2024 Annual Conservation Reports

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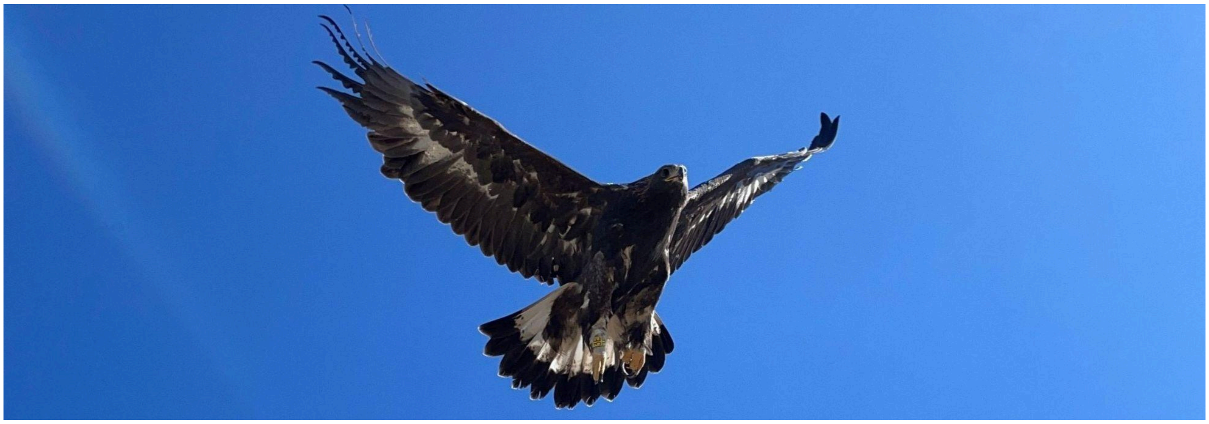
Contents

Raptor Migration in South-central Montana: Identifying Key Golden Eagle Habitats, Populations Trends, and Marking Techniques



Project Partners:

Teton Raptor Center

Raptor View Research Institute

Study Background & Objectives:

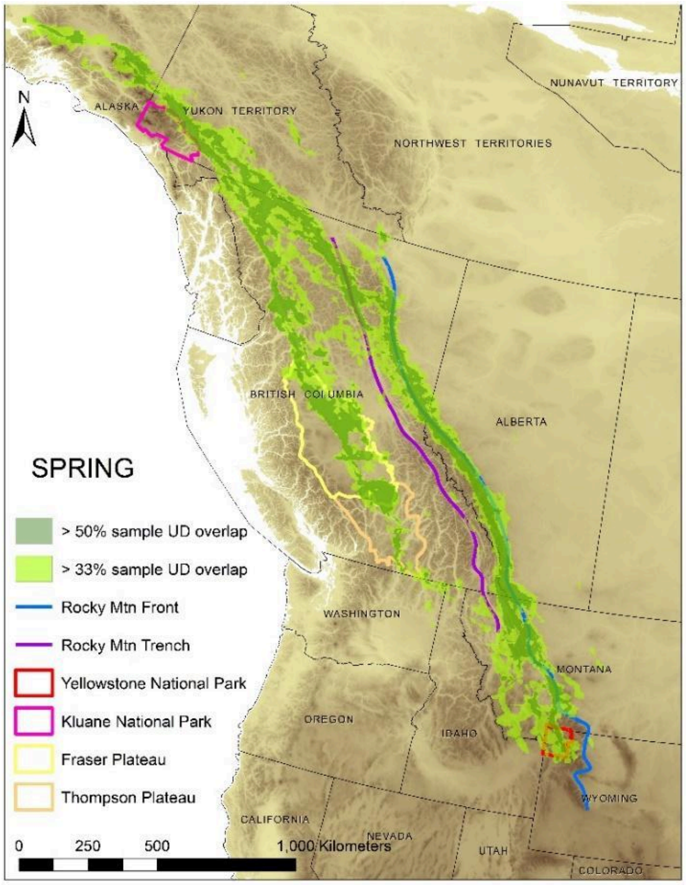
Sagebrush steppe and grassland habitats that dominate much of the landscape across the West are increasingly at risk due to a variety of compounding factors including direct habitat loss, fragmentation, fire, invasive species, and grazing regimes. The cumulative effects from loss and disturbance in these 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 Act and Eagle 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. 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 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 ft 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 (see photo) on all captured golden eagles. These new bands are yellow with a black alphanumeric code to allow for re-sighting banded eagles and identifying them to the individual level. 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. As part of that study, we deployed 20 transmitters on first-year golden eagles during this project with the support of MS graduate student Zach Bordner (right). The ultimate goal is to compare behaviors of migrant eagles with locals (see Bighorn Basin report for details on tagging local eagles). 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 season.

Since beginning this study in 2018, we have kept count records for all raptors passing the site, in consistent raptor migration count methodology. In 2024, we experienced exceptionally good weather, with only one day during the entire season we were unable to count for the whole day. In total, we observed for 239.8 hours from 19 September through 21 October. From 2018 to 2024, 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 (golden eagles/hr) between years (Figure 1). The passage rates among the past 5 years has been relatively consistent, with the increase in total eagles seen this year likely a factor of our greater number of observation hours.

While observing migrating eagles, we classified individuals by age (hatch-year, sub-adult, and adult). In 2024, we observed more hatch-year eagles than any other year (Figure 2). Because it can be difficult to accurately separate hatch-year from sub-adults, we combined those two age classes during this same time period. We determined that 39% of the counted eagles were pre-adult, slightly higher than other years from 2018-2023 (30, 33, 34, 31, 23, 36%, respectively). We also quantified the age and sex of captured eagles and continued to experience a strong male bias in captured eagles with 67% of eagles captured being males [all other years 63-72% males (Figure 3].

2024 was an unusual year, in that the weather was extremely favorable and allowed counting on nearly every day during the season. We had higher than usual passage rates (>1.0 eagles/hr) in the first week of observations (Figure 4). We did not experience as many "peaks and valleys" in counts this year, likely because eagles were not held up by weather patterns and could consistently move most days.

From 2022-2024, 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. Between the 2022 - 2024 seasons, we collected and analyzed 60 blood samples from the following raptor species: Golden Eagle (GOEA; n=13), Sharp-shinned Hawk (SSHA; n=12), American Goshawk (AGOS; n=7), Merlin (MERL; n=7), Cooper's Hawk (COHA; n=6), Red-tailed Hawk (RTHA; n=5), Northern Harrier (NOHA; n=2), Peregrine Falcon (PEFA; n=2), Prairie Falcon (PRFA; n=2), American Kestrel (AMKE; n=2), Broad-winged Hawk (BWHA; n=1), and Rough-legged Hawk (RLHA; n=1) (Figure 5).

Excluding golden eagles, the five most common raptors observed passing our field site from September 20th to October 21st were Sharp-shinned Hawks, Northern Harriers, Red-tailed Hawks, American Kestrels, and Merlins (Figure 6). This year, we used both a starling and a sparrow on the smaller bow-net in order to capture more small raptors such as Sharp-shinned Hawks and American Kestrels. After Golden Eagles (71), Sharp-shinned Hawks were the most frequent species captured (60), followed by Merlins (11), Cooper's Hawks (10), Northern Goshawks (7), and American Kestrels (6) (Table 2). We banded all raptors with USGS bands and collected blood samples from as many raptors as we could. Excitingly, one of the Golden Eagles was a recapture, originally banded by another researcher in Wyoming in 2020. We also caught two Broad-winged hawks, only the fifth capture of the species at this site. Broad-winged hawks are increasingly being caught and observed at other fall migration sites throughout the west in recent years.

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	1386	138.1	10.0	114	8.2%
2020	787	117.7	6.7	78	9.9%
2021	753	134.1	5.6	60	8.0%
2022	989	158.9	6.2	99	10.0%
2023	914	139.5	6.6	71	7.8%
2024	1262	188.2	6.7	154	12.2%

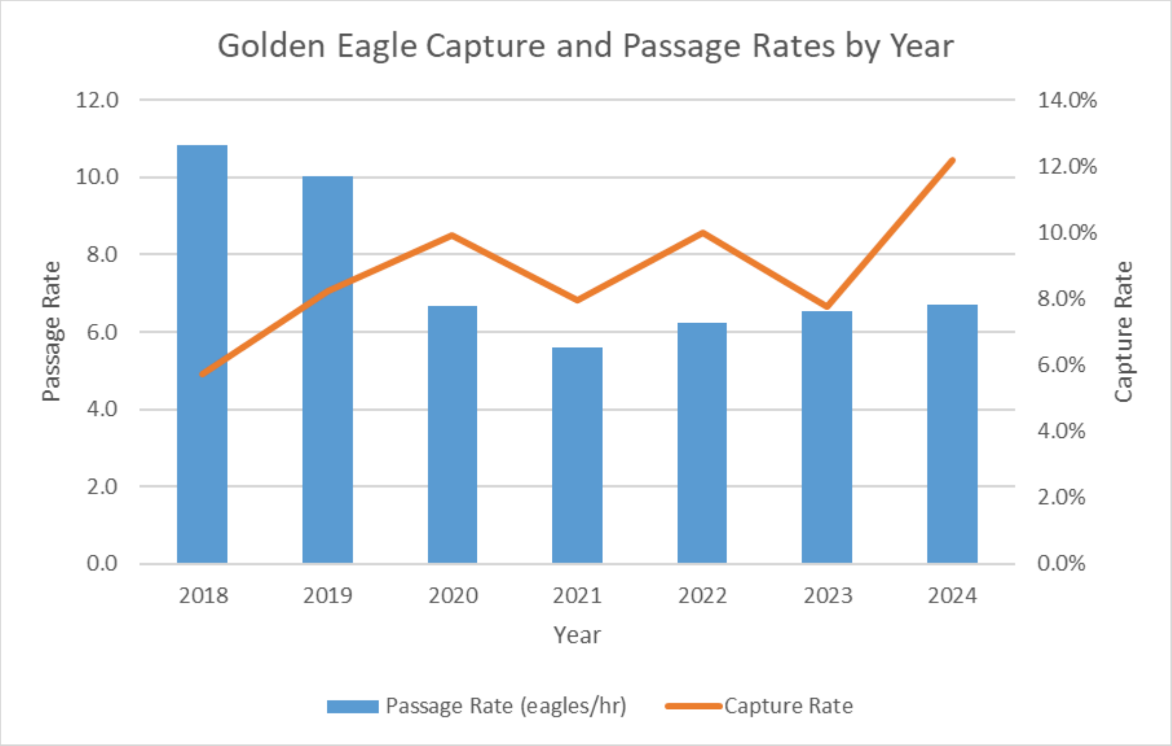


Figure 1. *GOEA passage and capture rates by year for the observation period of 9/27 to 10/21*

