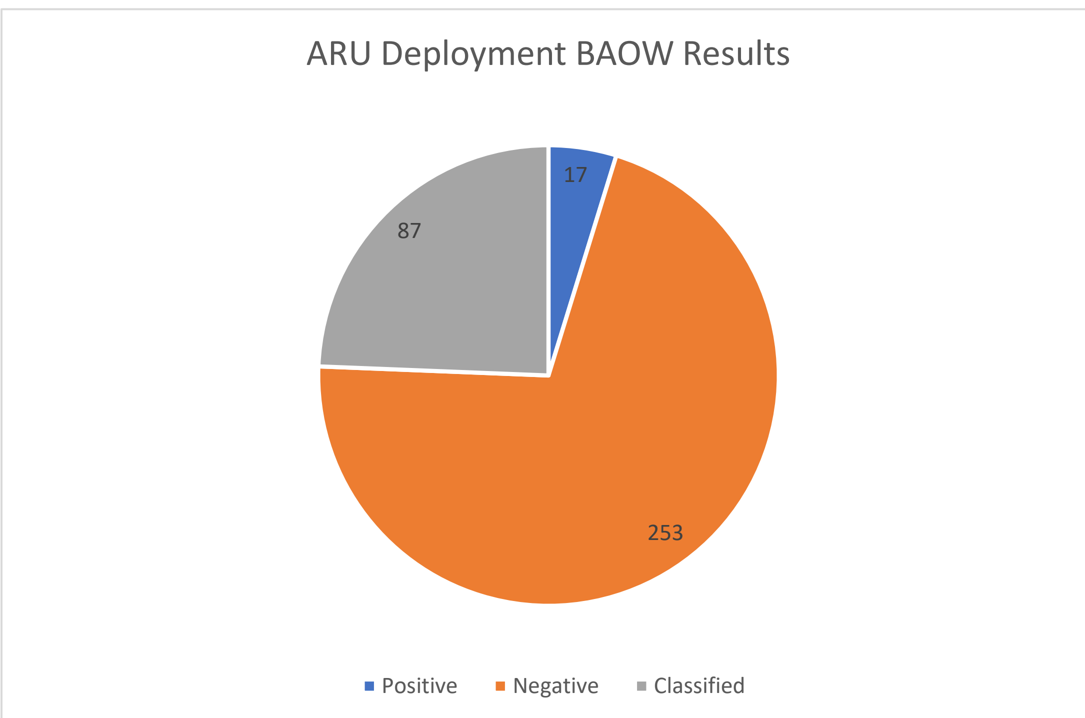


Figure 4. Automated Recording Unit (ARU) deployment Barred Owl (BAOW) detection results. 17 ARUs had positive BAOW detections, 253 did not detect BAOWs and 87 have been classified but not yet reviewed for BAOWs.

Discussion

Our initial year of the Barred Owl expansion monitoring study indicates that one breeding pair is present within our study area. Another lone male was also detected regularly and had a high degree of calling activity throughout the early breeding season. Based on this information Barred Owls are making a slow expansion into the Jackson Hole region of the GYE, but with a limited capacity to deploy ARUs within the early breeding season window we could be missing additional individuals. Notably, both regions of Barred Owl activity overlap with known Great Gray Owl territories. The active Barred Owl nesting territory used to be an active Great Gray Owl territory but had not been active with Great Gray Owls since Barred Owls began nesting there in 2023. In the other region with the lone Barred Owl male calling regularly we found a pair of Great Gray Owls during night-time call playback surveys, again indicating overlap between the species.

As is evidenced in the Pacific Northwest with one of the most contentious management actions of the present day, the expansion of Barred Owls into habitats of other sensitive species has serious biodiversity implications. Barred, spotted, and great gray owls are all in the Genus *Strix*. It is abundantly clear that Barred Owls will actively outcompete Spotted Owls and their presence has been a huge factor driving Spotted Owls to near extirpation across much of their range. We do not know how Barred Owls will impact Great Gray Owls because there are no studies in areas where the two species overlap. Our long-term research with Great Gray Owls is the most extensive study that has ever been conducted on this species in North America. This sets the stage to be the only opportunity to conduct a study of this nature and provide critical information for all other areas where these species overlap.

The rate of expansion of Barred Owls is unknown. The impact of this invasive species on biodiversity in the GYE is unknown. If we draw inferences from similar ecosystems, we can infer that Barred Owls will expand rapidly and have disproportionately large impacts on local species. As with any invasive species, undertaking management action early in an invasive species expansion is much more effective than trying to fix an ecosystem after that invasive has gained a stronghold and widespread dispersal. Therefore, our goal is to continue to monitor Barred Owls in the GYE, detect active territories, and monitor nesting productivity and movements of individuals to understand their influence on the ecosystem.

Acknowledgements

We could not have completed this project without the huge efforts of our volunteer crew including John Norton (volunteer crew lead) who assisted with both audio review and ARU deployments, Bev Boyton, Ray White, Steve Poole, Missy Whelan, Jean Schreiber, and Audrey Fanjoy who assisted with ARU deployments, and Vivien Zepf, Andrea Brophy, Martha Glenn, Hannah Robart, and Matt Hill for their assistance reviewing audio data for Barred Owls. Funding for the project was provided by the Meg and Bert Raynes Wildlife Fund, Wyoming Governors Big Game License Coalition, Community Foundation of Jackson Hole, and Teton Conservation District.

Literature Cited

Audubon (2025). Survival by Degrees Project. https://www.audubon.org/field-guide/bird/great-gray-owl?adm1=WY&country=US#bird-climate-vulnerability. Accessed 1.24.25

Franklin, A. B., Dugger, K. M., Lesmeister, D. B., Davis, R. J., Wiens, J. D., White, G. C., ... & H. Wise (2021). Range-wide declines of northern spotted owl populations in the Pacific Northwest: A meta-analysis. *Biological Conservation*, 259:109168.

Long, L.L., and J. D. Wolfe (2019). Review of the effects of barred owls on spotted owls. *Journal of Wildlife Management* 83:1281–1296.

Mendelsohn, B., Bedrosian, B., Love Stowell, S. M., Gagne, R. B., LaCava, M. E., Godwin, B. L., ... & Ernest, H. B. (2020). Population genomic diversity and structure at the discontinuous southern range of the Great Gray Owl in North America. *Conservation Genetics*, 21:693-706.

Potts, A. L. (2024) Better Understanding the Barred Owl. Graduate Student Theses, Dissertations, & Professional Papers. 12333. https://scholarworks.umt.edu/etd/12333

Turner, M. G., K. H. Braziunas, W. D. Hansen, T. J. Hoecker, W. Rammer, Z. Ratajczak, A. L. Westerling, and R. Seidl. (2022). The magnitude, direction, and tempo of forest change in Greater Yellowstone in a warmer world with more fire. *Ecological Monographs* 92:e01485. 10.1002/ecm.1485

Smith, A. T. (2020). Conservation status of American pikas (Ochotona princeps). *Journal of Mammalogy* 101.6: 1466-1488.

Wilkin, K. M., D. D. Ackerly, and S. L. Stephens. (2016) Climate Change Refugia, Fire Ecology and Management. *Forests*, *7*, 77. https://doi.org/10.3390/f7040077

USFWS. 2024. Final Environmental Impact Statement for the Barred Owl Management Strategy. https://www.fws.gov/sites/default/files/documents/2024-07/final-eis-barred-owl-management-strategy.pdf

Osprey nest platform monitoring

2025 Annual Report

Methods

In 2025, Teton Raptor Center Ambassadors monitored approximately 39 potential Osprey (OSPR) territories in Jackson Hole, WY for occupancy and nest productivity during the breeding season. Those territories contain 64 artificial nest platforms and one manmade structure on which Osprey nested. We determined territory occupancy by observing Osprey at or near platforms during the breeding season and we determined productivity by observing the number of nestlings produced by each territorial pair. Teton Raptor Center Ambassadors visited nest platforms at least once per month during the first two months of the breeding season (April and May). In occupied territories with active nests, Ambassadors continued monitoring until September to determine the fate of each active nest. We also documented the number of platforms occupied by Canada Geese this year.

Results

Territory Occupancy

We observed territorial Osprey at least once during the breeding season in 21 of the territories (54%). Four platforms were occupied by nesting Canada Geese; two Osprey territories had nesting geese early in the season that were later occupied by Osprey resulting in successful Osprey nests, and two territories had geese that nested and Osprey that did not. In one case a monitor observed both a Bald Eagle and an Osprey at a platform. The Osprey was seen after the eagle stopped visiting the nest, and neither species had a successful nest on the platform.

An additional thirteen Osprey territories contained platforms that were not used for nesting by any species this year throughout the study area (33%). Three territories were not monitored in 2025, so we are unsure on their occupancy (8%; Figure 1).

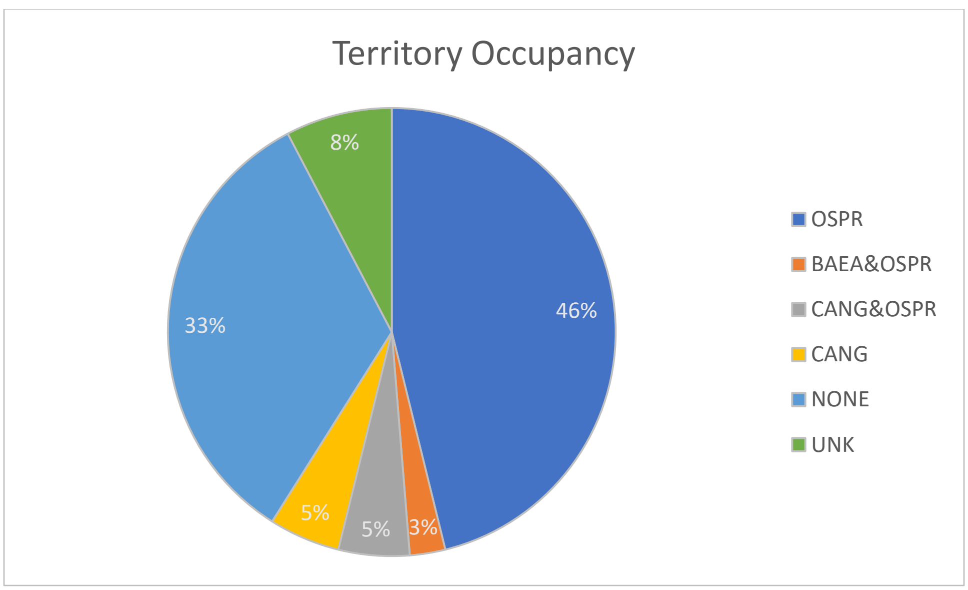


Figure 1. The proportion of occupied territories within the Osprey study area in Jackson Hole, WY in 2025. Twenty-three territories were occupied by only Osprey (46%), two territories were occupied by both CANG and OSPR (5%), two territories were occupied only by CANG, and thirteen territories were not occupied by any species (33%). A Bald Eagle was seen in one territory that was also occupied by Osprey and three territories were not monitored, so we are uncertain if they were occupied or not.

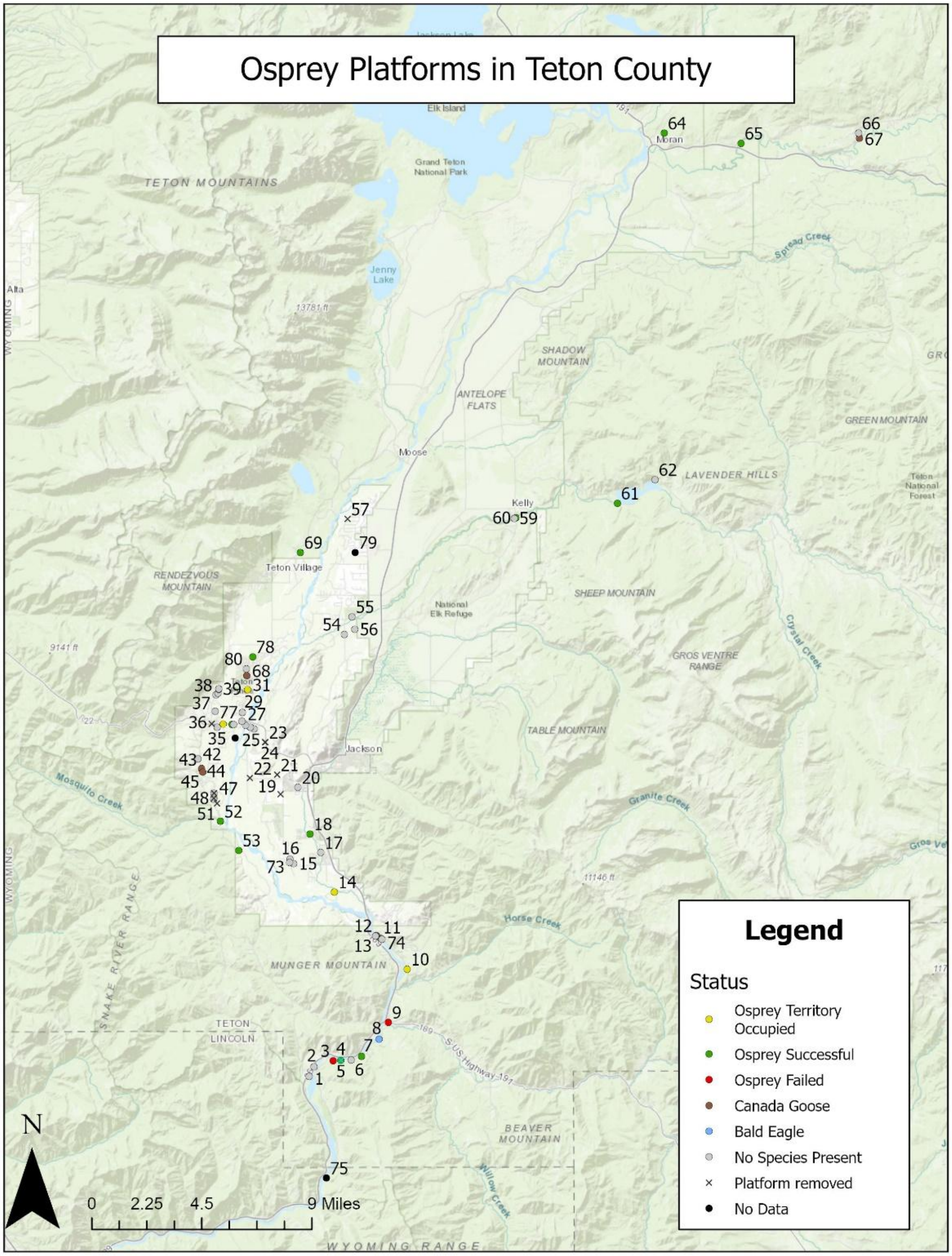


Figure 2. Osprey nesting platform status across the Jackson Hole Valley in 2025.

Nest Productivity

There are 64 platforms and one manmade structure with a nest on it throughout the study area (Figure 2). We monitored 96% of the study area platforms this year and observed Osprey at 22 platforms. Sixteen platforms had active Osprey nests this year and all of the active nests reached the nestling stage. Fourteen of the platforms were successful (88%), producing 29 fledglings. One monitor found an active Osprey nest on a cell tower in Wilson, which produced two fledglings. These data were added to platform data in Table 1. Additionally, four Canada Goose nests were documented on platforms, and we assume most were successful, although it is difficult to determine as the young leave the nest soon after hatching so monitors did not often observe anything past the incubation stage. Thirty-four platforms had no nesting activity and 15 platforms that we monitored in previous years have been removed from the study area for various reasons (Table 1).