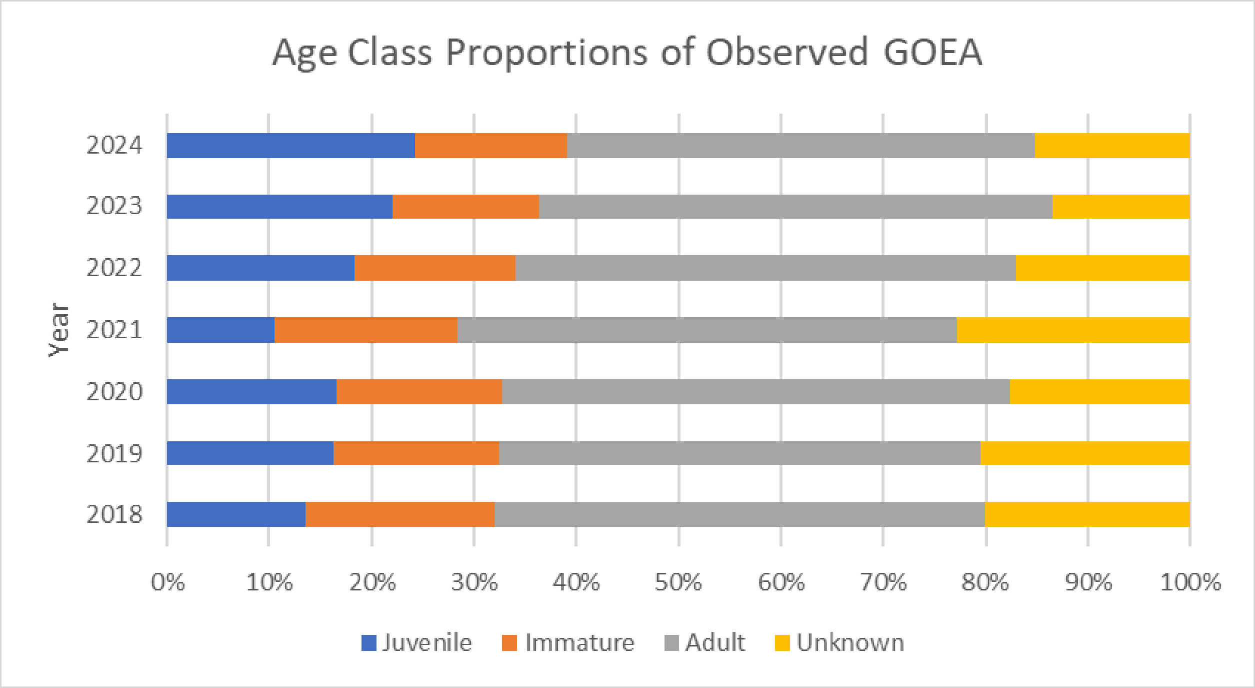


Figure 2. *Age class proportions of observed Golden Eagles each year during 9/27 to 10/21 period.*

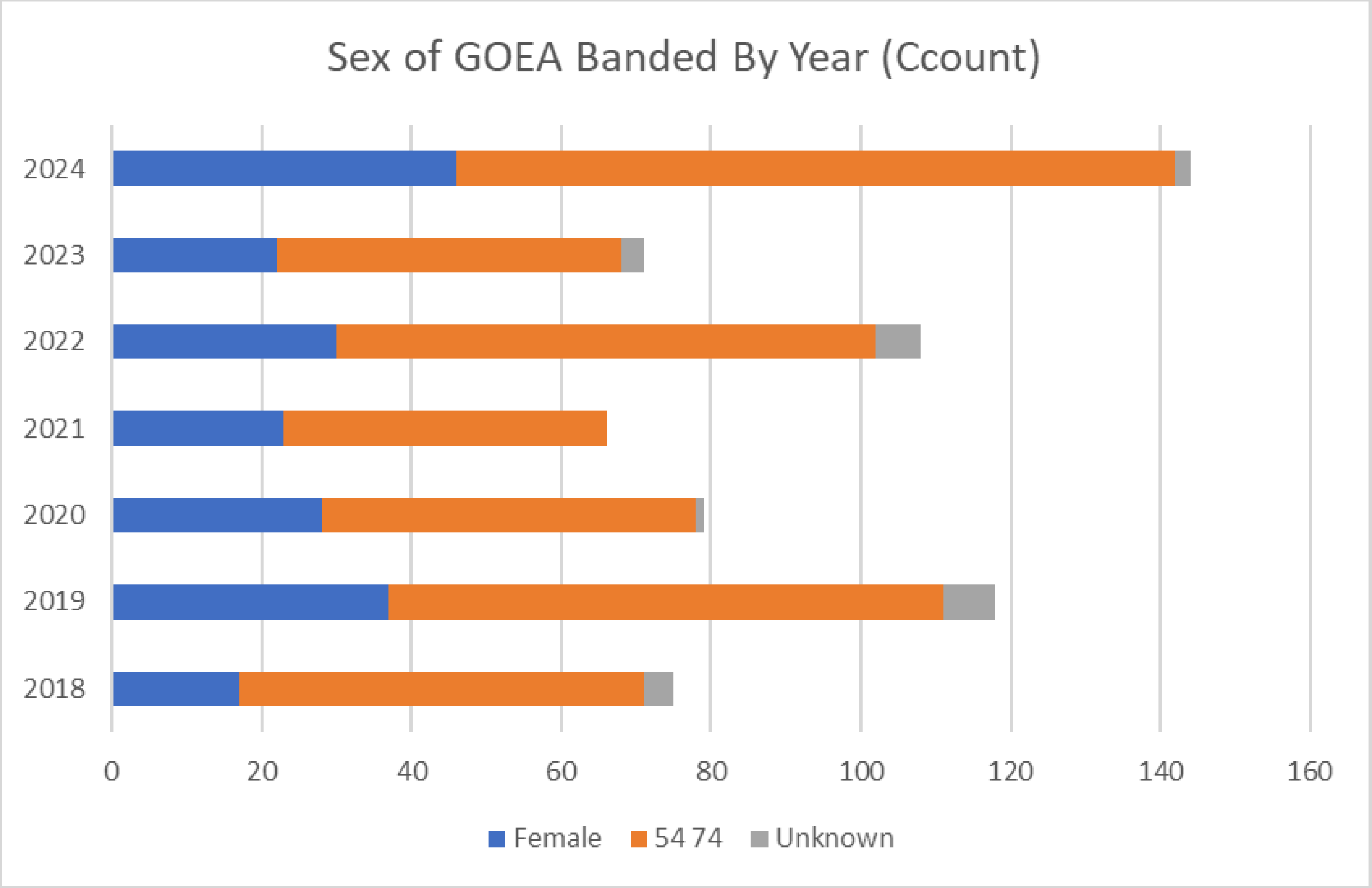


Figure 3. *Count of golden eagles banded by year by sex.*

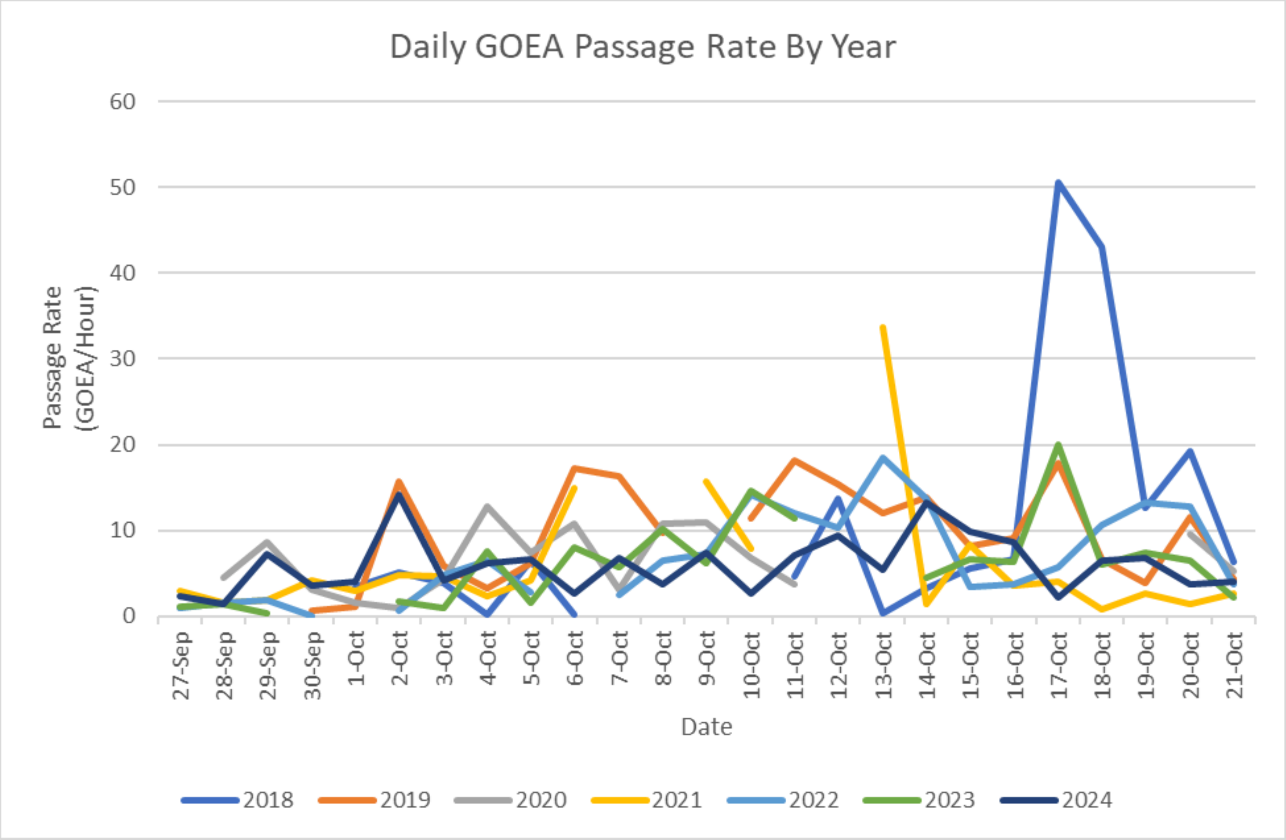


Figure 4. *Daily passage rates of golden eagles each day from 2018 to 2024.*

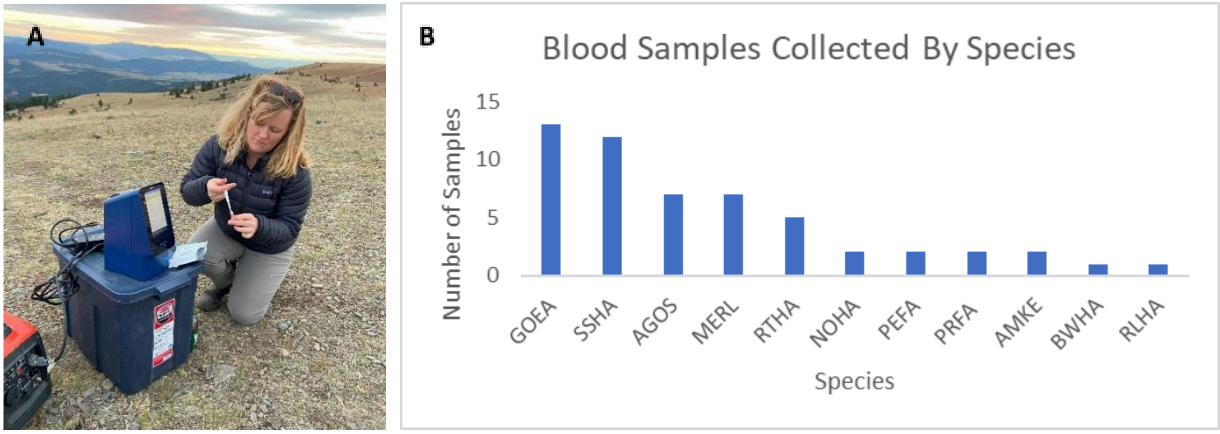


Figure 5. *A) Preparing a raptor blood sample for analysis on an Abaxis machine; B) Number of blood samples collected and analyzed for different raptor species between 2022 and 2024 at Grassy Mountain.*

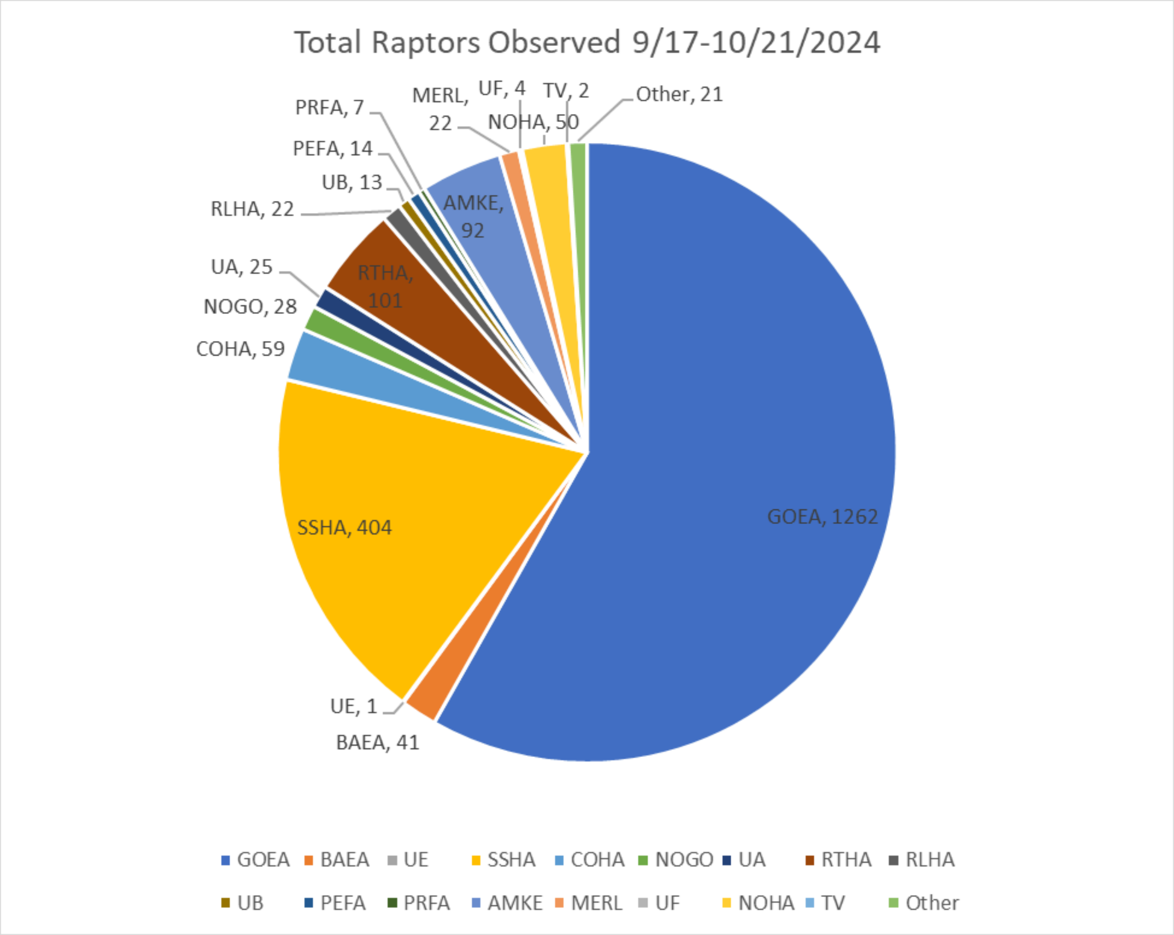


Figure 6. *Total Raptors (2168) observed during the 2024 season (9/17 to 10/21/2024).*

Table 2. Number of banded birds by species in 2024.

2024 Banded Birds by Species	
GOEA	144
SSHA	78
RTHA	14
COHA	11
AGOS	10
AMKE	4
MERL	3
PRFA	2
PEFA	1
NOHA	1
BWHA	1
Total	174

Discussion:

The study site in the Big Belt Mountains remains an extremely effective location to monitor golden eagles on migration in Montana. We captured more golden eagles in 2024 than any previous year and deployed color bands on nearly all eagles captured. The timing of migration appeared to be fairly consistent across the whole season, which was likely due to favorable weather all fall.

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

Several interesting captures occurred this year. For the second year in a row, we recaptured a HY golden eagle tagged the previous day from Roger's Pass. We also recaptured an eagle we had tagged with a transmitter two days prior. Finally, we recaptured a second-year golden eagle we captured and tagged in 2023. This eagle did not have the color band we placed on it in 2023. The color band was a double, wrap-around Darvic band made by Haggie and secured with chemical sealant. The quick loss of the plastic color band is very concerning and points to the need for metal auxiliary bands for golden eagles.

This year, we successfully published a paper on winter habitat for Golden Eagles in Wyoming using previously collected GPS data from birds tagged in this study to support RaptorMapper.com.

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
- Fine-scale weather influences 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, Skyler Bol, Olivia Cano, Zach Bordner, Katherine Gura, Rob Domenech, Nathan Hough, and Chloe Hernandez. 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, Lauri Hanuska-Brown). 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.

RaptorMapper: Estimating Golden Eagle Territories in Wyoming- How many and where are they?

Project Partners:

Bryan Bedrosian[1,2], Brian Woodbridge[3], Jeffrey R. Dunk[4], Dave LaPlante[5]

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[5]Natural Resource Geospatial, Montague, CA

FIeldwork completed by A Rouse

Conservation Issue:

Wyoming is critical for golden eagle conservation in North America. The state has the largest known breeding population in the continental US, is the wintering grounds for a large portion of migratory eagles from Alaska and Canada and is traversed by the most important migration corridor on the continent. Recent estimates project 800-1,000 golden eagle mortalities per year from existing and planned wind-power generation facilities in Wyoming alone. This additional source of mortality is far above the estimated threshold (200 deaths/year) to maintain a stable population of eagles in Wyoming. It is therefore essential and extremely time sensitive to identify critical habitats across the state to protect from future development, minimize risks, and maximize benefit of conservation actions.

Golden Eagle Decision Support Tool Refinement:

We have been diligently working over the past several years to map the “best-of-the-best” habitats for eagles in Wyoming and designed a custom, free online mapping and analysis tool, raptormapper.com. We have received overwhelmingly positive feedback from managers and other users on these products. Raptormapper.com provides managers, conservationists, and other users a defensible and easy-to-use tool to identify how important eagle habitats, expressed as Relative Density, are distributed across the state and within their proposed project area. The DST enables users to estimate whether an area has, for example, 2x, 10x, 100x, higher/lower densities than other areas of equal size.

This current aspect of our project is designed to refine our relative eagle density models. Although our models provide great value and are already being used for conservation, they do not estimate actual densities of eagles, breeding sites, or individual territories. This project will enhance our breeding model by predicting where individual nesting territories occur across Wyoming, and subsequently estimate landscape-scale territory densities. The goal was to accomplish this by quantifying the composition of ~1,000 known individual territories, then forecast where other areas occur across the state that meet or exceed that composition. The initial product of this analysis will be a series of maps depicting the distribution of predicted golden eagle territories at different levels of territory quality and sizes. The accuracy of the predicted territories will then be field tested.