Table 1. The number of active nests per species, the number of nests that had nestlings, the number of successful nests, and the number of fledglings produced in the study area.

	Active Nests	Nests with Nestlings	Successful Nests	Number of Fledglings
CANG	4	4	4	?
OSPR	17	17	15	31
NONE	34	*n/a*	*n/a*	*n/a*
GONE	15	*n/a*	*n/a*	*n/a*

Osprey nested successfully on two of the platforms near Moran and one Osprey platform was occupied by Canada Geese in 2025 (Figure 3). The two successful Osprey nests produced four fledglings.

Near Kelly, one platform was occupied by Osprey and produced one fledgling. A platform near Lower Slide Lake also produced two fledglings. Osprey occupied platform 69 near Poker Flats and produced three chicks in 2025 (Figure 4).

Near Wilson, platform 33 produced two fledglings, continuing the success of this platform over the years. Additionally, a nest was found atop a cell tower by one of the Wilson monitors. This nest produced two fledglings (Figure 5).

Platforms along Fall Creek Road were inhabited by Canada Geese (platforms 43, 45, and 48); however, three active Osprey nests on platforms 44, 52 and 53 produced 6 fledglings in 2025 (Figure 6).

Osprey platforms south of Jackson were largely unoccupied, but there was a successful Osprey nest at platform 18, which produced two fledglings (Figure 7).

In the Hoback area, Osprey were observed near or on many of the platforms along the Snake River. There were three active nests in 2024 (7, 9 and 72). Nests on platforms 9 and 72 failed before the nestling stage and platform 7 fledged three young (Figure 8).

Results for each platform can be found in Table 2.

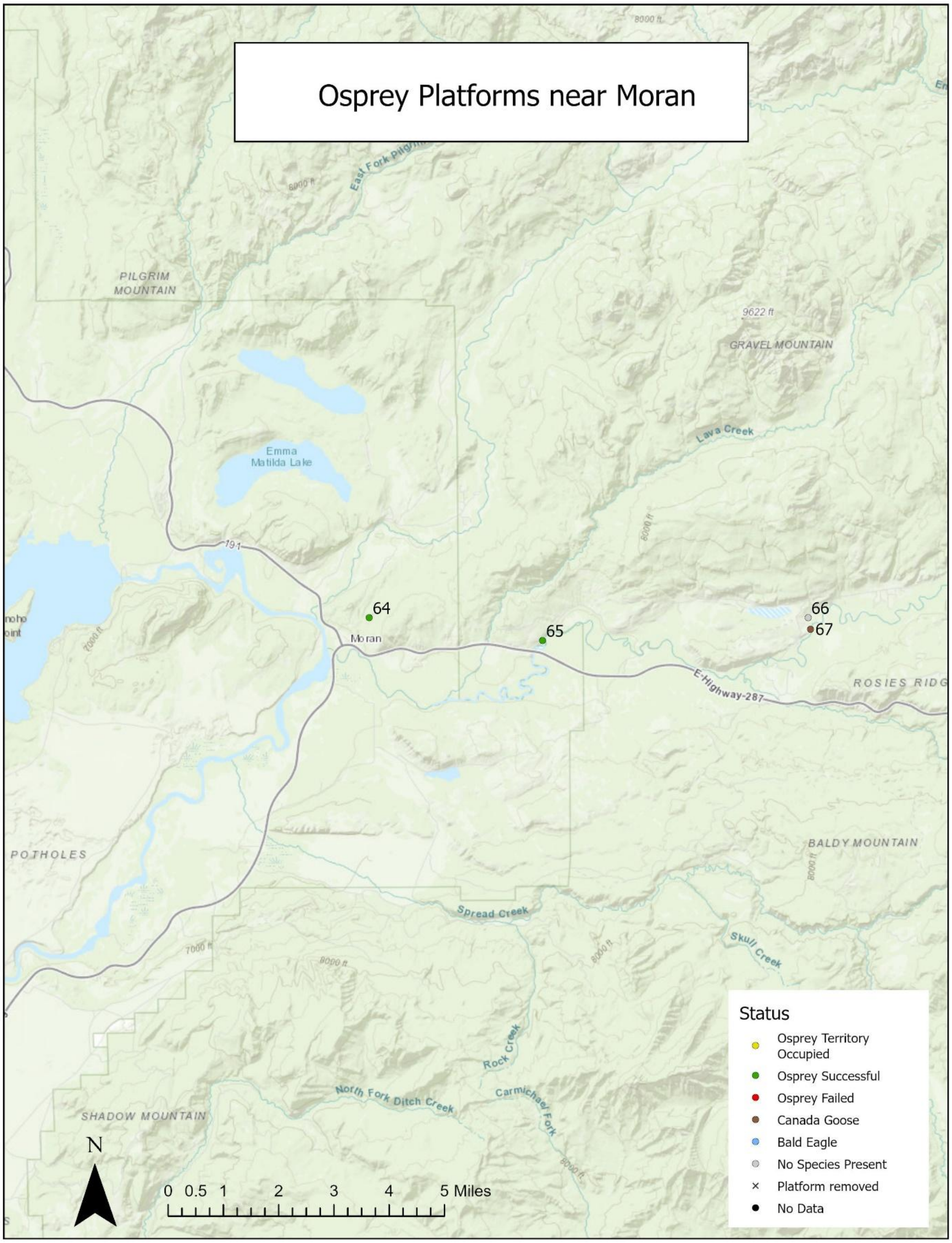


Figure 3. Two platforms near Moran had successful Osprey nests and one platform was occupied by Canada Geese in 2025.

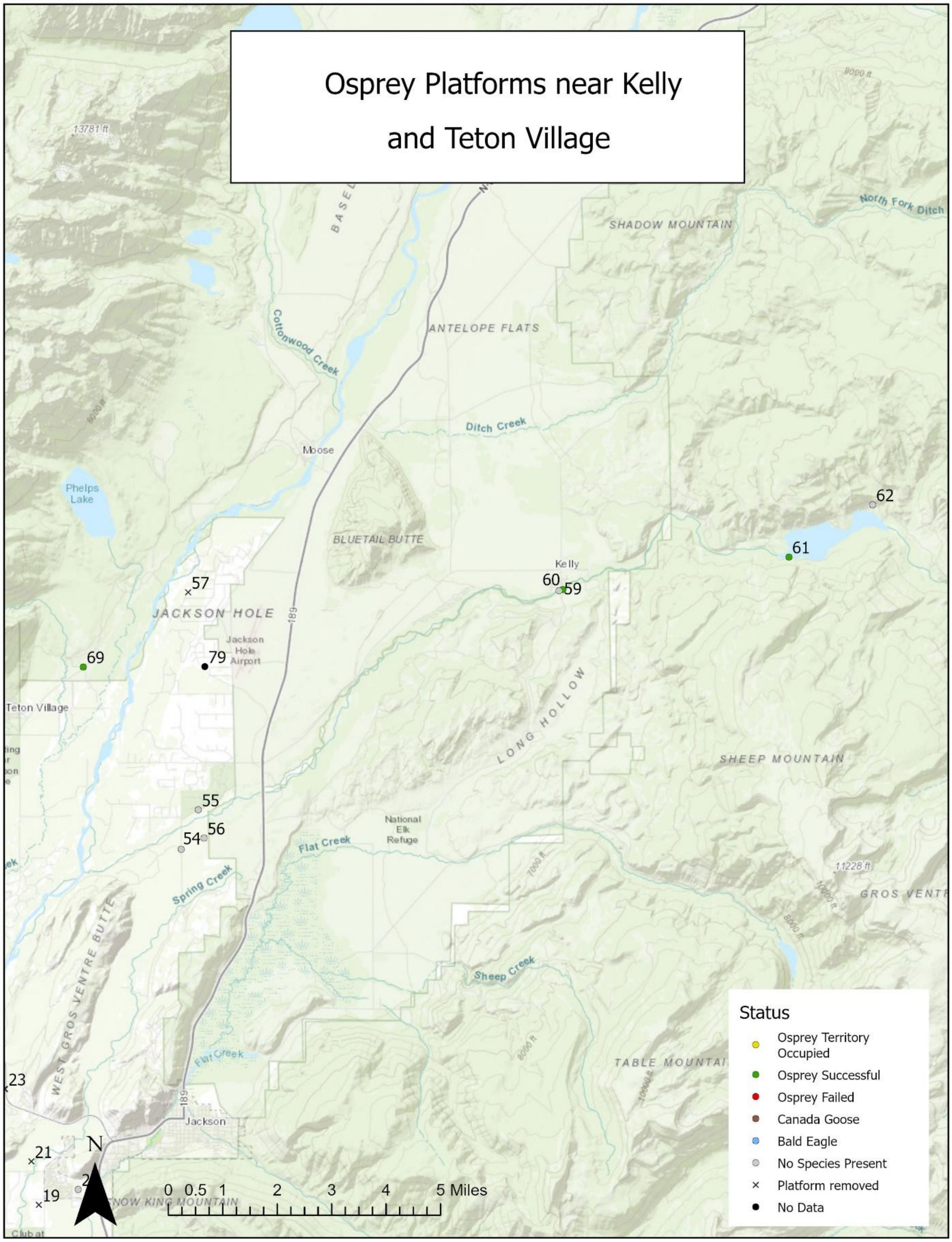


Figure 4. Platforms 60 and 61 produced three fledglings and an Osprey pair at platform 69 produced three fledglings in 2025.

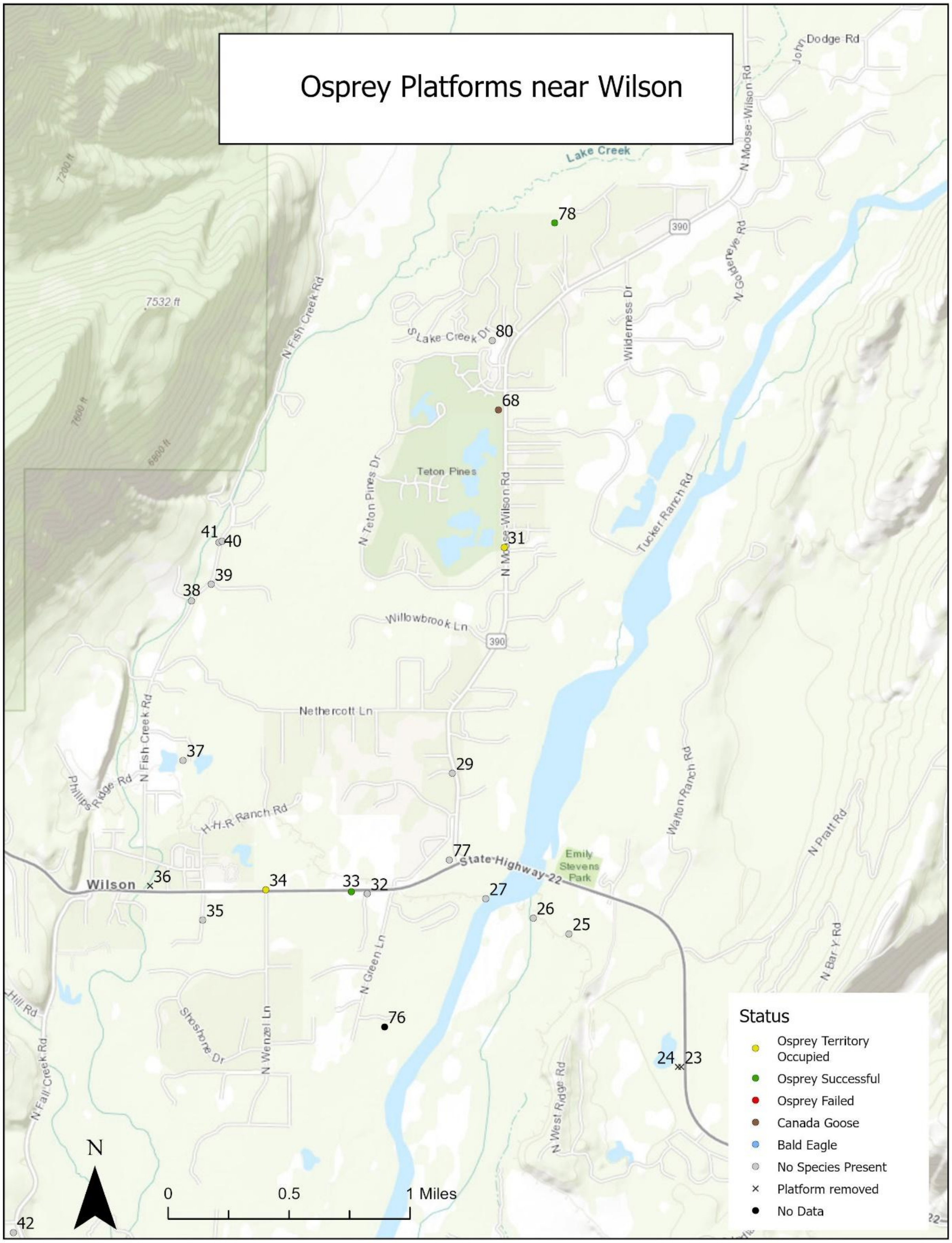


Figure 5. Platform 33 near Teton Raptor Center produced two fledglings! A new nest was found atop a cell tower north of Wilson and that nest produced three fledglings.

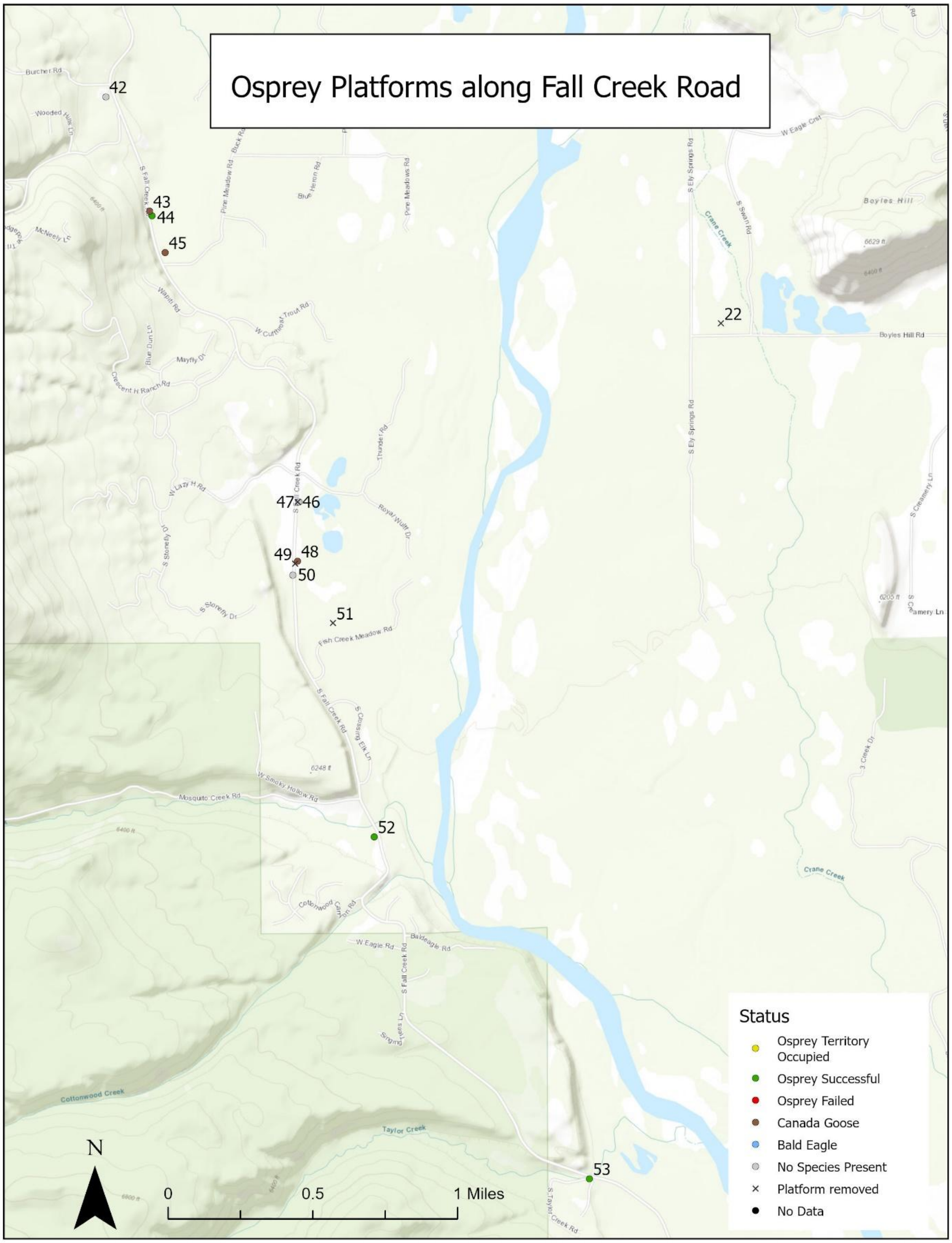


Figure 6. Fall Creek Road had three Canada Goose nests (platforms 43, 45, and 48) and three Osprey nests. Platforms 44, 52, and 53 each produced two fledglings, tripling productivity over last year.