This year, we began fieldwork to accomplish this project. We used aerial surveys oriented across the state to gather a large dataset of known-density eagle nesting to augment existing study areas being surveyed. The ultimate goal of data collection was to gather information on existing eagle nests and areas that are devoid of nests in regions that have not been formally surveyed for golden eagles.

Accurate predictions of the location and density of territories gives a significant added value to our existing work when assessing conservation values of parcels and projects. For example, from our previous work, we can say, “This wind project area includes the top 10% of breeding habitat in the county.” This project would enable us to report additional results such as: “This project area is predicted to have 10 eagle territories, or 50% of the territories in the county.” Further, these data would give managers an estimate of the number of breeding territories in Wyoming, enabling actual estimates of impacts of development and conservation actions on eagle populations.

Methods & Results:

In 2024, we developed several methods to translate our estimates of relative density to actual density estimates. In short, the goal is to have a large sample of territory locations that we can assess relative habitat values within. Assessing the values within territories will be an iterative process that is informed by average territory size, multiple shapes, etc. Once those evaluations are complete from territories in a wide array of overall habitat quality (i.e., territory densities), we will be able to predict where those conditions exist in areas that have not been surveyed. By “filling” the landscape of Wyoming with “predicted territories” that hold the correct habitat values to support an eagle territory, we will be able to estimate the number and locations of golden eagle territories across the state.

In order to have a representative sample of eagle nests, we first queried and mapped existing study areas where we have confidence in known densities and complete eagle nest surveys (see NPL, Cody, and CCOGP reports). We used surveys completed in 2023 in each of these three study areas to begin building the sample of occupied and confirmed, unoccupied territories. We then stratified the state based on RND values and randomly created 2-township survey areas across the rest of Wyoming that were in proximity to flight base areas. We created our final survey areas after visually inspecting all potentials for non-habitat (e.g., urban areas) and selected the subset that was feasible to complete within our time and budget constraints.
We surveyed a total of 25 2-township sections across Wyoming in 2024 via a husky aircraft (Figure 2). We located a total of 138 raptor nests, of which 108 were classified as golden eagle (43 occupied and 65 unoccupied). We have reduced the dataset to exclude any potential alternate nest sites by running a step-wise analysis that prioritizes

active or occupied nests and removed any alternatives within ½ the closest nearest neighbor distance (1.4km) to define an “eagle territory.” The next step we are currently assessing predictive values within eagle territories (occupied) and areas that are not eagle territories (available) for the various modeling treatments.

We anticipate completing this project by the middle of 2025.

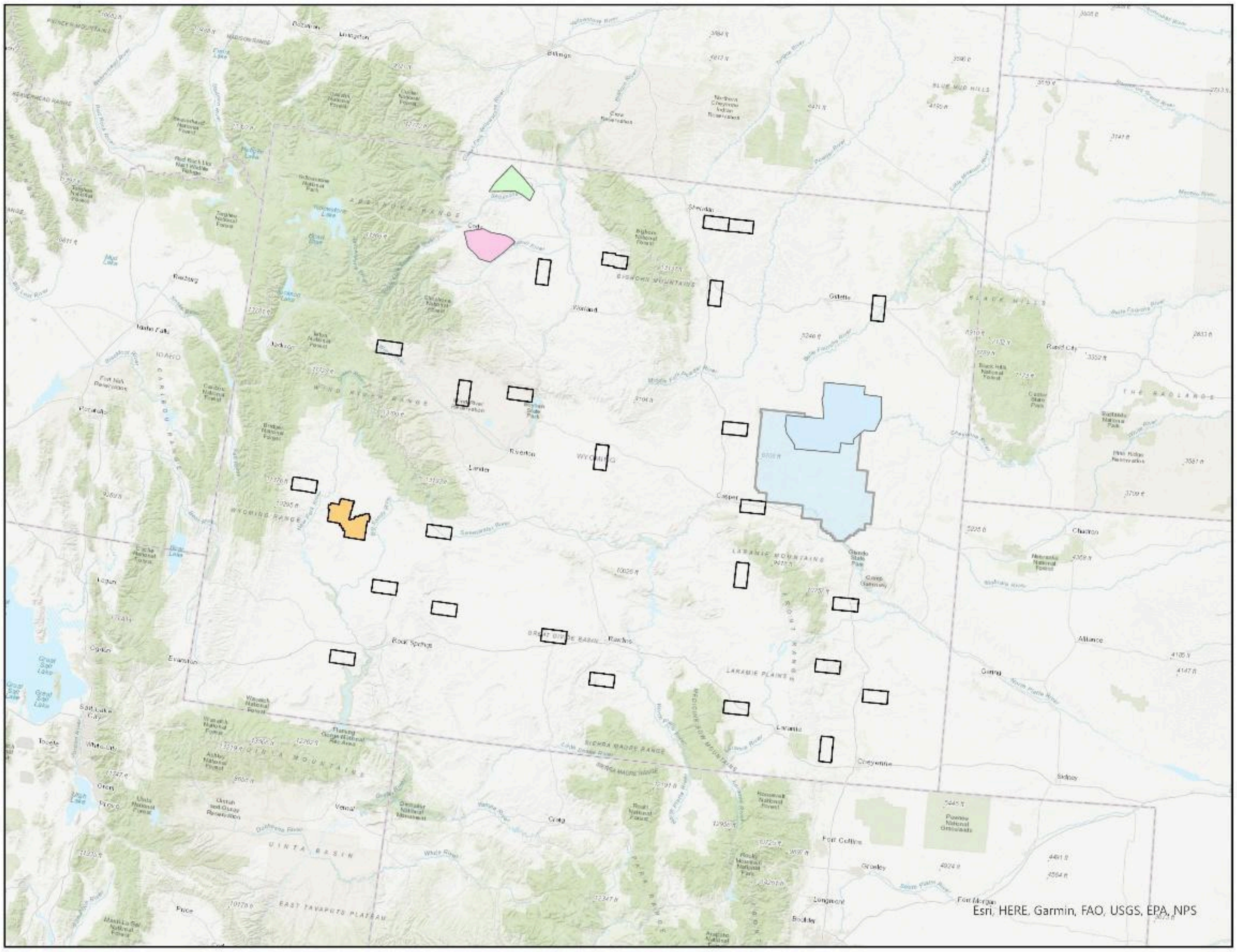


Figure 1. *Survey areas across Wyoming. Colored areas represent existing project areas and black rectangles are new 2-township areas placed in stratified random locations across the state.*

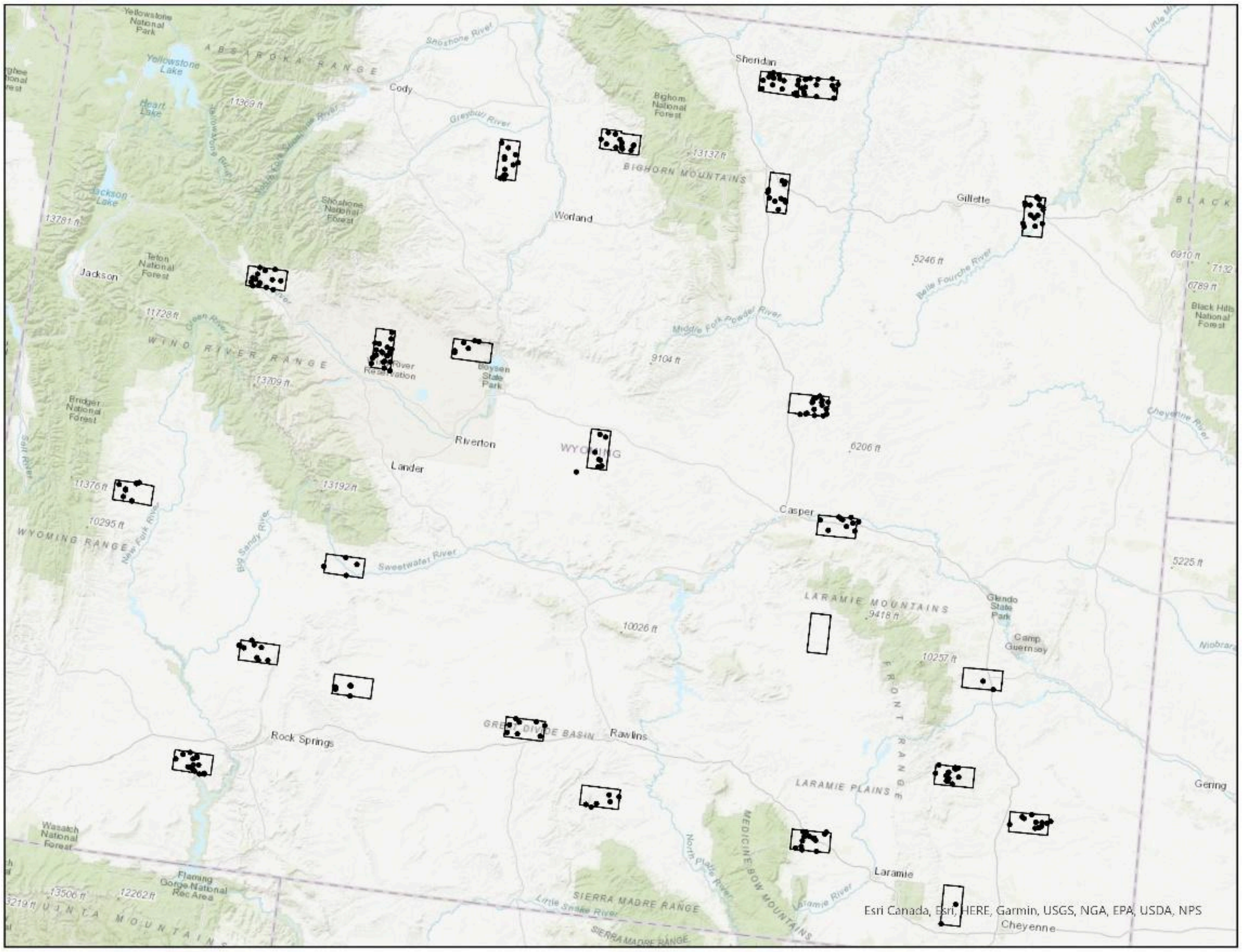


Figure 2. *Golden eagle nest locations found during 2024 aerial surveys of 2-township study areas.*

Great Gray Owl Ecology in Northwestern Wyoming

Project Partners:

[1]Teton Raptor Center

University of Wyoming; Katherine Gura[1], Anna Chalfoun

[1] Current Address: Colorado State University

Introduction:

In 2024 we continued a multi-year study on Great Gray Owls in northwestern Wyoming that began in 2013. As part of Dr. Katherine Gura's graduate project at the University of Wyoming, we continued collecting GPS location data on adult Great Gray Owls in order to assess breeding-season and winter home ranges and habitat selection. Additionally, we continued to collect data on territory occupancy, primarily through the use of automated recording units (ARUs); nest initiation rates, productivity, and survival of previously marked owls. We also continued our long-term data collection of prey abundance and snow characteristics within Great Gray Owl territories to assess how snow conditions relate to Great Gray Owl habitat use, movements, and nest success across years.