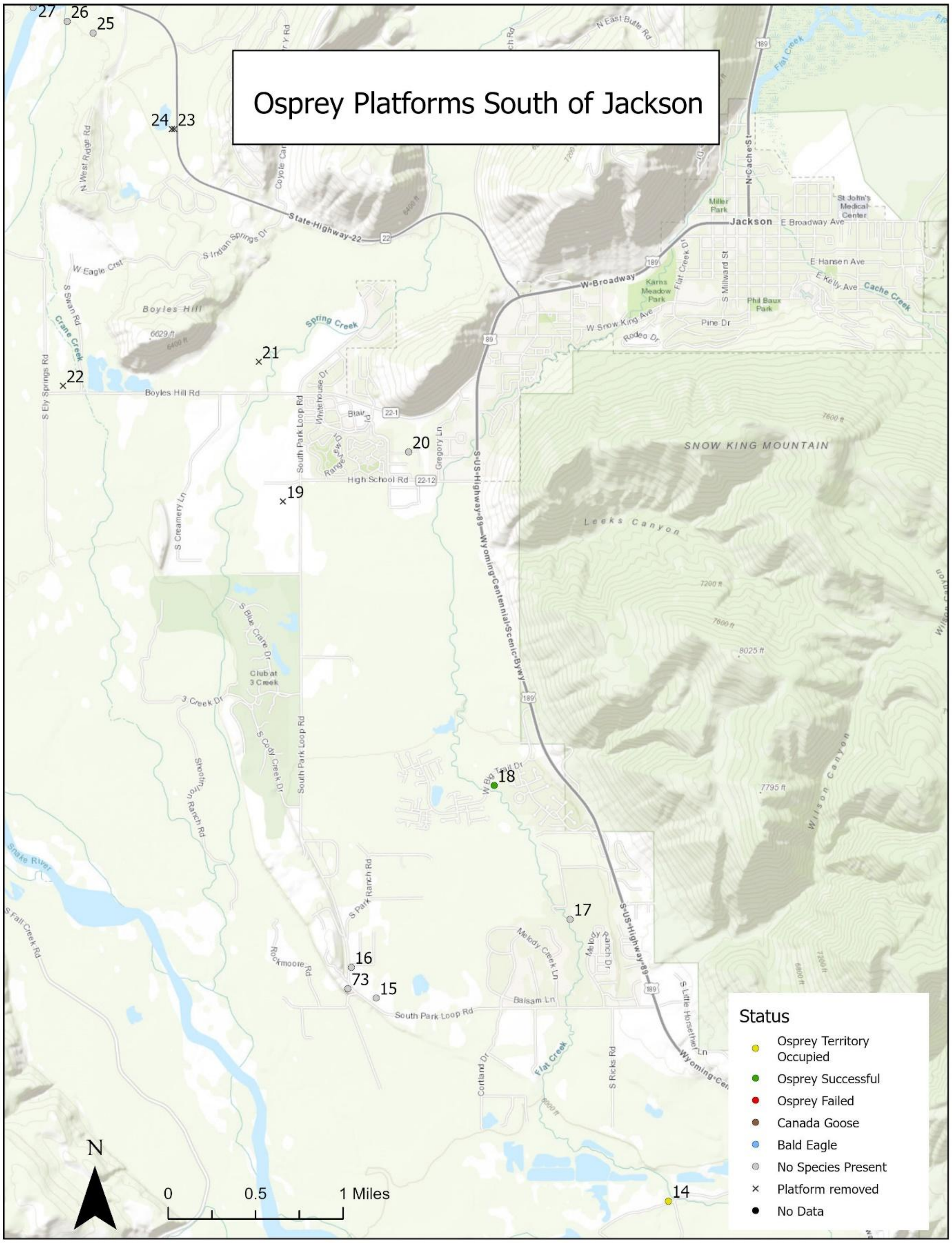


Figure 7. Osprey platforms south of Jackson were largely unoccupied, but there was one successful Osprey nest at platform 18, which fledged two chicks.

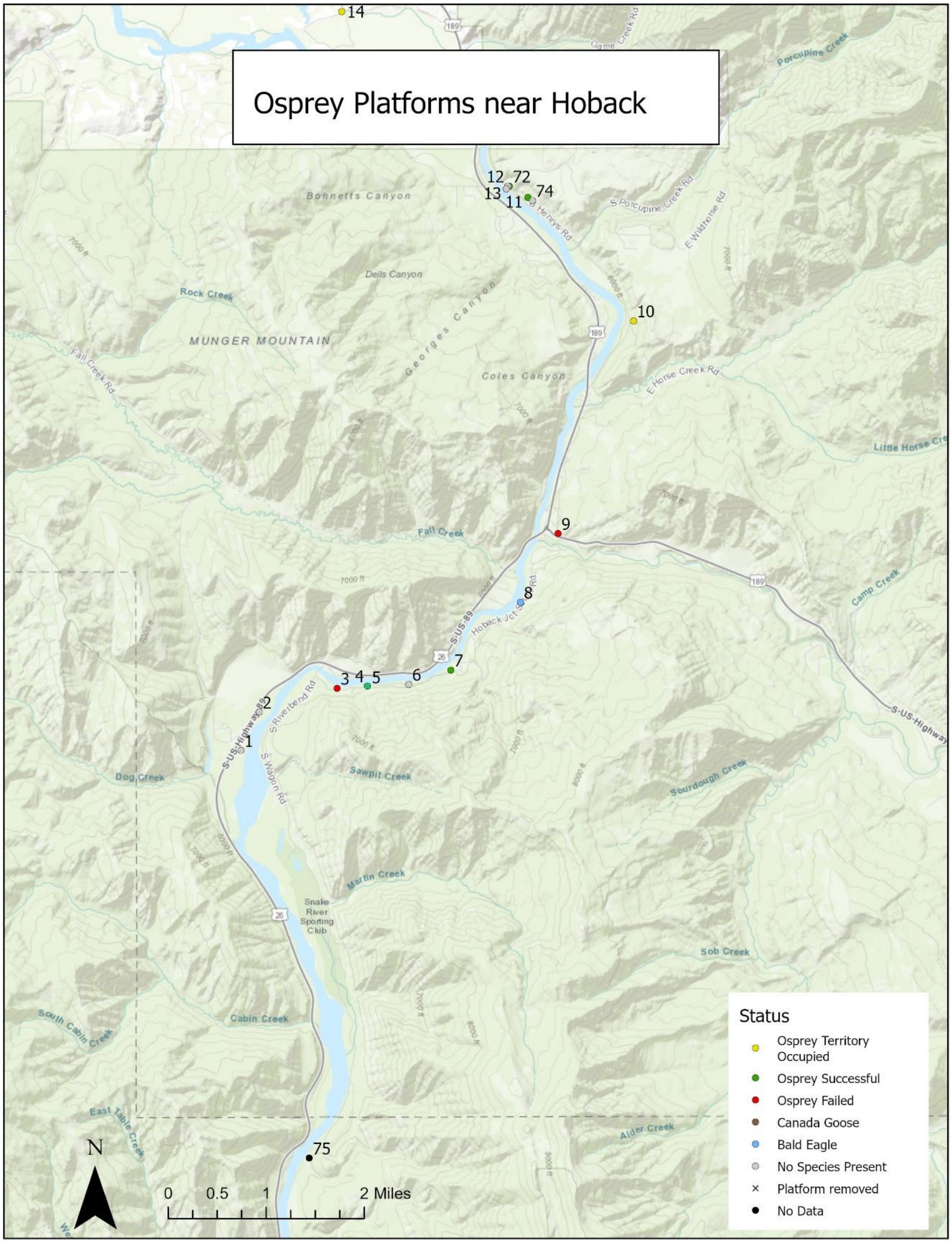


Figure 8. In the Hoback area, Osprey were observed near or on many of the platforms along the Snake River. There were three active nests in 2025 (4, 7, and 72). Osprey nests on platforms 5 and 7 produced two and one fledgling, respectively, and platform 72 fledged two young. Nests were also present on platforms 3 and 9, but these failed.

Table 2. Individual platform observation results, including presence, activity, and fate.

Platform Number	Species Present	Platform Active?	Nest Fate
1	NONE	N	
2	NONE	N	
3	OSPR	Y	Failed
4	OSPR	Y	Fledged
5	NONE	N	
6	NONE	N	
7	OSPR	Y	Fledged
8	BAEA	N	No nest
9	OSPR	Y	Failed
10	OSPR	N	No nest
11	OSPR	Y	Fledged
12	OSPR	N	No nest
13	OSPR	N	No nest
14	OSPR	N	No nest
15	NONE	N	
16	NONE	N	
17	NONE	N	
18	OSPR	Y	Fledged
20	NONE	N	
21	BROKEN	N	
25	NONE	N	
26	NONE	N	
27	NONE	N	
29	NONE	N	
31	OSPR	N	No nest
32	NONE	N	
33	OSPR	Y	Fledged
34	OSPR	N	No nest
35	NONE	N	
37	NONE	N	
38	NONE	N	
39	NONE	N	
40	NONE	N	
41	NONE	N	
42	NONE	N	
43	CANG	CANG	CANG
44	OSPR	Y	Fledged
45	CANG	CANG	CANG
47	NONE	N	
48	CANG	CANG	CANG
50	NONE	N	
52	OSPR	Y	Fledged
53	OSPR	Y	Fledged
54	NONE	N	
55	NONE	N	
56	NONE	N	
58	NONE	N	
59	NONE	N	
60	OSPR	Y	Fledged
61	OSPR	Y	Fledged
62	NONE	N	
64	OSPR	Y	Fledged
65	OSPR	Y	Fledged
66N	NONE	N	
66S	NONE	N	
67	CANG	CANG	CANG
68	CANG	CANG	CANG
80	NONE	N	
69	OSPR	Y	Fledged
72	OSPR	Y	Fledged
73	NONE	N	
74	NONE	N	
75	UNK	U	Unknown
76	UNK	U	Unknown
77	NONE	N	
78	OSPR	Y	Fledged
79	UNK	U	Unknown

Osprey Observation Summary 2018-2025

From 2018 to 2025, Teton Raptor Center Ambassadors have monitored a total of 79 nest platforms for Osprey activity. The number of platforms monitored each year has varied between 36 and 65 (Table 3). From 2018-2025 Osprey were observed at between 33% (2023) and 50% (2022) of monitored platforms. In 2025, 35% of monitored platforms had at least one Osprey observed on or near them at least once throughout the season (Figure 9). From 2018-2025 an average of eleven active Osprey nests produced chicks and an average of 19% of platforms monitored produced chicks. In 2025, 31 Osprey fledglings were produced from fifteen active nests.

Table 3. Number of Osprey platforms monitored each year with results for platforms with Osprey observed, Osprey incubating, and Osprey chicks observed from 2018-2025.

Year	# of Platforms monitored	# of Platforms not monitored	# with Osprey observed	# with Osprey incubating	# with Osprey chicks observed
2018	60	18	27	20	13
2019	59	19	26	19	7
2020	65	13	30	19	10
2021	62	16	22	14	11
2022	48	32	24	16	13
2023	36	44	12	7	6
2024	65	0	27	15	10
2025	63	3	22	17	15

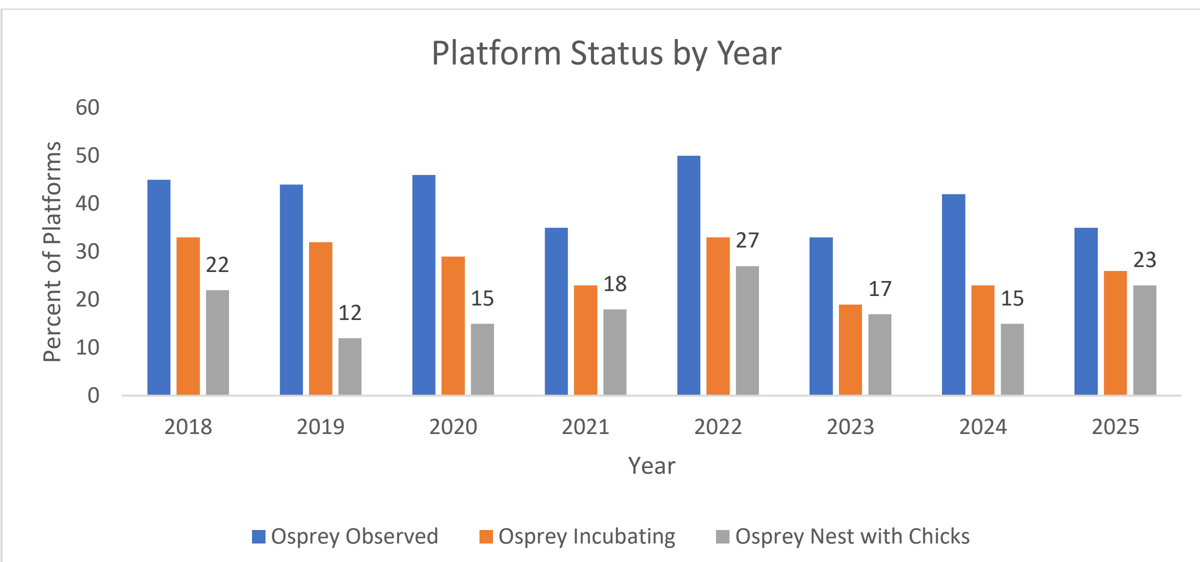


Figure 24. Osprey platform status by year based on percent of monitored platforms. 2025 was similar to previous years in all three categories. Note that these values will not add to 100% as a platform may have had osprey observed, then subsequently have Osprey incubating and then chicks in the nest and therefore be counted within all three categories.

In 2018, 60 Osprey nesting platforms were monitored. Of those a total of 27 platforms had Osprey observed at them, 20 of those platforms had Osprey incubating, and 13 of those had Osprey chicks observed on them. In terms of goose activity, 15 platforms had geese observed incubating on them. There was no osprey or goose activity documented at 18 of the platforms that were monitored in 2018.

In 2019, 59 Osprey nesting platforms were monitored. Of those a total of 26 platforms had Osprey observed at them, 19 of those platforms had osprey incubating, and 7 of those had Osprey chicks observed on them. In terms of goose activity, 14 platforms had geese observed incubating on them. There was no Osprey or goose activity documented at 19 of the platforms that were monitored in 2019.

In 2020, 65 Osprey nesting platforms were monitored. Of those a total of 30 platforms had Osprey observed at them, 19 of those platforms had Osprey incubating, and 10 of those had Osprey chicks observed on them. In terms of goose activity, 14 platforms had geese observed incubating on them. There was no Osprey or goose activity documented at 21 of the platforms that were monitored in 2020.

In 2021, 62 Osprey nesting platforms were monitored. Of those a total of 22 platforms had Osprey observed at them, 14 of those platforms had Osprey incubating, and 11 of those had Osprey chicks observed on them. In terms of goose activity, 13 platforms had geese observed incubating on them. There was no Osprey or goose activity documented at 27 of the platforms that were monitored in 2021.

In 2022, 48 Osprey nesting platforms were monitored. Of those a total of 24 platforms had Osprey observed at them, 16 of those platforms had Osprey incubating, and 13 of those had Osprey chicks observed on them. In terms of goose activity, 8 platforms had geese observed incubating on them.

In 2023, 36 Osprey nesting platforms were monitored. Of those a total of 12 platforms had Osprey observed at them, 7 of those platforms had Osprey incubating, and 6 of those had Osprey chicks observed on them. In terms of goose activity, 8 platforms had geese observed incubating on them.

In 2024, 69 Osprey nesting platforms were monitored. Of those a total of 27 platforms had Osprey observed at them, 15 of those platforms had Osprey incubating, and 10 of those had Osprey chicks observed on them. In terms of goose activity, 8 platforms had geese observed incubating on them.

In 2025, 63 Osprey nesting platforms were monitored. Of those, a total of 22 platforms had Osprey observed at them, 17 of those platforms had Osprey incubating, and 10 of those had Osprey chicks observed on them. In terms of goose activity, 4 platforms had geese observed incubating on them.

Discussion

Osprey productivity was double that of last year, when only 14 fledglings were produced. We were surprised by this difference and worked to verify with monitors that their nestling and fledgling counts were accurate. It seemed that they were, so we looked into some of the differences between 2024 and 2025. In 2024, only one of the platforms near Moran was successful, fledging two chicks, so two successful nests in 2025 doubled the productivity for that area. In 2024, Osprey were observed at platform 69 but they did not nest. That nest produced 3 fledglings this year! Near Kelly, productivity was the same as it was in 2024, with one nest producing two fledglings and the other producing one fledgling. Platform 33 on Highway 22 near Teton Raptor Center produced two fledglings. That section of road was modified to mitigate ungulate-vehicle collisions, with the construction wrapping up in mid-summer 2025. That platform was successful for several years, even fledging two young during the height of the construction, but often the fledglings from that nest are killed or injured by traffic. This year represented the first year in memory that fledglings from this nest were not admitted to the rehab center. We do not know if the exclusionary fencing along the highway played a role in this, but it will be interesting to monitor this trend into the future. Along Fall Creek Road, platforms 44, 52, and 53 each produced two fledglings, tripling productivity over last year, as only one of those platforms produced two fledglings in 2024. Platforms immediately south of Jackson had reduced productivity in 2025 compared to 2024. Only one platform produced two fledglings this year. In 2024, an additional platform produced one fledgling in that area. Near Hoback, productivity was higher than 2024 as well. Platform 72 failed last year, and produced two fledglings this year. Nests were initiated on four platforms south of Hoback in 2025, but only two of them were successful, fledging three young total. Interestingly, in 2024, platform 7 produced three fledglings, so productivity was similar in this area between the two years.

Conclusions

The annual monitoring of nest platforms in the Jackson Hole Valley for Osprey is important for understanding long-term trends in Osprey nesting activity and productivity for conservation efforts. Due to the large number of platforms across the study area, this project is completely dependent on the time and commitment of Teton Raptor Center Ambassadors to monitor the nest platforms throughout the breeding season. A summary of the past seven years of data indicates that Osprey have been observed at an average of 41% of the monitored platforms. Additionally, an average of 28% of monitored platforms have had Osprey incubating with 19% having had chicks observed on the nest.

Acknowledgements

This monitoring effort could not be completed without the volunteered time and dedication of Teton Raptor Center Ambassadors. We acknowledge Anne Hare, Bev Boynton, Ray White, Laura Timmerman, Kim Springer, Ty Cook, Becky Hawkins, Linnea Gardner, Hugh Byron and Bayless Sword, and Deb Patla for monitoring nest platforms in 2025, as well as dozens of other Teton Raptor Center Ambassadors who have spent countless hours monitoring platforms over the last ten years.

Establishing baseline hematological values for wild North American raptors to improve rehabilitation diagnosis

2025 Annual Report

Wyoming Permit 33-1410
Montana Permit (RVRI) 2024-2021-W
Idaho Permit 107449
BBL Permit 24140

Background

Wildlife rehabbers in North America annually care for thousands of raptors after they have been orphaned, injured, or poisoned by anthropogenic causes. Blood chemistry values can be helpful in diagnosing illnesses in wildlife, but there are limited data on baseline ranges for many raptors in North America, including Golden Eagle (GOEA), Great Gray Owl (GGOW), Ferruginous Hawk (FEHA), Swainson's Hawk (SWHA), American Goshawk (AGOS), Sharp-shinned Hawk (SSHA), Rough-legged Hawk (RLHA), Cooper's Hawk (COHA) and Merlin (MERL). For some of these species there are published blood chemistry ranges with a sample size of only one or two birds. Therefore, the data on blood chemistry could greatly be improved.

Blood chemistries have been tested for Golden Eagles in the eastern hemisphere, as well as in captivity (Polo et al. 2007, Nazif et al. 2008, Sonne et al. 2010) but there are no published normal ranges for blood chemistry values for wild Golden Eagles in North America. Similarly, while some hematological samples have been gathered from Great Gray Owls in captivity (Ammersbach et al. 2015), no samples exist from wild-caught owls.

Existing studies of captive birds can be evaluated against hematological data captured of wild raptors to evaluate the level of agreement between individual analytes and parameter ranges between captive and wild populations. Golden Eagles and Great Gray Owls are designated Species of Greatest Conservation Need in most states where they reside and other raptor species targeted in this project are either sensitive, understudied, or are of conservation concern. There is minimal research that has established normal hematological ranges for many North American raptors. Blood chemistry values can also be helpful caring for captive-bred populations of animals (Polo et al. 1992).

Recent advances in medical technology now allow for the in-house benchtop testing of blood samples to gather a wide suite of blood chemistry values. By using this technology to enhance our understanding and establish normal hematological values for understudied species, we can generate significant progress in the care of injured and sick North America raptors at rehabilitation centers and other facilities that house captive raptors. The successful completion of this project will aid in diagnostics and veterinary care for injured or ill raptors in wildlife rehabilitation and zoo facilities by providing accurate healthy blood chemistry ranges.

Methods

We are working to gather baseline data on hematological values for healthy, wild-captured understudied, and sensitive raptor species in North America using an Abaxis VetScan II benchtop blood chemistry analyzer. To achieve this, we aim to collect between 10-20 blood samples for each of the nine study species (GOEA, GGOW, FEHA, SWHA, AGOS, SSHA, RLHA, COHA, and MERL) with a combination of samples from both nestling (NSTL) and non-nestling (non-NSTL) individuals, when possible, to compare reference values for those age classes and avoid bias in the study by collecting only samples from nestlings which are being fed by their parents, possibly affecting their blood chemistry readings.

Teton Raptor Center’s research team runs a fall migration raptor banding station in the Big Belt Mountains near Townsend, Montana. This site is known to host a large concentration of migratory raptors with >1,300 raptors migrating through the site while it is stationed. During this annual migration study, we safely capture, band, and sample between 150-200 wild individuals of our nine study species, as well as other species that we capture and sample opportunistically. We also have ongoing studies with GGOW, AGOS, and FEHA which allow us to retrieve blood samples from most of our target species throughout the year. We can supplement our sample sizes as necessary through target trapping.

Once a raptor is in-hand, we collect whole blood to analyze the blood chemistry. Birds that are deemed unhealthy due to low body condition, major injury, or heavy ectoparasite loads are not included in the study. Raptors with any food in the crop are not sampled as the recent meal may cause lab value aberrations that would skew a normal range. The collection will take place at the same time in the afternoon between 10:00 AM and 5:00 PM, to reduce diurnal variation biases (Sennels et al. 2011).

We collect ~ 0.5 - 1.0mL of whole blood via basilic vein into syringes with varying gauge needle sizes depending on the species and move blood quickly and carefully to a Lithium heparin microtube. To maximize accuracy of the results, the blood analyses are run within 2 hours and denoted as such if unable to be run within the targeted time.

To minimize the effects of capture myopathy on the creatine kinase levels, participants' heads are covered with falconer hoods to reduce visual stimuli, and venous collection is performed as quickly as possible once each bird is safely captured and restrained. The Vetscan II provides indices for hemolysis, lipemia, and icterus values on a scale of 0 (clear)-3+(gross). Samples which had an index of greater than 2+(moderate) are discarded. To reduce the impacts of hemolysis on sample analysis, the largest gauge needles are used per species, but in the case of the smallest raptors, insulin syringes must be used. To reduce the impact of lipemia on sample analysis, birds with full crops are not sampled, as recent meals can impact fat levels in the blood. See Appendix 2 and 3 for full results of all samples and samples with acceptable QC levels.

Samples are collected and run by our team of research biologists, interns, as well as our veterinary medical team. All those involved with the study have been trained in proper sample retrieval and operation of the Vetscan II. The samples are collected from raptors in Montana, Wyoming, and Idaho and include both resident and migratory populations. Sample acquisition began in 2022 and is targeted to be complete by fall 2026. The study is monitored by a combination of Teton Raptor Center staff including Bryan Bedrosian (Conservation Director), Hilary Turner (Research Biologist), and Dr. Salene Freeman (DVM).

Abaxis VetScan II provides values on 12 analytes (Appendix 1) and we performed calculations of the mean, median, minimum, and maximum values for each species (Appendix 2 and 3). Once we have a minimum of ten samples for each species, we will use them to determine an interval for each species (Appendices 2 and 3).

Results

In 2025, we collected samples from 27 raptors, representing 7 species (Figure 1). Species captured and sampled included FEHA, SSHA, COHA, MERL, Northern Harrier (NOHA), Broad-winged Hawk (BWHA), and Harlan's Red-tailed Hawk. All samples were collected from non-NSTL individuals this year.

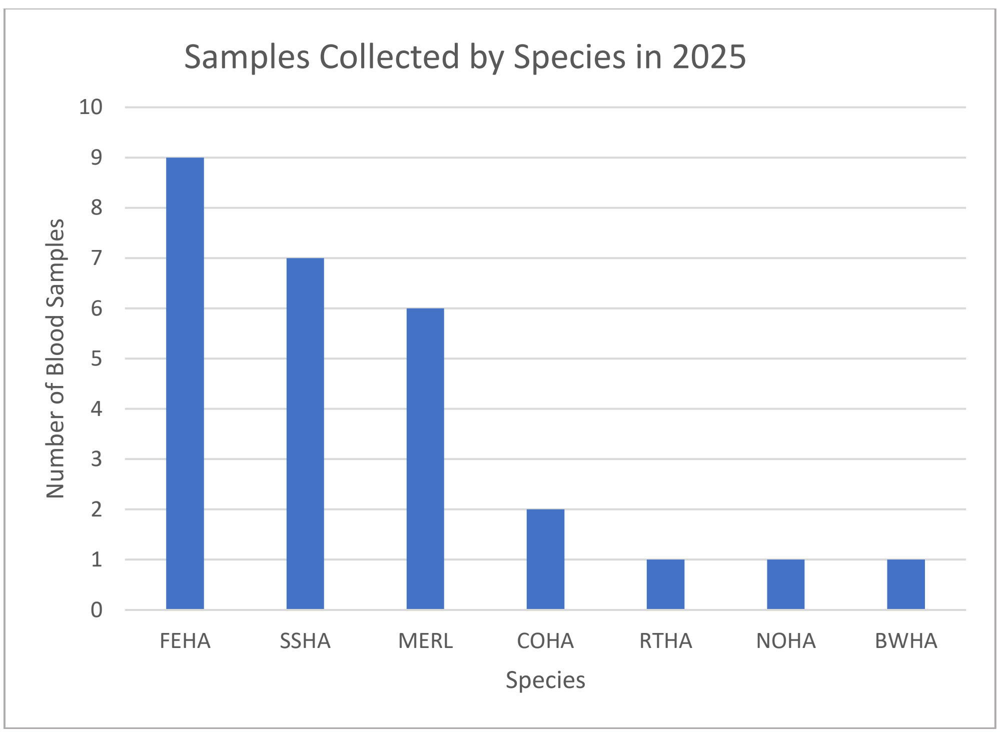


Figure 25. In 2024, we collected blood samples from 9 FEHA, 7 SSHA, 6 MERL, 2 COHA, 1 RTHA (Harlan's subspecies), 1 NOHA, and 1 BWHA. All of the individuals sampled this year were fully flighted.

Since the study commenced in 2022, we have collected and analyzed 140 blood samples from 17 species in Wyoming, Idaho, and Montana (Figure 2; Appendix 3 and 4). Species captured and sampled included FEHA, SSHA, COHA, AGOS, SWHA, MERL, RTHA, PRFA, AMKE, NOHA, PEFA, BWHA, BAEA, GGOW, RLHA, and Common Raven (CORA). We have been able to collect both NSTL and non-NSTL samples from GOEA, AGOS, FEHA, SWHA and GGOW. The rest of the species are only represented by non-NSTL individuals.

Of the 140 samples, 120 are from the nine species we outlined for this study (Figure 3). We aim to collect between 10-20 samples for each of these species and we have acquired sufficient samples for FEHA, GOEA, AGOS, SSHA and GGOW. However, our goal is to include both NSTL and non-NSTL individuals in our samples, when possible, to avoid bias and some study species are skewed in one direction or the other. In 2025, all samples collected were from non-NSTL individuals.