Additionally, we deployed ARUs in known and suspected Barred Owl territories and habitat to begin assessing occupancy of this new species within Grand Teton National Park (referred to as GTNP here on out). In 2023, we confirmed the first breeding record for this species in Wyoming, within GTNP.

Methods:

The primary study area includes the base and foothills of the Teton Range as well as the Snake River riparian corridor, stretching from Red Top Meadows north to the Blackrock area on Bridger-Teton National Forest. Within Grand Teton National Park (GTNP) the study area ranged from Granite Canyon trailhead near Teton Village north to Moose, WY in the southern end of the park, and it also included northern areas within GTNP (e.g., Emma-Matilda/Two Oceans area). The typical forest habitats consisted of Douglas fir, lodgepole pine, subalpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*) surrounding the valley and mixed cottonwood (*Populus* spp.) spruce (*Picea* spp.) forests within riparian areas.

Territory Occupancy:

During the courtship period of Great Gray Owls (mid-February – April), we deployed audio recorders adjacent to known nest sites across the study area to determine whether Great Gray Owls were present. Our main intent was to determine whether these known territories were occupied or not. We analyzed the recordings by running them through Kaleidoscope®, an automated bioacoustics software. We trained the software to locate Great Gray Owl territorial calls, and if Great Gray Owl calls were detected, we determined the territory was occupied.

We also deployed ARUs in known and suspected Barred Owl territories in GTNP this year. Specifically, we deployed several ARUs in the occupied territory we located in 2023. We deployed ARU arrays in four other suspected territories (based on historical records and habitat) in the northern section of GTNP. We deployed ARUs twice at each territory, once in early spring and again later in the summer. Similar to Great Gray Owls, we trained software to locate Barred Owl calls and if they were detected, we determined the territory was occupied.

Nest Monitoring:

We monitored all known Great Gray Owl territories. We considered a territory "active" only if we found direct evidence of breeding, such as an incubating female or fledglings. We considered a territory "occupied" if we documented a territorial Great Gray Owl on our recordings. A nest was considered active if a female began incubation, and a nest was considered successful if it fledged young. We also monitored the known Barred Owl nest.

Gopher Surveys:

We surveyed for pocket gopher abundance following van Riper et al. (2013). We digitized all meadows within 500 m of known nests and randomly selected three (when available) for surveys. We started at the head of each meadow and walked 45-degree diagonal transects back and forth until reaching the end of the meadow, tallying fresh and old gopher mounds visible within 10 m of the transect. We are interested in relative abundance between years and among territories, so we tallied total survey area (total transect length x 20 m) for each territory and divided by the total number of mounds to create an index of gopher abundance. Because we regularly observe owls hunting within forested areas, we also added a survey transect bisecting the territory through representative forest habitat. We tested for correlations between new, old, and total gopher mound abundance and between forest and meadow. We tested for relationships between years and between gopher abundance and productivity.

Tracking:

We continued to monitor Great Gray Owls that were outfitted with GPS transmitters. We downloaded location data from these owls bi-weekly. Additionally, in order to better assess Great Gray Owl breeding-season as well as winter habitat selection, Gura deployed additional GPS remote-download back-back transmitters Lotek Wireless Inc., unit weight = 30g) on adult Great Gray Owls beginning in April of 2020. A number of these transmitters are expected to last through 2022.

Snow Measurements:

In the winter of 2024, we continued conducting snow measurements near known Great Gray Owl territories across the study area. We measured each territory on the same day. We collected snow data one day/month from January-April. We measured snow depth by placing a measuring stick vertically down through the snow until it reached the ground. We measured snow crust strength by dropping a filled 1-liter Nalgene water bottle (ca. the same weight as an adult Great Gray Owl) one meter above the top of the snow (not the ground) and measuring how far the bottle penetrated the snow. We dropped the bottle both horizontally and vertically and averaged the depths. In each territory, we measured snow characteristics in a meadow and in a forest representative of the territory. The same meadow and forest sites were consistently measured across years. We made sure to conduct the measurements in areas representative of the area's average snow conditions (i.e. not directly in a tree well, nor in an area disturbed by human activities).

Results:

Territory and Nest Monitoring:

In 2024, we monitored 32 known Great Gray Owl breeding territories in the study area. Throughout the study area, 75% of the territories were occupied (n=24), 25% were confirmed with active nests (n=8; observed initiation). Out of the active nests, only two (25%) nests were successful (fledged young), and five nests failed. We were unable to confirm whether one nest successfully fledged young or not.
Across years, occupancy, nest initiation, and nest success have varied considerably. Continued monitoring of productivity is essential to understand what drives this variation. It is important to note that, due to the Covid-19 pandemic, we were required to scale back our field effort compared to past years. We were unable to incorporate volunteers and field assistants to the extent that we have in past years, therefore it is possible we failed to locate nesting birds within occupied territories simply due to reduced search effort.

Barred owls were detected at all five deployment sites during spring deployments. We found the previously breeding pair of Barred Owls nested in the same cavity as it did in 2023, but the nest failed for unknown reasons. Very few Barred Owls were detected during the second round of ARU deployments in the summer, suggesting that spring is a better time to detect Barred Owls in the GYE with ARUs.

Gopher Surveys:

In 2024, we conducted pocket gopher surveys at 17 owl territories. We will incorporate 2024 data into across-year analyses to assess how gopher abundance might relate to productivity, and we will continue long-term monitoring of prey and productivity in future years.

Snow Measurements:

We conducted snow measurements at 17 known Great Gray Owl territories across the study area. We took measurements at each site once/month (January, February, March and April), and measurements occurred at all territories on the same day. We will incorporate 2024 snow data into across-year analyses to evaluate how snow conditions within Great Gray Owl territories might influence productivity. Similar to prey data, we will continue long-term monitoring of snow conditions and productivity to determine whether there is a pattern across years.

Banding and Tracking:

We outfitted an additional 2 owls with GPS transmitters in 2024 (one pair of owls at Trails End) and we banded four fledglings at two Great Gray Owls nesting areas.

Conclusion:

Long-term monitoring of Great Gray Owls is essential in order to assess overall population health. 2024 was a low-productivity year. As noted, nest searching efforts were scaled during the breeding season. However, the variation in nest initiation and productivity observed across years highlights the importance of long-term monitoring of this species.

Future research steps include continuing to monitor Great Gray Owl territories within GTNP to determine occupancy using ARUs. We will continue using recordings to determine vocal individuality based on calls, which can lead to improved population metrics such as apparent survival and territory turn-over rates. These analyses will expand our monitoring beyond productivity, prey, and individual movement data to collect critical population-level metrics.

Additionally, we will monitor known and potential Barred Owl territories with ARUs in the coming years. In 2025, we will expand our Teton Raptor Center research on this new species. We will expand ARU deployments in additional habitats and when Barred Owls are detected, we will attempt to capture and tag them with GPS transmitters to further understand their movements and impacts on native forest owls within the Jackson Hole Valley.

Effects of Anthropogenic Disturbance on Behavior of Golden Eagles

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 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 an 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 has been significantly declining 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 include 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 has 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).

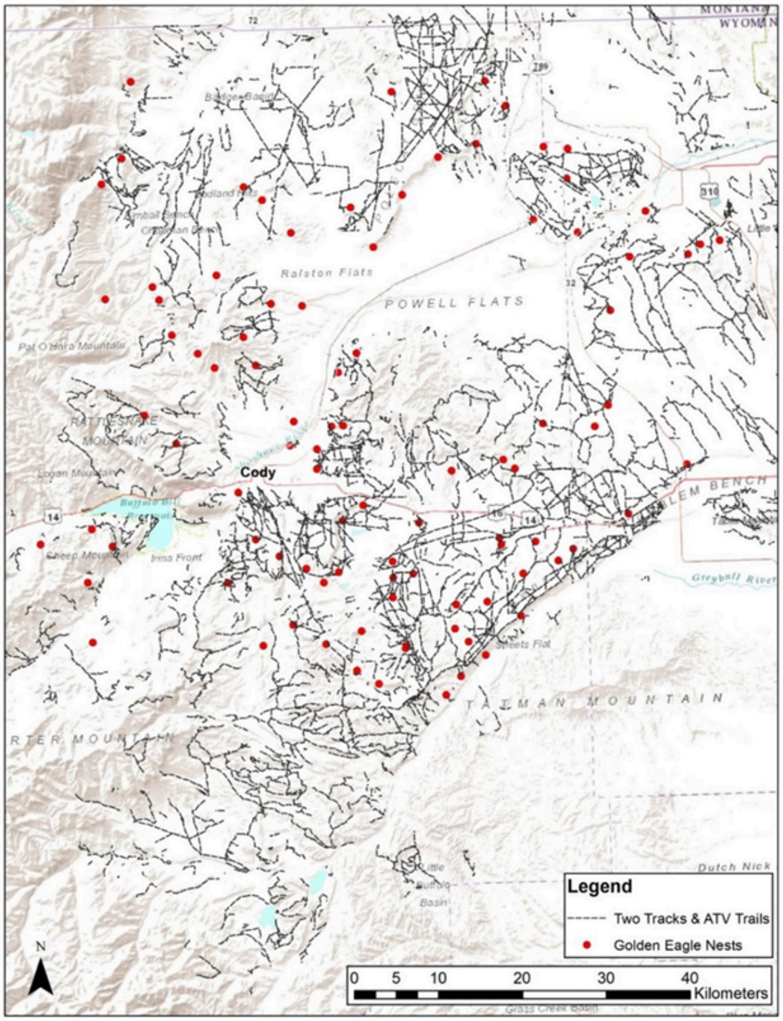


Figure 1. *Golden eagle nest locations, known two tracks and ATV trails within the Bighorn Basin*

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 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 on 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.