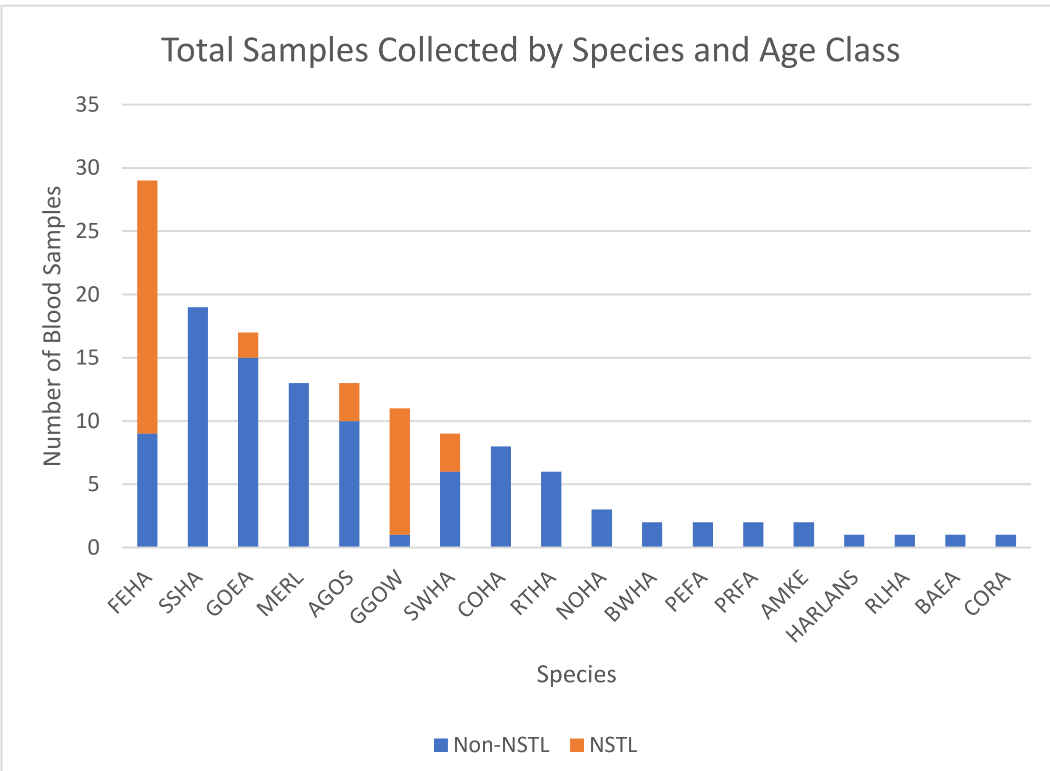


Figure 26. The number of samples per species collected since the start of the study by age class.

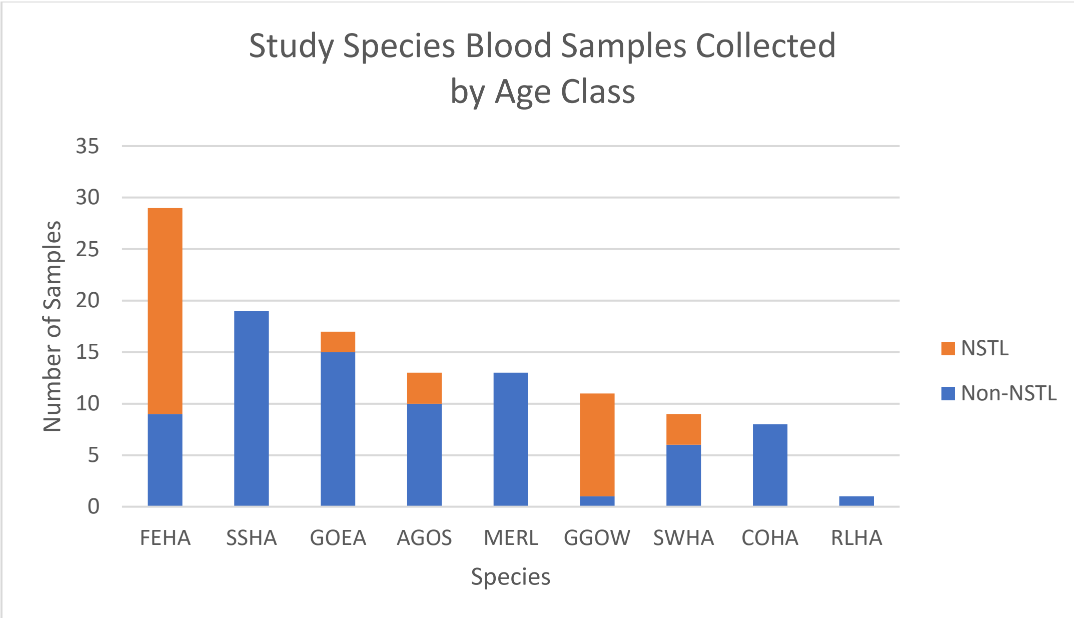


Figure 27. The total number of blood samples collected from study species by age class since the study started in 2022. We collected 20 FEHA NSTL and 9 FEHA NON-NSTL samples, 15 GOEA NON-NSTL and 2 GOEA NSTL samples, 10 AGOS NON-NSTL and 3 AGOS NSTL samples, 19 SSHA NON-NSTL samples, 10 GGOW NSTL and 1 GGOW NON-NSTL samples, 6 SWHA NON-NSTL samples and 3 SWHA NSTL samples, 13 MERL NON-NSTL samples, 8 COHA NON-NSTL samples, and 1 RLHA NON-NSTL sample.

Ferruginous Hawk Results

Our sample size of quality-controlled data for Ferruginous Hawks allowed us to do a more thorough analysis to compare some of the blood chemistry values for adults (n = 7) and nestlings (n = 10). We compared values for 11 blood analytes (Table 1). We found that there was a significant difference (p-value <0.05) between adults and nestlings for seven of the blood analytes: CK U/L, UA mg/dL, GLU mg/dL, CA mg/dL, PHOS mg/dL, TP g/dL and K+ mmol/L (Figure 4). All the other blood analytes were not significantly different between adults and nestlings.

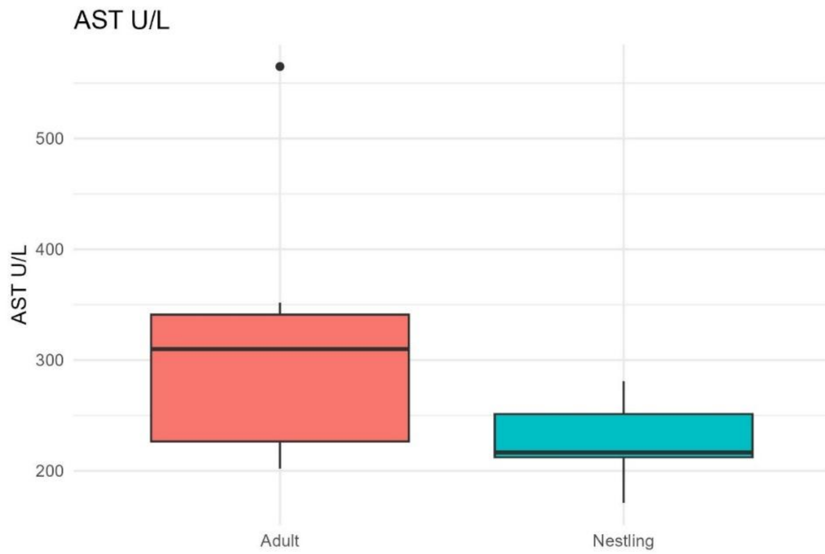
Table 1. Blood Analyte values (mean +/- sd) for adult and nestling Ferruginous Hawks with test statistic and p-values for t-tests comparing the two. Significant p-values at the <0.05 level are represented by a *.

Analyte	Adult	Nestling	statistic	p-value
AST U/L	316 +/- 124	226 +/- 33	1.88	0.105
CK U/L	955 +/- 1006	2127 +/- 589	-2.77	0.022*
UA mg/dL	4.7 +/- 1.5	11.7 +/- 3.6	-5.53	<0.001*
GLU mg/dL	359 +/- 42	244 +/- 26	6.40	<0.001*
CA mg/dL	9.5 +/- 0.3	10.9 +/- 0.4	-7.51	<0.001*
PHOS mg/dL	1.5 +/- 0.7	6.2 +/- 0.5	-14.66	<0.001*
TP g/dL	3.8 +/- 0.2	3.4 +/- 0.2	3.45	<0.005*
ALB g/dL	3.0 +/- 0.3	2.8 +/- 0.2	1.71	0.120
GLOB g/dL	0.7 +/- 0.4	0.6 +/- 0.1	0.74	0.486

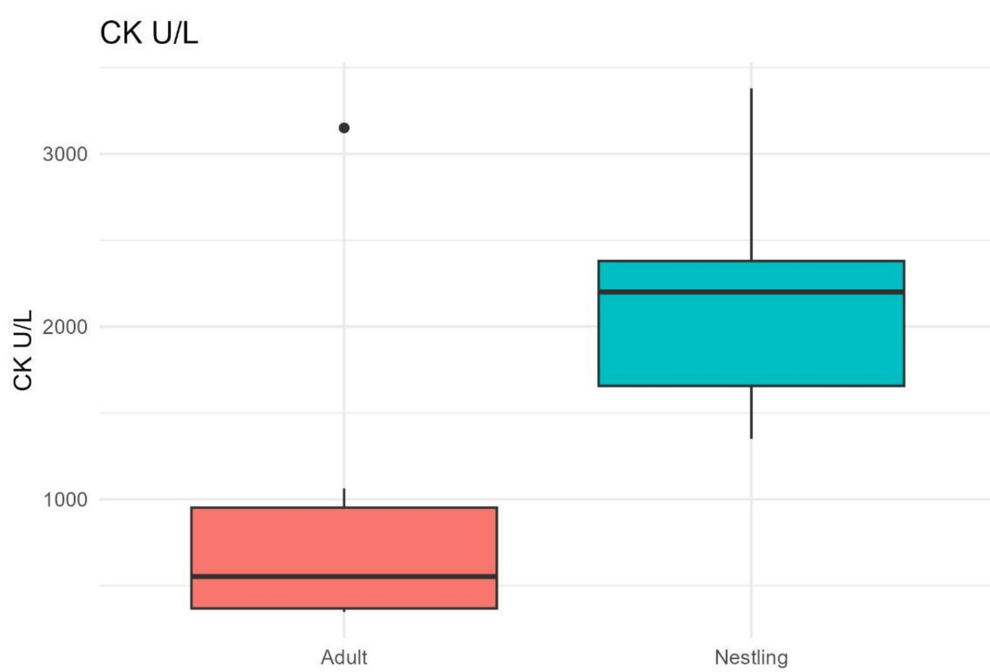
K+ mmol/L	2.2 +/- 0.8	4.0 +/-1.4	-3.19	0.008*
NA+ mmol/L	145.7 +/- 3.8	144 +/- 4	1.03	0.319

Figure 4. Boxplots of blood analyte values adult vs. young (nestling) Ferruginous Hawks for (A) AST U/L, (B) CK U/L, (C) UA mg/dL, (D) GLU mg/dL, (E) CA mg/dL, (F) PHOS mg/dL, (G) TP g/dL, (H) ALB g/dL, (I) GLOB g/dL, (J) K+ mmol/L, and (K) NA+ mmol/L.

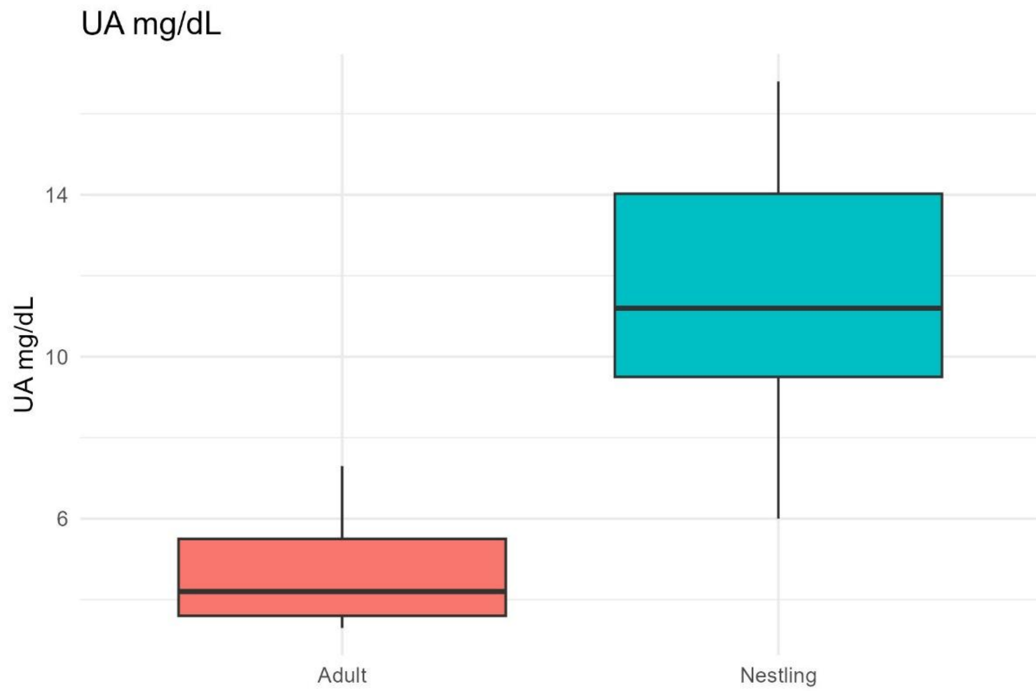
(A) Aspartate Aminotransferase – Ferruginous Hawks