The Bureau of Land Management's Resource Management plans to 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, graveled 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, 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 nestling and fledgling Golden Eagles as part of a lifelong learning study for the species.

Methods:

We purchased 20 E-obs 45g transmitters to deploy on breeding golden eagles in 2024. However, transmitters were delayed and we were unable to begin trapping until the end of February, which is several weeks later than we had planned. Once we arrived in the Bighorn Basin study area, we quickly conducted on-the-ground surveys of previously known active territories to confirm whether they were active. Once territories were confirmed as active territories (i.e. adult pairs, nest building, territorial displays), we began trapping using net launchers, using road-kill roadkill as bait. Traps were maintained (battery/bait changes, snow removal, etc.) pre-dawn or post-dusk to minimize detection of our traps by target birds. Active territories where traps were set up were monitored continually from a distance of ca. 1mi during all daylight hours. While we did capture our first eagle rather quickly after starting trapping, it became evident that breeding eagles were not being attracted by carrion. This is likely because we were too close to active breeding and pairs had switched to live prey to assess the annual prey base. We pivoted our techniques to include bal-chatris and bow nets (depending on the conditions at each site) using live bait and watching from nearby pop-up blinds. Once we captured eagles, we took morphometric measurements, banded them with USGS and color bands, and fitted them with transmitters. We continued our trapping efforts through early-April and ceased all activity once females began laying eggs. Beginning in May, we deployed trail cameras and autonomous recording units (ARUs) in and around territories where we had tagged breeding eagles to measure human disturbance levels in those territories.

While we had surveyed many territories during our trapping efforts for occupancy and activity, we returned to the study site in mid-April to conduct aerial surveys in the study area to confirm nesting activity. Flights were conducted after we suspected nearly all nests had begun incubating to maximize our estimates of occupied territories and active nests before any failed. We targeted the Pole Cat and Oregon Basin areas for complete nest surveys (i.e., full aerial surveys designed in such a way to locate all nesting attempts). We also surveyed all previous territory and nest locations (see Preston et al. 2024) to determine nest status but we did not spend a concerted effort to locate new or additional nests in the areas outside of Pole Cat Bench and Oregon Basin (Figure 1). Detailed monitoring of active nests was completed by the team and partners (See Preston et al. 2024). We conducted a second round of flights in June to measure productivity at active nests.

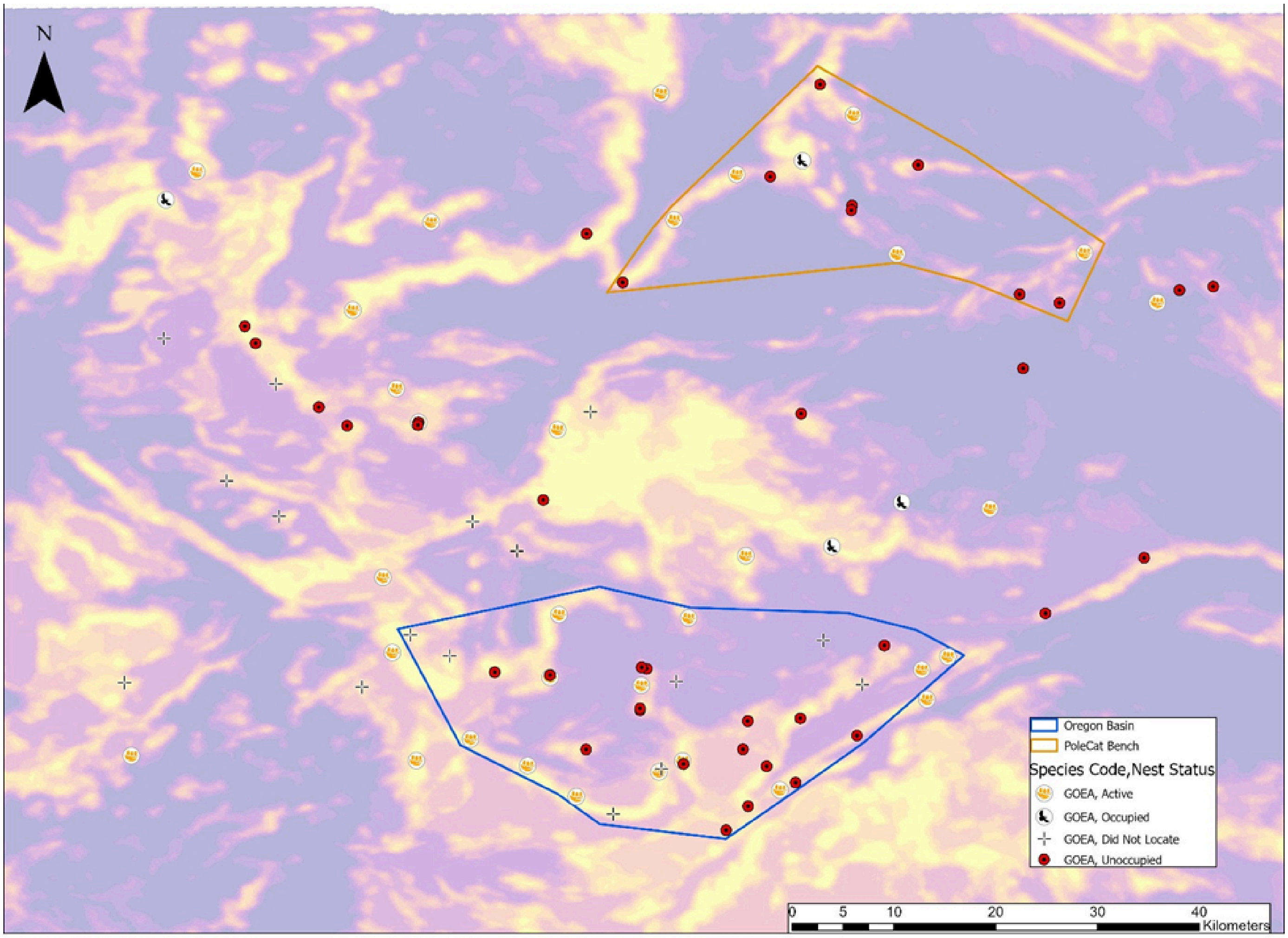


Figure 1. *Golden Eagle nests by status that were determined from aerial flights in 2024. The PoleCat Bench and Oregon Basin studies areas have complete nest surveys, while other historic nests outside these study areas were checked for occupancy. Background is the predicted relative nesting density (raptormapper.com).*

Results:

During the first year of the study, we successfully trapped and deployed transmitters on the breeding males at only two territories (Figure 2). We did have three other territorial eagles hit BCs but failed to get caught. Territory 2 successfully raised one fledgling and territory 30 failed, with one dead chick (>80% of fledgling age) found in the nest in June. We deployed two trail cameras and ARUs at each of the nesting territories. We will analyze those data when we retrieve the trail cameras during another round of winter trapping in February 2025.

Over the past 9 months, we have collected a total of 708,144 locations from the two tagged breeding males (Figure 2). From the male at Nest 1, we collected 474,902 locations (Figure 3). The vast majority of these locations were close to the nest site, with a few forays to the SW in late July and early August. Through our collaborations with Ellen Aikens at UWYO, we did place transmitters on 20 young in this study area in 2024 (Figure 4), including the young from nest 1. The young were making flights in late August to the same area to the southwest the male explored in early July (Figure 4). However, on the dates that the young were there, the male was still near the nest. Both males exhibited very tight KDEs around the nest sites (Figure 3), while Nest 1 male had an approximate home range of 12.5 mi^2 (32 km^2) and Nest 30 male was 9.4 mi^2 (24 km^2). Nest 30 male made one long-distance foray north. Notable, this movement was made very near the estimated time of death of the male's offspring.

The two transmitters deployed in 2025 provided exceptional data through the breeding season. Transmitters were set to give very high frequency data (1 second) when the battery was fully charged. When the battery was not fully charged, the unit would still collect many locations, but not in super high resolution. This is why some tracks appear with continuous locations and others appear to have "holes" (Figure 3).

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. As such, the units were trying to find and connect to the network daily but were unable to find a 2G or 3G tower. This led to significant battery drain and essentially stopped the units from gathering or sending data. We have been actively working with the manufacturing company to find a workable solution for our study.

We have found a solution that will work with our existing transmitters. 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 (Figures 2,3). We have 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 will then be able to download all the stored data several times a year. This will actually allow us to gather more data since the unit is not using power to upload all the data via the cell networks. We are programming all transmitters for deployment in 2025 with this new programming, and we will be able to send new programming to the deployed units.