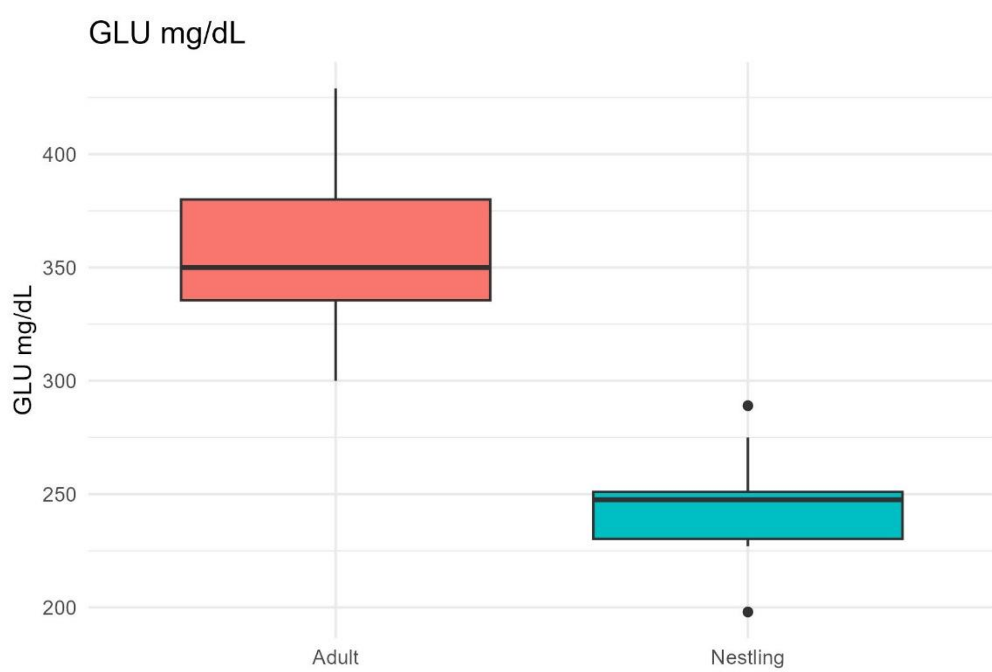
(B) Creatine Kinase – Ferruginous Hawks



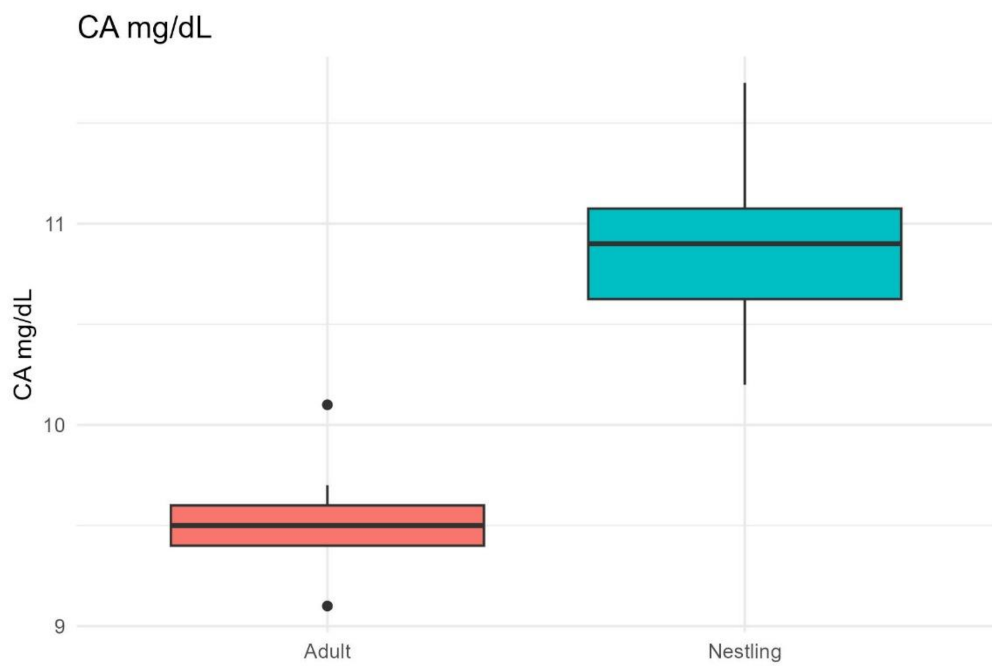
(C) Uric Acids – Ferruginous Hawks



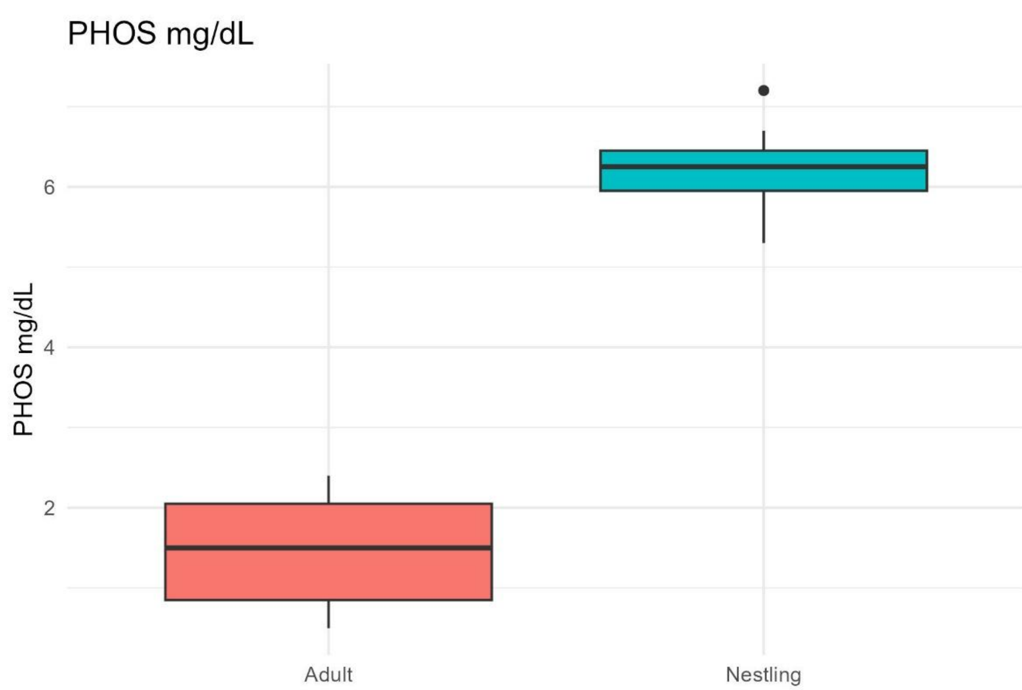
(D) Glucose – Ferruginous Hawks



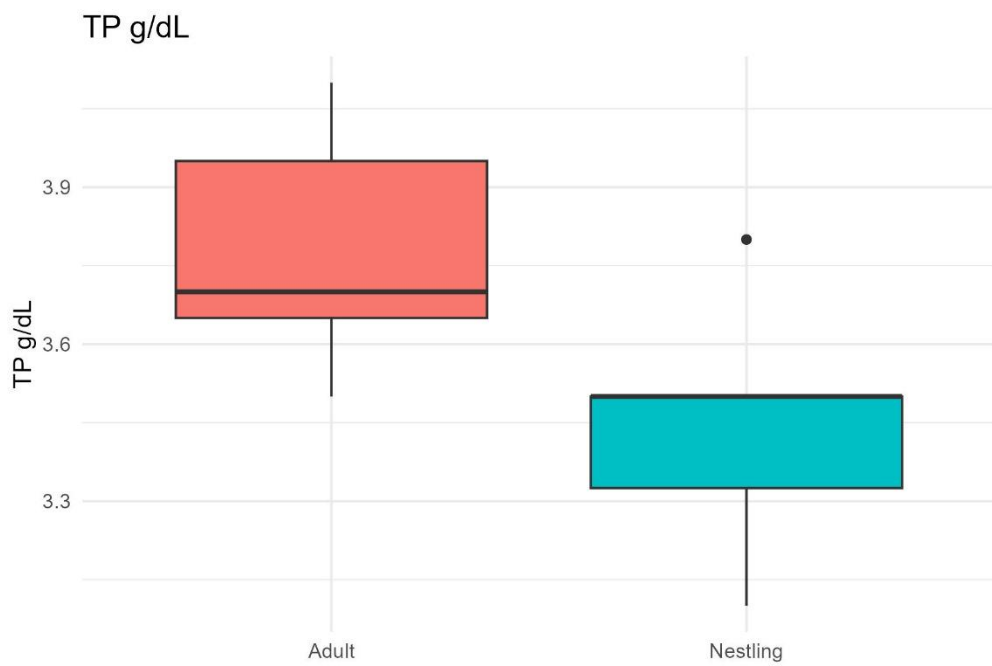
(E) Calcium – Ferruginous Hawks



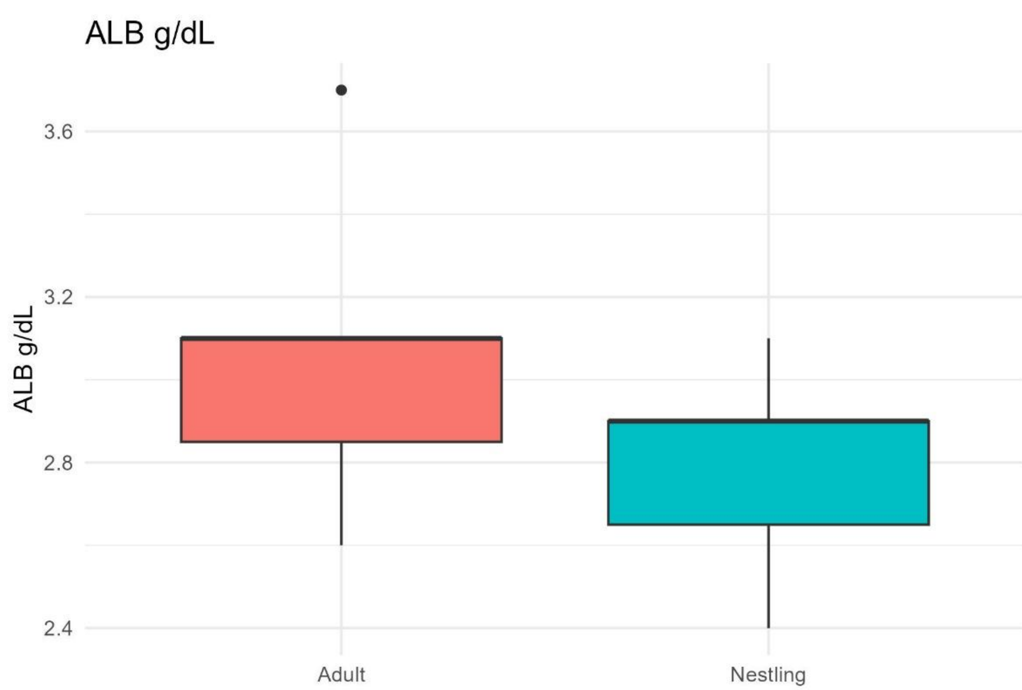
(F) Phosphorus – Ferruginous Hawks



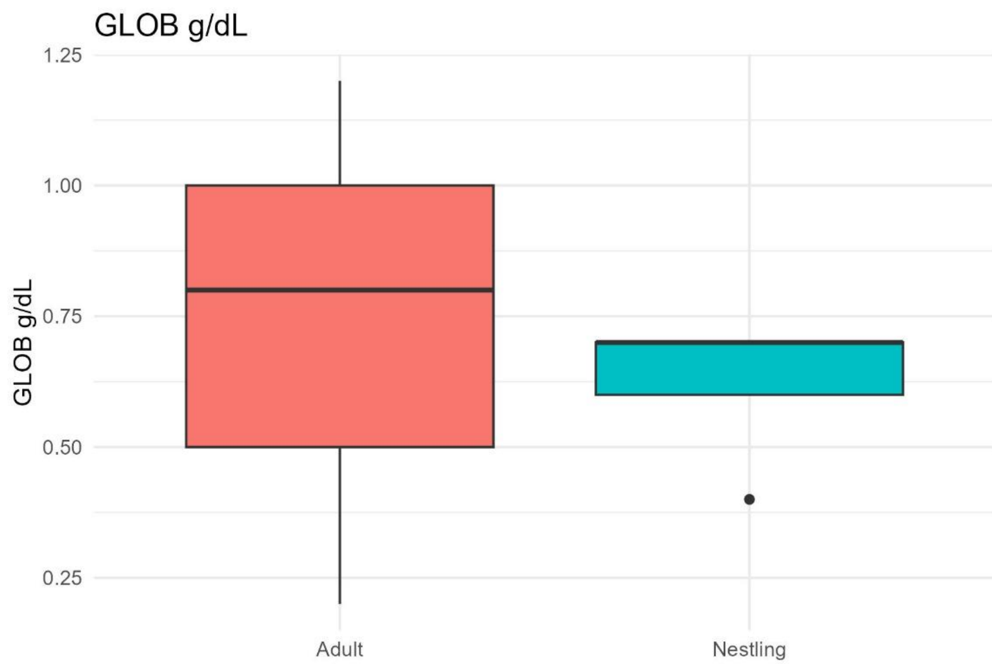
(G) Total Protein - Ferruginous Hawks



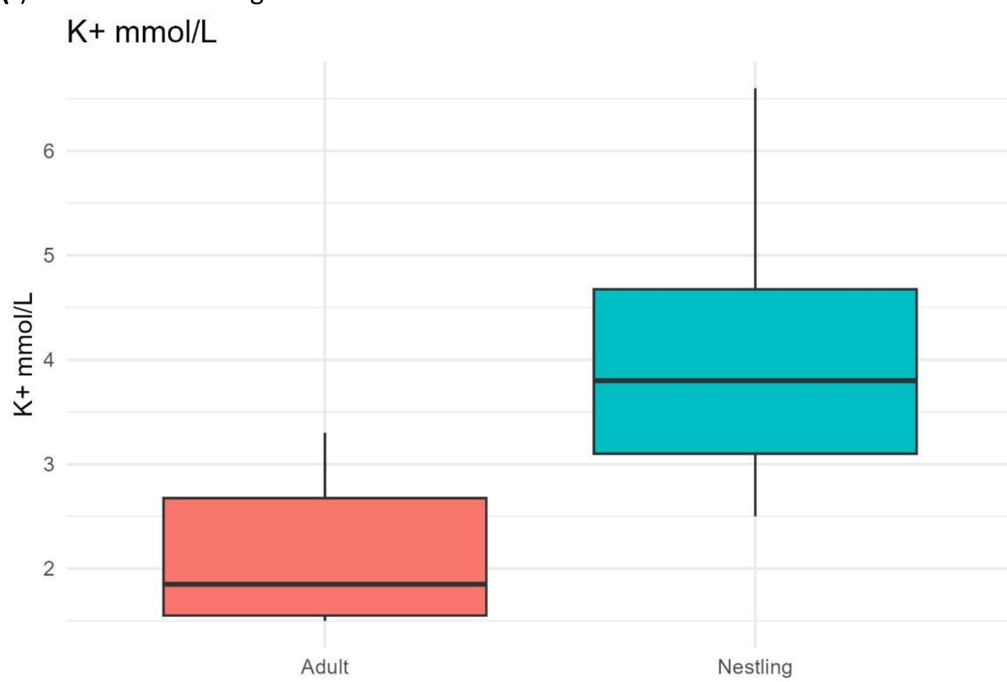
(H) Albumin – Ferruginous Hawks



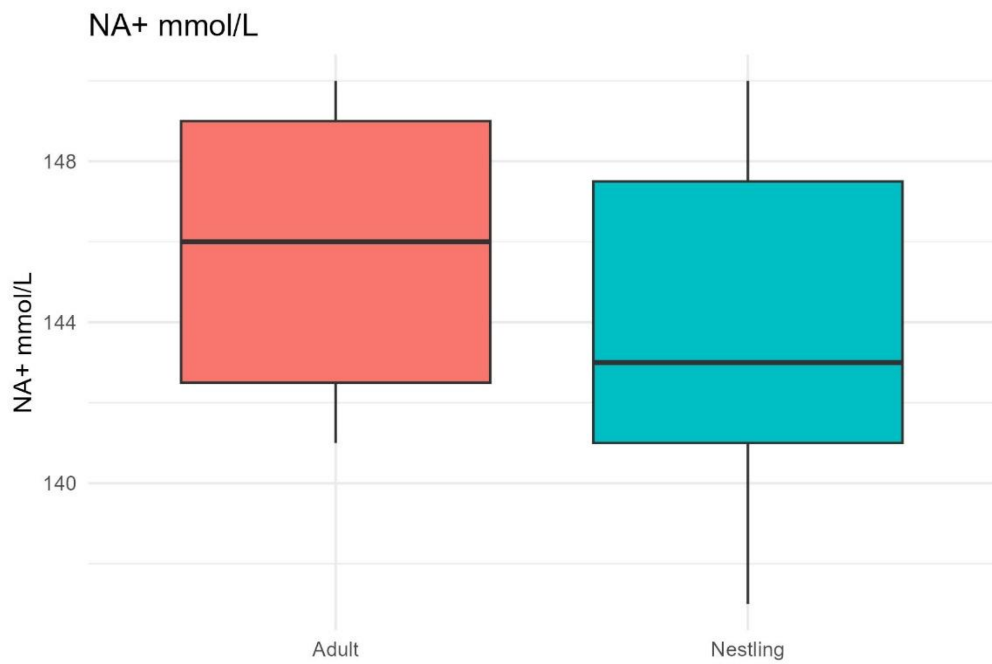
(I) Globulin – Ferruginous Hawks



(J) Potassium – Ferruginous Hawks



(K) Sodium – Ferruginous Hawks



Importance of Quality Controlled Data

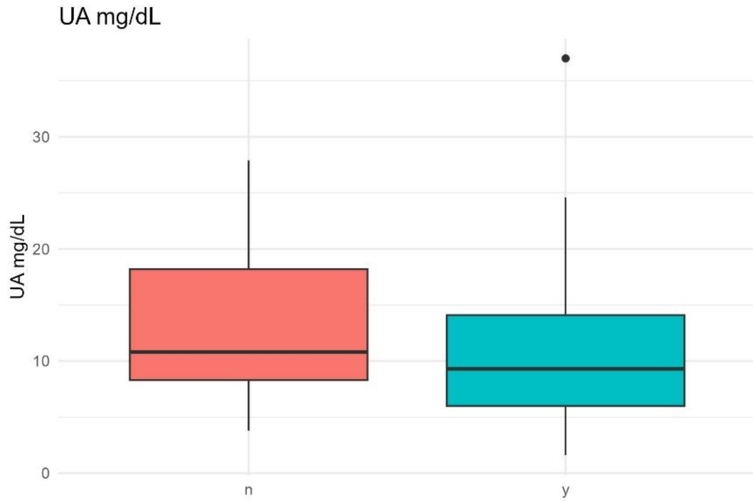
Quality-controlled (QC) data for the purposes of our study are determined based on having HEM, LIP and ICT values of less than 2+. To determine how using quality-controlled data vs. non-quality-controlled data influences the blood analyte values we compared the results of 11 blood analytes across all species. In total, 74 samples were QC, while 53 samples were non-QC. We found that there was a significant difference between two blood analytes, CA mg/dL and ALB g/dL based on a p-value of <0.05 (Table 2, Figure 5). We had one additional variable that was marginal, UA mg/dL which had a p-value of 0.057. These results indicate the importance of using quality-controlled data when analyzing the results of those three blood analytes across all raptor species.