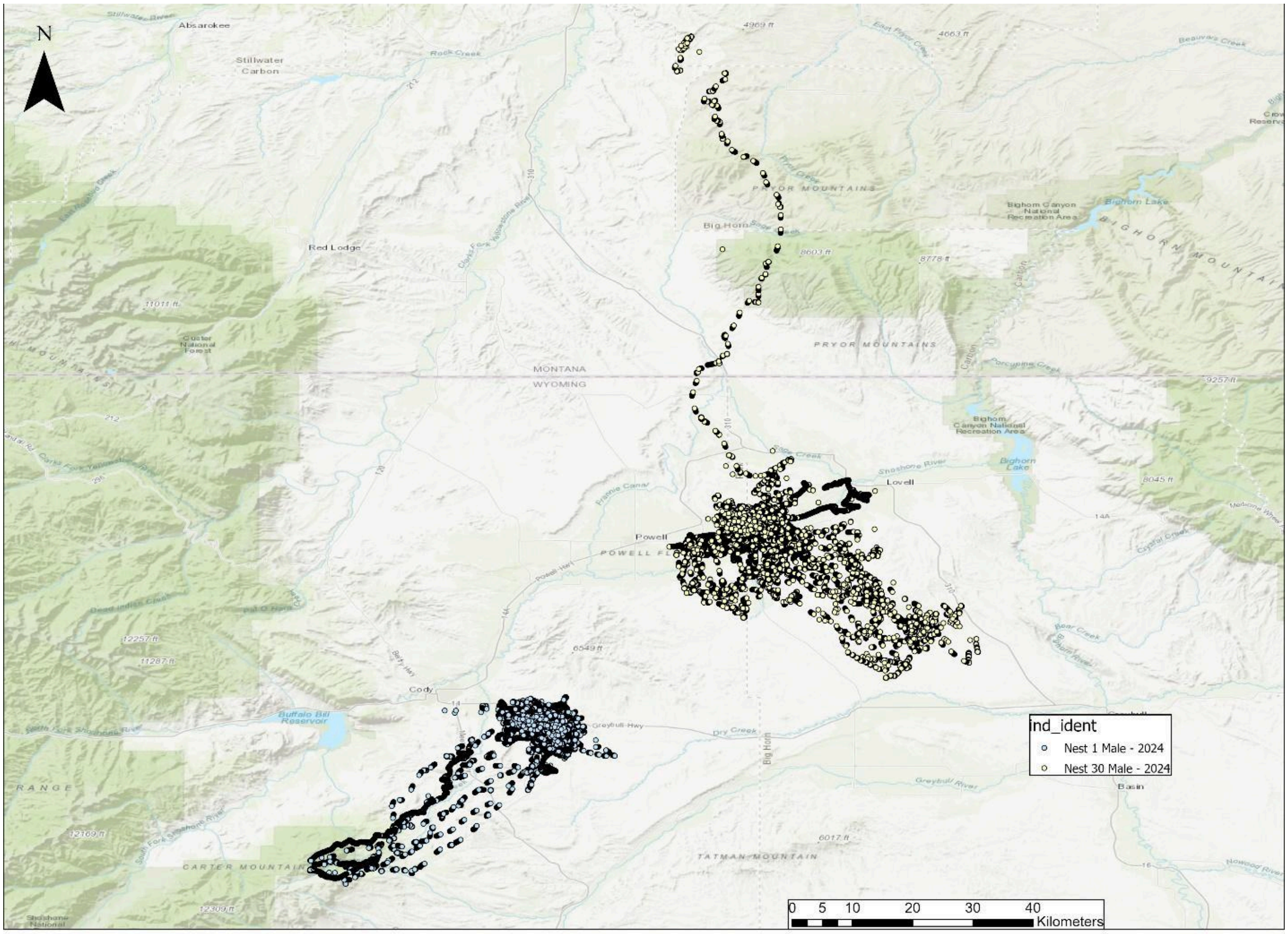


Figure 2. *All locations of two adult, breeding male golden eagles in 2024.*

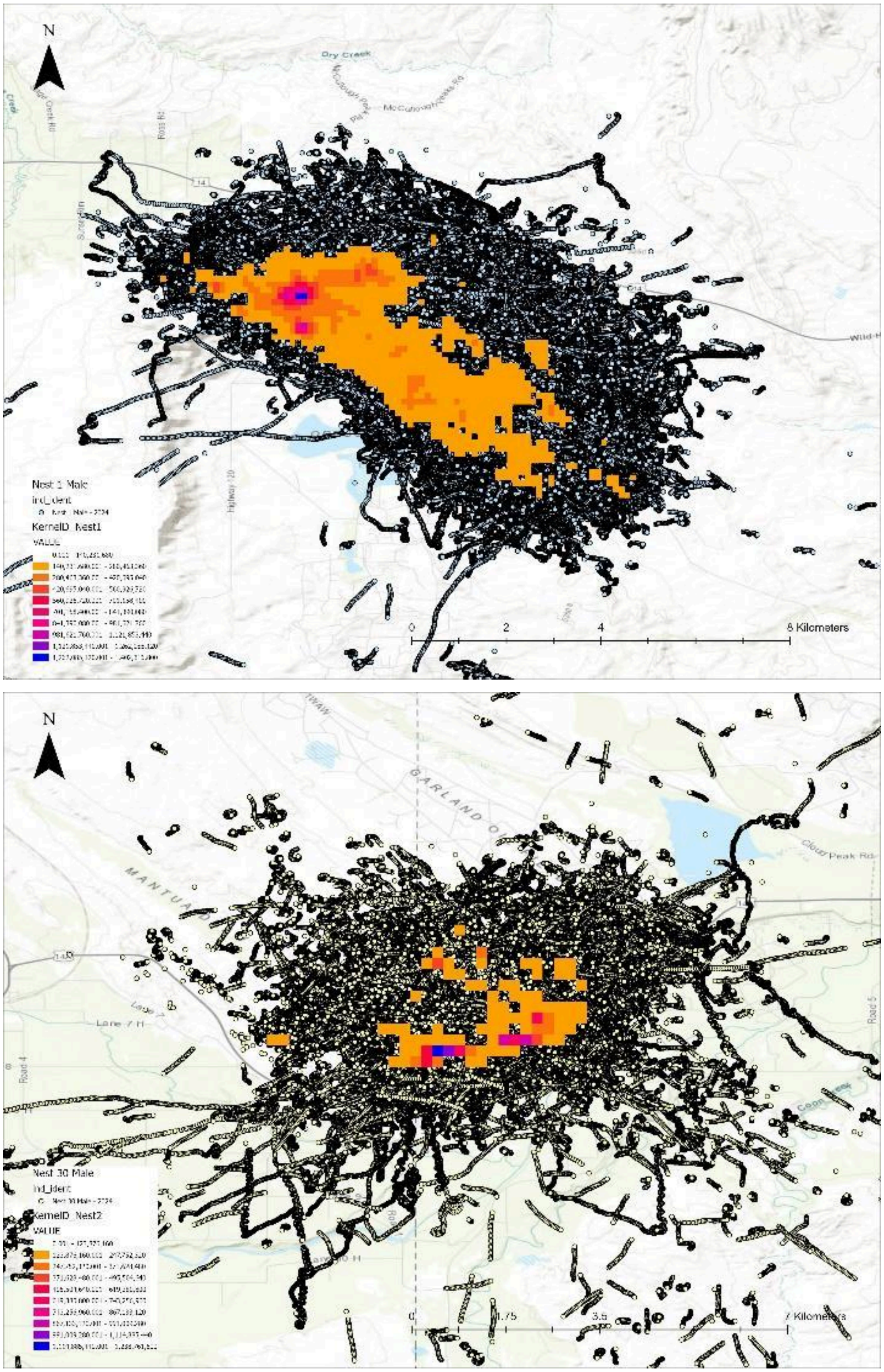
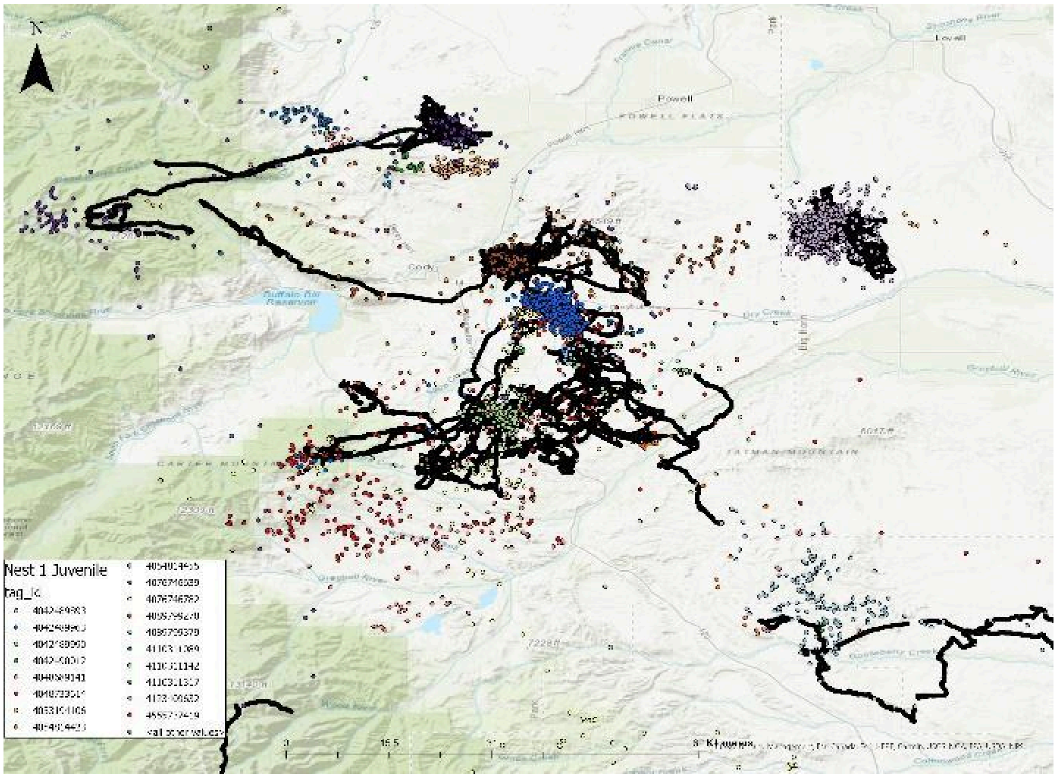


Figure 3. *Locations of breeding male golden eagles, zoomed in on core territories and kernel density estimate home ranges during 2024.*