Table 2. Blood Analyte values (mean +/- sd) for quality controlled (QC) vs. non-QC data across all species with test statistic and p-values for t-tests comparing the two. Significant p-values at the <0.05 level are represented by a *.

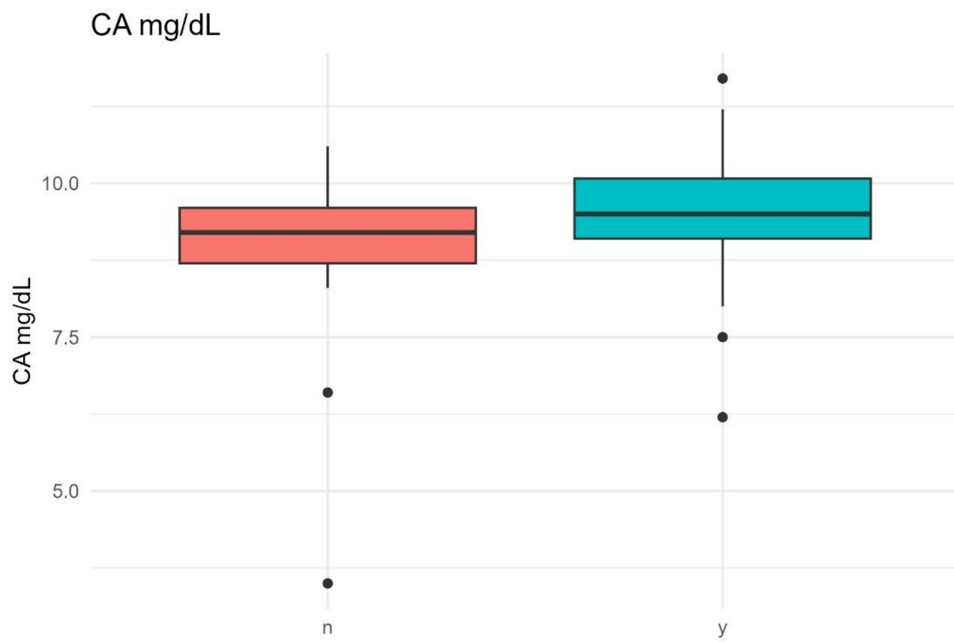
Analyte	QC data	Non-QC data	test statistic	p-value
AST U/L	346 +/- 238	394 +/- 322	0.92	0.3623
CK U/L	1155 +/- 786	1319 +/-735	1.19	0.2382
UA mg/dL	10.5 +/- 6.3	12.7 +/- 5.9	1.93	0.0570
GLU mg/dL	319 +/- 51	330 +/-45	1.29	0.1985
CA mg/dL	9.6 +/- 0.9	9.0 +/- 1.0	-2.99	0.0035*
PHOS mg/dL	3.8 +/- 2.0	3.4 +/- 1.8	-1.10	0.2716
TP g/dL	3.4 +/- 0.4	3.5 +/- 0.5	0.95	0.3423
ALB g/dL	2.5 +/- 0.5	2.7 +/- 0.4	2.05	0.0423*
GLOB g/dL	0.9 +/- 0.5	0.8 +/- 0.7	-0.89	0.3763
K+ mmol/L	3.1 +/- 0.9	3.3 +/- 1.5	0.61	0.5463
NA+ mmol/L	147 +/- 4	148 +/-5.6	0.47	0.6425

Figure 5. Boxplots of blood analyte values quality controlled (QC) vs. non-QC data across all species samples for (A) UA mg/dL, (B) CA mg/dL, and (C) ALB g/dL.

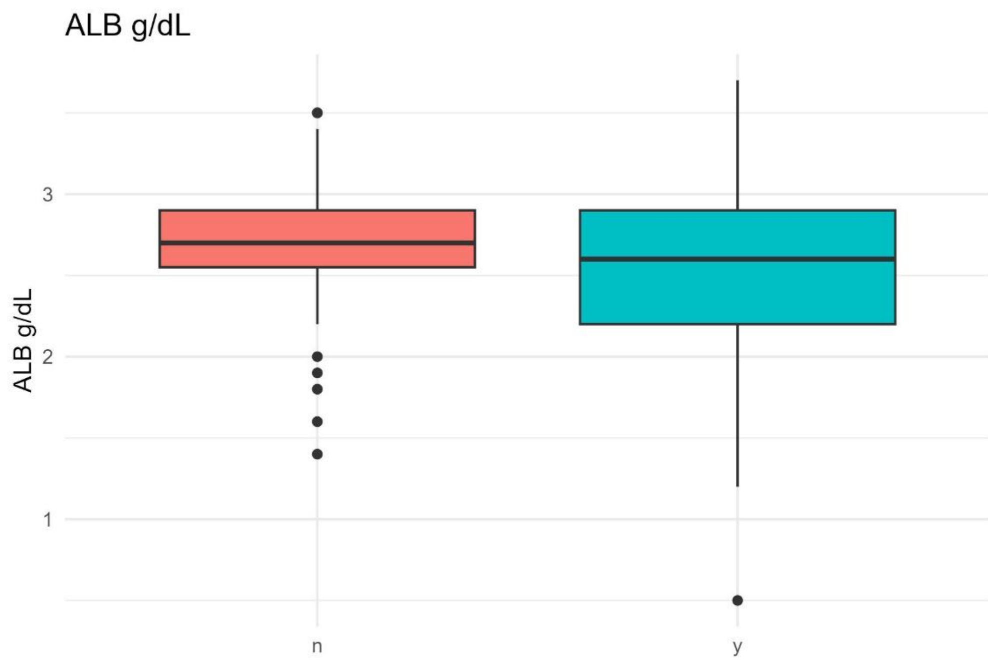
(A) Uric Acids – non-QC (n) vs. QC (y) data



(B) Calcium – non-QC (n) vs. QC (y) data



(C) Albumin – non-QC (n) vs. QC (y) data



Next Steps

We will continue the project to augment sample sizes for those with fewer than twenty samples per species. We were unable to obtain sufficient samples of several species at our migration site so we will target them via road trapping with bal-chatris during 2026 and we will aim to wrap up data collection at our migration site in fall 2026.

Acknowledgments

We thank Meghan Warren, Sheena Patel, Connor Hartnet, Selene Freeman, and other TRC clinic staff and interns for support of this project. Funding was provided by Teton Conservation District, Meg and Bert Raynes Wildlife Foundation and Zoetis.

Appendix 1. Blood Analytes and their definitions.

Aspartate Aminotransferase (AST)
AST is a non-specific liver leakage enzyme meaning that when there is direct liver damage or inflammation, this enzyme is released from the hepatocytes. Elevations in AST typically take 12-48 hours to rise. AST is also a skeletal muscle leakage enzyme and is found in the muscles, heart, and brain. Direct damage to muscle can cause an increase in this value as well and take 12-48 hours to rise.

Creatine Kinase (CK)
CK is a specific muscle leakage enzyme that increases in blood with muscle damage or inflammation. CK values are quick to rise within 1-6 hours of incident and begin to decrease around 24 hours. In combination with AST, we know that there has been muscle damage within the last 12-48 hours.

Uric Acids (UA)
Uric acids are a product of nitrogenous waste that are produced in the liver and excreted by the kidneys. When values are elevated, we know that toxins are not being excreted from the body, so there is dysfunction of some sort.

Glucose
Glucose is stored in the liver as glucagon and is a primary metabolite for all homeostasis in the body.

Calcium (Ca)
Regulated by parathyroid hormone (PTH) (the gland above the thyroid). PTH acts to increase serum Ca from bone, kidneys, and from the diet in the intestines.

Phosphorus (Phos)
Filtered and excreted by the kidneys. There is a P:Ca transporter in the kidneys.

Potassium (K+)
Filtered and excreted by the kidneys via the Na/K/ATPase pump. Intracellular electrolyte, so it is not normal to have large amounts of potassium in circulation. K also important for heart contractions.

Sodium (Na)
Primary osmolarity regulator in the body. Water follows salt everywhere. Filtered by kidneys via the Na/K/ATPase pump to regulate blood pressure (BP) and hydration status. Na also important for skeletal muscle contraction.

Total Protein (TP)
TP= Albumin + Globulins; looks at total protein in vasculature which is important for maintaining BP.

Albumin (Alb)
Comprise 40-50% of plasma proteins in vasculature and produced in the liver.

Globulin (Glob)
Comprised of antibodies and acute phase proteins (inflammatory proteins to signal inflammatory pathways).

Appendix 2. Mean, Median, Minimum, and Maximum Values for 11 analytes from all raptors sampled during the study regardless of QC index.

		AST U/L				CK U/L				UA mg/dL				GLU mg/dL				CA mg/dL				PHOS mg/dL				TP g/dL				ALB g/dL				GLOB g/dL				K+ mmol/L				NA+ mmol/L				HEM		LIP		ICT	
	N	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Min	Max	Min	Max	Min	Max
GOEA																																																			
Nestling	**2**	255	255	159	351	1512	1512	1339	1685	15.9	15.9	13.5	18.2	266	266	250	281	9.9	9.9	9.8	9.9	3.6	3.6	3.2	4.0	3.3	3.3	3.0	3.5	1.5	1.5	1.4	1.6	1.7	1.7	1.5	1.9	3.4	3.4	2.8	4.0	143	143	142	144	0	1+	3+	3+	0	0
Non-Nestling	**15**	218	183	107	406	1059	726	342	4412	7.5	5.8	1.6	16.8	340	338	291	407	9.1	9.3	6.2	10.5	2.6	2.7	1.9	3.7	3.3	3.5	2.5	3.8	1.9	2.0	1.2	2.5	1.5	1.4	1.0	2.5	3.5	3.5	2.0	5.7	148	148	143	153	0	2+	0	1+	0	0
Total	***17***	222	183	107	406	1112	819	342	4412	8.5	8.8	1.6	18.2	331	331	250	407	9.2	9.4	6.2	10.5	2.8	2.7	1.9	4.0	3.3	3.4	2.5	3.8	1.9	1.8	1.2	2.5	1.5	1.5	1.0	2.5	3.6	3.5	2.0	5.7	147	147	142	153	0	2+	0	3+	0	0
GGOW																																																			
Nestling	**10**	222	211	195	276	1567	1465	510	3301	8.0	7.7	3.8	14.8	297	302	224	341	10.0	10.1	8.8	10.6	7.5	7.7	4.7	10.6	3.4	3.3	3.1	4.0	2.3	2.2	2.1	2.7	1.1	1.1	0.8	1.3	2.9	3.1	1.8	3.8	142	144	120	151	0	3+	0	1+	1+	1+
Non-Nestling	**1**	135				877				8.4				304				9.4				5.0				3.3				1.9				1.4				2.3				143				1+		0		0	
Total	***11***	214	209	135	276	1504	1461	510	3301	8.0	8.1	3.8	14.8	297	304	224	341	10.0	10.0	8.8	10.6	7.3	7.6	4.7	10.6	3.4	3.3	3.1	4.0	2.2	2.2	1.9	2.7	1.1	1.1	0.8	1.4	2.8	2.9	1.8	3.8	142	143	120	151	0	3+	0	1+	0	1+
FEHA																																																			
Nestling	**20**	217	216	171	281	2195	2234	1351	3380	11.5	11.1	6.0	16.8	244	247	198	289	10.9	10.9	10.2	11.7	6.2	6.3	5.3	7.2	3.5	3.5	3.1	3.8	2.8	2.9	2.4	3.1	0.6	0.7	0.4	0.7	3.9	2.5	1.5	6.6	144	142	137	150	0	2+	0	1+	0	0
Non-Nestling	**9**	311	310	202	565	1074	840	347	3151	5.4	4.9	3.3	16.8	358	350	300	429	9.5	9.4	9.1	10.1	1.6	1.8	0.5	2.5	3.7	3.7	2.9	4.1	3.0	2.9	2.5	3.7	0.8	0.8	0.1	1.6	2.0	1.7	1.5	3.3	145	146	141	150	0	2+	0	2+	0	1+
Total	***29***	246	217	171	565	1847	2175	347	3380	9.6	9.6	3.3	16.8	279	248	198	429	10.5	10.6	9.1	11.7	4.8	5.9	0.5	7.2	3.5	3.5	2.9	4.1	2.9	2.9	2.4	3.7	0.7	0.7	0.1	1.6	3.5	3.3	1.5	6.6	144	144	137	150	0	2+	0	2+	0	1+
AGOS																																																			
Nestling	**3**	732	728	473	994	2119	2431	1493	2433	16.0	16.0	12.0	19.9	252	264	211	281	9.5	9.3	9.2	10.0	4.6	4.2	2.6	7.0	2.7	2.7	2.4	3.0	1.8	1.8	1.3	2.2	0.9	0.9	0.8	1.1	4.0	4.0	2.4	5.6	154	151	150	160	0	1+	0	1+	0	0
Non-Nestling	**10**	564	477	350	1123	611	577	372	964	14.3	12.8	5.1	25.0	335	330	257	444	8.7	8.7	8.0	9.4	2.7	2.5	0.8	4.6	3.2	3.1	2.6	3.5	2.3	2.5	0.5	3.0	0.7	0.5	0.1	1.5	2.5	2.2	2.0	3.7	149	149	143	155	0	2+	0	1+	0	0
Total	***13***	653	538	350	1194	975	756	372	2433	14.7	14.6	5.1	25.0	319	323	211	444	8.9	8.9	8.0	10.0	3.2	2.6	0.8	7.0	3.0	3.1	2.4	3.5	2.2	2.4	0.5	3.0	0.7	0.5	0.1	1.5	2.7	2.4	1.7	5.6	149	150	143	160	0	2+	0	1+	0	1+
SSHA																																																			
Non-Nestling	**18**	598	528	378	1475	859	791	470	1532	11.6	9.4	4.9	22.8	337	334	279	383	9.2	9.2	8.3	10.2	3.5	3.4	1.9	5.7	3.4	3.5	2.8	3.9	3.0	3.0	2.5	3.5	0.5	0.4	0.1	1.1	3.0	3.1	1.6	5.0	152	152	147	157	0	3+	0	2+	0	0
SWHA																																																			
Nestling	**3**	311	313	242	377	1559	1611	1320	1745	12.9	13.6	11.1	13.9	263	260	249	280	10.0	10.0	9.4	10.6	5.2	5.3	4.8	5.6	3.2	3.1	3.0	3.6	2.5	2.3	2.3	2.8	0.8	0.8	0.7	0.8	3.2	3.3	3.1	3.3	145	146	142	147	0	0	0	1+	0	0
Non-Nestling	**6**	434	427	236	758	951	921	614	1745	12.4	14.1	4.5	18.5	299	296	274	341	9.8	9.8	9.6	10.6	3.4	3.0	1.5	6.4	4.4	4.5	3.5	5.1	2.4	2.4	1.9	3.1	2.0	2.1	0.4	3.1	1.9	1.9	1.7	3.3	145	145	141	151	0	2+	0	3+	0	1+
Total	***9***	393	377	236	758	1211	1320	614	1745	12.5	13.6	4.5	18.5	287	282	249	341	9.9	9.9	9.4	10.6	4.0	4.7	1.5	6.4	4.0	4.1	3.0	5.1	2.4	2.3	1.9	3.1	1.6	1.3	0.4	3.1	2.5	2.2	1.7	3.3	145	145	141	151	0	2+	0	3+	0	1+
COHA																																																			
Non-Nestling	**6**	722	542	348	1903	1321	1164	367	2640	17.1	18.7	6.3	25.0	327	333	290	382	8.6	9.3	3.5	9.8	4.0	3.5	2.3	6.7	3.7	3.8	2.9	4.0	2.8	2.7	2.6	3.4	0.8	0.8	0.4	1.2	3.2	3.1	2.0	4.7	152	152	146	157	0	2+	0	3+	0	1+
MERL																																																			
Non-Nestling	**9**	120	125	66	187	1466	1364	936	2150	10.9	10.3	4.5	21.2	327	320	290	371	8.5	8.5	7.5	9.0	2.2	1.9	1.6	3.2	3.0	3.0	2.4	3.5	2.8	2.9	2.1	3.1	0.2	0.1	0.0	0.5	4.0	3.4	2.4	6.3	148	149	143	153	1+	3+	0	3+	0	1+
RTHA																																																			
Non-Nestling	**7**	342	362	233	412	1321	1243	603	2485	11.3	9.8	6.6	17.1	336	329	292	371	9.6	9.6	8.7	10.5	3.3	3.5	2.0	4.6	3.9	4.0	3.1	4.2	2.6	2.7	2.0	3.0	1.3	1.3	1.0	1.8	3.4	3.3	2.8	4.2	149	148	147	152	0	2+	0	3+	0	0
PEFA																																																			
Non-Nestling	**2**	108	108	77	139	800	800	791	808	11.3	11.3	11.3	11.3	319	319	279	359	8.7	8.7	8.5	8.8	2.5	2.5	1.6	3.3	3.2	3.2	3.1	3.2	2.8	2.8	2.7	2.8	0.4	0.4	0.3	0.4	1.8	1.8	1.8	1.8	147	147	146	147	2+	3	0	3	0	0
NOHA																																																			
Non-Nestling	**3**	415	396	361	487	587	585	487	690	22.9	22.9	8.8	37.0	355	339	333	394	9.9	9.9	9.5	10.3	4.3	3.7	3.4	5.9	3.9	3.5	3.3	4.8	2.9	2.9	2.8	2.9	1.0	0.6	0.5	1.9	4.3	4.2	2.5	6.1	149	148	147	151	0	2+	0	1+	0	0
PRFA																																																			
Non-Nestling	**2**	79	79	67	91	1012	1012	812	1212	8.4	8.4	7.4	9.3	358	358	318	397	9.5	9.5	9.2	9.7	1.9	1.9	1.8	2.0	3.3	3.3	3.1	3.5	2.5	2.5	2.3	2.6	0.9	0.9	0.6	1.2	2.2	2.2	2.0	2.3	148	148	144	152	0	0	0	0	0	1+
AMKE																																																			
Non-Nestling	**3**	136	154	95	160	2041	1218	810	4094	15.5	16.4	11.6	18.5	417	416	384	451	8.6	8.7	8.4	8.8	2.0	1.9	1.6	2.6	3.2	3.2	3.0	3.3	2.6	2.6	2.3	2.8	0.6	0.7	0.5	0.7	5.4	5.8	4.2	6.2	147	148	145	148	2+	3+	0	3+	0	1+
BWHA																																																			
Non-Nestling	**2**	320	320	295	344	1167	1167	1154	1179	14.2	14.2	3.6	24.7	343	343	337	348	9.7	9.7	9.6	9.8	3.1	3.1	2.9	3.2	3.9	3.9	3.8	3.9	3.4	3.4	3.2	3.5	0.6	0.6	0.5	0.6	3.8	3.8	3.2	4.4	151	151	149	153	1+	2+	0	0	0	0
RLHA																																																			
Non-Nestling	**1**	324				772				6.9				390				8.7				2.8				3.1				2.6				0.5				3.7				147				2+		0		0	
BAEA																																																			
Non-Nestling	**1**	414				2706				0.9				245				10.1				3.4				3.2				1.8				1.4				3.8				147									
CORA																																																			
Non-Nestling	**1**	392				254				9.5				411				8.9				1.4				4.1				3.5				0.7				4.3				154				2+		3+		0	

Appendix 3. Mean, Median, Minimum, and Maximum Values for 12 analytes from all raptors sampled during the study, which had an acceptable HEM QC index of <2+

	N	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max
GOEA																									
Nestling	**0**																								
Non-Nestling	**14**	216	179	107	406	1069	691	342	4412	7.1	4.3	1.6	16.8	341	340	291	407	9.1	9.3	6.2	10.5	2.7	2.7	2.0	3.7
Total	***14***	216	179	107	406	1069	691	342	4412	7.1	4.3	1.6	16.8	341	340	291	407	9.1	9.3	6.2	10.5	2.7	2.7	2.0	3.7
GGOW																									
Nestling	**6**	215	204	195	276	1398	1371	914	1955	7.9	6.7	5.4	14.8	295	297	263	326	10.1	10.1	9.9	10.4	7.4	7.7	6.4	8.5
Non-Nestling	**1**	135				877				8.4				304				9.4				5.0			
Total	***7***	203	199	135	276	1323	1281	877	1955	7.9	7.3	5.4	14.8	296	299	263	326	10.0	10.0	9.4	10.4	7.1	7.6	5.0	8.5
FEHA																									
Nestling	**20**	220	216	171	281	2186	2226	1351	3380	11.5	10.4	6.0	16.8	245	248	198	289	10.9	10.9	10.2	11.7	6.2	6.2	5.3	7.2
Non-Nestling	**9**	309	286	202	565	1046	696	347	3151	5.3	4.6	3.3	9.6	360	358	300	429	9.5	9.5	9.1	10.1	1.5	1.7	0.5	2.4
Total	***29***	248	217	171	565	1768	1976	347	3380	9.2	9.5	3.3	16.8	270	250	198	429	10.1	10.7	9.1	11.7	4.6	5.9	0.5	7.2
AGOS																									
Nestling	**3**	732	728	473	994	2119	2431	1493	2433	16.0	16.0	12.0	19.9	252	264	211	281	9.5	9.3	9.2	10.0	4.6	4.2	2.6	7.0
Non-Nestling	**8**	564	477	350	1123	611	577	372	964	14.3	12.8	5.1	25.0	335	330	257	444	8.7	8.7	8.0	9.4	2.7	2.5	0.8	4.6
Total	***11***	610	504	350	1123	1022	756	372	2433	14.8	14.6	5.1	25.0	312	311	211	444	8.9	8.8	8.0	10.0	3.2	2.6	0.8	7.0
SSHA																									
Non-Nestling	**7**	616	468	378	1475	687	717	470	813	13.6	12.9	7.3	22.8	348	352	307	383	9.3	9.1	8.8	9.8	3.7	3.9	2.6	4.3
SWHA																									
Nestling	**3**	311	313	242	377	1559	1611	1320	1745	12.9	13.6	11.1	13.9	263	260	249	280	10.0	10.0	9.4	10.6	5.2	5.3	4.8	5.6
Non-Nestling	**3**	377	377	239	516	930	829	614	1348	11.2	10.9	4.5	18.3	311	297	294	341	9.7	9.7	9.6	9.9	2.1	2.0	1.5	2.8
Total	***6***	344	345	239	516	1245	1334	614	1745	12.1	12.4	4.5	18.3	287	287	249	341	9.9	9.8	9.4	10.6	3.7	3.8	1.5	5.6
COHA																									
Non-Nestling	**3**	554	536	518	608	898	1131	367	1196	15.8	15.5	12.3	19.7	326	328	312	337	9.4	9.3	9.1	9.8	4.4	3.5	3.1	6.7
MERL																									
Non-Nestling	**3**	75	76	66	83	1037	1065	936	1109	9.7	9.7	9.3	10.0	327	320	290	370	8.3	8.7	7.5	8.8	2.2	1.7	1.7	3.2
RTHA																									
Non-Nestling	**4**	340	340	270	412	928	827	603	1453	9.9	8.9	6.6	15.1	344	342	320	371	9.7	9.8	8.7	10.5	3.1	3.3	2.0	3.7
NOHA																									
Non-Nestling	**2**	379	379	361	396	536	536	487	585	37.0	37.0	37.0	37.0	367	367	339	394	9.9	9.9	9.5	10.3	4.8	4.8	3.7	5.9
PRFA																									
Non-Nestling	**2**	79		67	91	1012		812	1212	8.4		7.4	9.3	358		318	397	9.5		9.2	9.7	1.9		1.8	2.0
RLHA																									
Non-Nestling	**1**	324				772				6.9				390				8.7				2.8			
BWHA																									
Non-Nestling	**1**	295				1154				3.6				337				9.8				3.2			
BAEA																									
Non-Nestling	**1**	414				2706				0.9				245				10.1				3.4			
CORA																									
Non-Nestling	**0**																								
PEFA																									
Non-Nestling	**0**																								
AMKE																									
Non-Nestling	**0**																								

	N	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Min	Max	Min	Max	Min	Max
GOEA																											
Nestling	**0**																										
Non-Nestling	**14**	3.3	3.5	2.5	3.8	1.9	2.1	1.2	2.5	1.4	1.4	1.0	2.5	3.4	3.4	2.0	5.3	148	148	143	153	0	1+	0	1+	0	0
Total	***14***	3.3	3.5	2.5	3.8	1.9	2.1	1.2	2.5	1.4	1.4	1.0	2.5	3.4	3.4	2.0	5.3	148	148	143	153	0	1+	0	1+	0	0
GGOW																											
Nestling	**6**	3.4	3.3	3.1	4.0	2.3	2.2	2.1	2.7	1.1	1.1	0.8	1.3	3.1	3.2	2.2	3.8	143	144	140	146	0	1+	0	1+	1+	1+
Non-Nestling	**1**	3.3				1.9				1.4				2.3				143					1+		0		0
Total	***7***	3.4	3.3	3.1	4.0	2.2	2.2	1.9	2.7	1.1	1.1	0.8	1.4	3.0	3.1	2.2	3.8	143	143	140	146	0	1+	0	1+	0	1+
FEHA																											
Nestling	**20**	3.5	3.5	3.1	3.8	2.8	2.9	2.4	3.1	0.6	0.7	0.4	0.7	3.8	3.4	2.5	6.6	143	142	137	150	0	1+	0	1+	0	0
Non-Nestling	**9**	3.7	3.7	2.9	4.1	3.0	3.0	2.6	3.7	0.7	0.7	0.1	1.2	2.1	1.7	1.5	3.3	146	146	141	150	0	1+	0	2+	0	1+
Total	***29***	3.4	3.5	2.9	4.1	2.8	2.9	2.4	3.7	0.6	0.7	0.1	1.2	3.1	3.3	1.5	6.6	139	144	137	150	0	1+	0	2+	0	1+
AGOS																											
Nestling	**3**	2.7	2.7	2.4	3.0	1.8	1.8	1.3	2.2	0.9	0.9	0.8	1.1	4.0	4.0	2.4	5.6	154	151	150	160	0	1+	0	1+	0	0
Non-Nestling	**8**	3.2	3.1	2.6	3.5	2.3	2.5	0.5	3.0	0.7	0.5	0.1	1.5	2.5	2.2	2.0	3.7	149	149	143	155	0	1+	0	1+	0	0
Total	***11***	3.0	3.1	2.4	3.5	2.1	2.3	0.5	3.0	0.7	0.7	0.1	1.5	2.8	2.4	2.0	5.6	150	150	143	160	1	1+	1	1+	0	0
SSHA																											
Non-Nestling	**7**	3.3	3.4	2.8	3.6	2.8	2.9	2.5	3.1	0.5	0.3	0.1	1.1	3.2	3.2	1.9	4.3	151	151	149	153	0	1+	0	1+	0	0
SWHA																											
Nestling	**3**	3.2	3.1	3.0	3.6	2.5	2.3	2.3	2.8	0.8	0.8	0.7	0.8	3.2	3.3	3.1	3.3	145	146	142	147	0	0	0	1+	0	0
Non-Nestling	**3**	4.1	4.1	3.5	4.7	2.7	2.8	2.2	3.1	1.4	1.3	0.4	2.5	2.2	2.2	2.2	2.2	147	146	145	151	0	0	0	0	0	1+
Total	***6***	3.7	3.6	3.0	4.7	2.6	2.6	2.2	3.1	1.1	0.8	0.4	2.5	3.0	3.2	2.2	3.3	146	146	142	151	0	0	0	1+	0	1+
COHA																											
Non-Nestling	**3**	3.8	3.8	3.5	4.0	2.9	2.7	2.7	3.4	0.8	0.8	0.6	1.1	2.8	3.1	2.0	3.2	155	155	152	157	0	1+	0	1+	0	1+
MERL																											
Non-Nestling	**3**	2.9	3.0	2.4	3.4	2.6	2.9	2.1	2.9	0.3	0.3	0.0	0.5	2.8	2.7	2.4	3.4	147	149	143	150	1+	1+	0	1+	0	1+
RTHA																											
Non-Nestling	**4**	3.7	3.8	3.1	4.1	2.6	2.6	2.0	3.0	1.2	1.2	1.0	1.3	3.2	3.2	2.8	3.7	149	149	147	152	0	1+	0	1+	0	0
NOHA																											
Non-Nestling	**2**	3.4	3.4	3.3	3.5	2.9	2.9	2.8	2.9	0.6	0.6	0.5	0.6	3.4	3.4	2.5	4.2	149	149	147	151	0	1	1	1+	0	0
PRFA																											
Non-Nestling	**2**	3.3		3.1	3.5	2.5		2.3	2.6	0.9		0.6	1.2	2.2		2.0	2.3	148		144	152	0	0	0	0	0	1+
RLHA																											
Non-Nestling	**1**	3.1				2.6				0.5				3.7				147				2+		0		0	
BWHA																											
Non-Nestling	**1**	3.8				3.2				0.6				4.4				153				1+		0		0	
BAEA																											
Non-Nestling	**1**	3.2				1.8				1.4				3.8				147				0		0		0	
CORA																											
Non-Nestling	**0**																										
PEFA																											
Non-Nestling	**0**																										
AMKE																											
Non-Nestling	**0**																										