Nest 1 Juvenile
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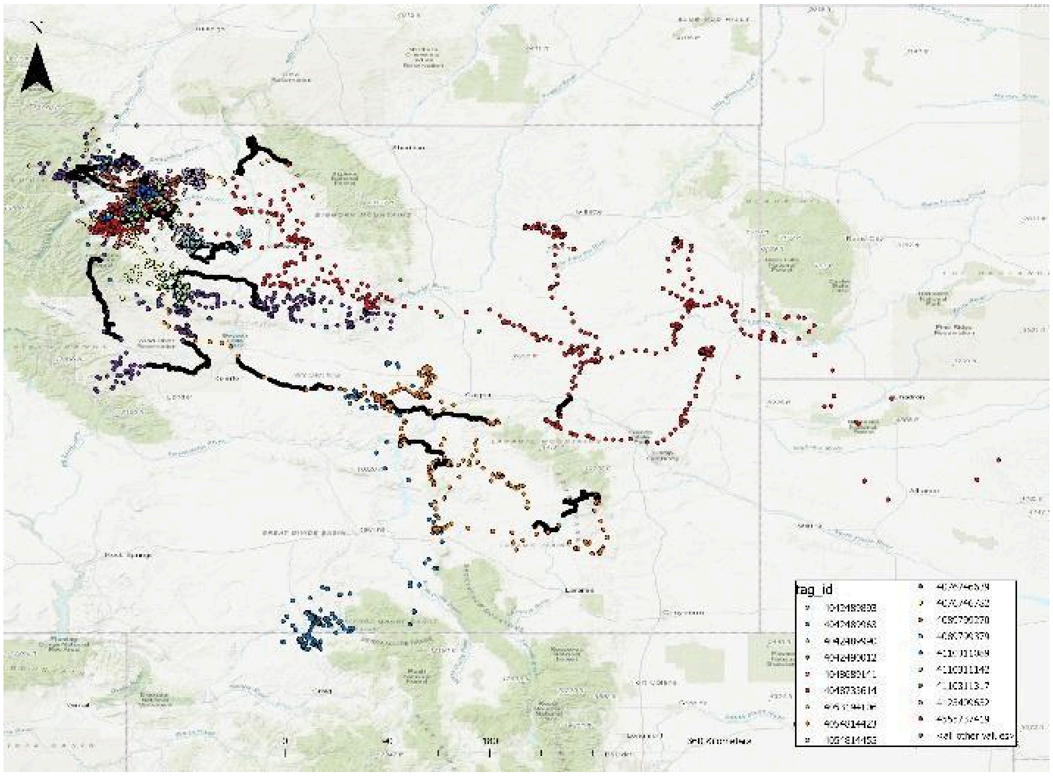
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GREAT DIVIDE BASIN
Lander
Casper
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Kilometers

Figure 4. *2024 locations of juveniles tagged in collaboration with Ellen Aikens, UWYO at the local scale (left) and complete scale (right)*

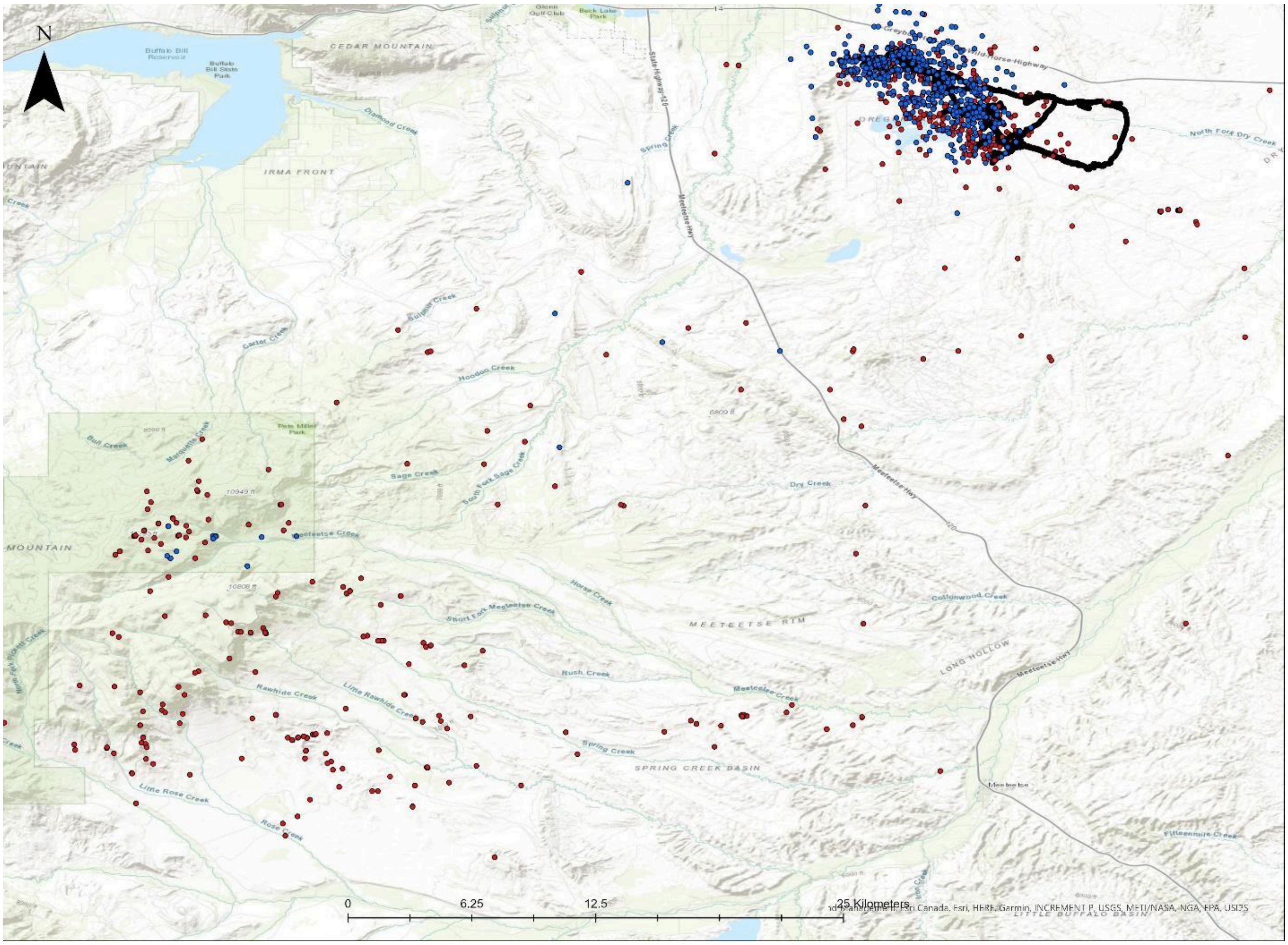

Figure 5. *Locations of Nest 1 male (blue) and juvenile (red) from July – September 2024. Adult male's location thinned to 1/hr for visibility. Note that the locations to the SW of the territory do not correspond in date.*

Discussion:

We had hoped to deploy more transmitters in the first year of the study, but a delay in the delivery of the transmitters affected our timing and success. We did, however, gain a better understanding of the study area, access, and territories for trapping efforts in 2025. The two transmitters deployed provided us with fantastic data during the 2024 breeding season. While data collection this fall and winter have been challenging due to the removal of the 3G cell network in October, we have developed new programming and fieldwork to overcome this significant hurdle. The two transmitter deployments in 2025 also allowed us to understand the nuance of these very sophisticated transmitters. This will be a great benefit to the study moving forward.

The 2024 field season also encouraged us to experiment with new trapping methods that will be beneficial in our 2025 efforts. We will be trapping in the month of February 2025 to increase our sample size. We will also continue to collaborate with Dr. Aikens to deploy additional transmitters on fledglings in 2025, after the units have been exchanged for new units that work with the LTE cell network (scheduled for March 2025). Particularly, we plan to outfit fledglings of tagged adults with transmitters to begin exploring adult/offspring learning.

Following additional adult transmitter deployments this year, we will also continue to deploy ARUs and trail cameras in those territories. We will return to the study area several times/year to download location data and maintain ARUs and trail cameras.   We will continue to aerially survey the two main study areas for full density, check all known territories for occupancy, and assess active nests for productivity later in the summer.

Bighorn Basin Golden Eagle Ecology Program: Reproductive Performance, Primary Prey Abundance, and Diet

Project Partners: Charles R. Preston[1,2], Bryan Bedrosian[2], Destin Harrell[3,4]

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[2] Teton Raptor Center, PO Box 1805, Wilson, WY 83014

[3] U.S. Bureau of Land Management, 1002 Blackburn St., Cody, WY 82414

[4] Current Address: U.S. Fish and Wildlife Service, Cody, WY 82414

Golden Eaglet, 6 days before fledging. *Photo courtesy of C. R. Preston*

Summary Narrative:

In 2024, we completed the sixteenth consecutive year monitoring golden eagle reproductive performance and nesting diet and the fifteenth consecutive 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 2024 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 55 territories in 2024 and found that 51 (91%) of these were occupied (please see Preston and Anco (2021) for explanation of terms. We determined the reproductive result for 48 of the occupied territories. Twenty-eight (58%) of these territories were successful in producing at least one fledgling. Together, these territories produced a total of 33 fledglings. The calculated reproductive rate was thus 0.69 fledglings per occupied territory — higher than 0.44 in 2023, and slightly higher than the 16-year mean of 0.68 (Table 1).

As we've demonstrated before (see Preston and Anco 2021), cottontails (*Sylvilagus* spp.) have been the primary prey for nesting golden eagles in the Bighorn Basin during our study, averaging 66% of nesting prey remains identified (Table 2). To assess nesting diet in 2024, we collected prey remains from a sample of 10 nests. Cottontails were the most frequently occurring species in prey remains (36%), followed by white-tailed jackrabbits (*Lepus townsendii*) (24%) — both substantially greater than in 2023 (22% and 8% respectively) (Table 2). The frequencies of pronghorn fawns (*Antilocapra americana*) (7%), mammals other than leporids and pronghorn (9%), and birds (compilation of at least 9 species) (22%) in the nesting diet of nests we sampled in 2024 were markedly lower than 2023 (24%, 30%, 35% respectively) (Table 2).

The index to relative cottontail abundance in 2024 was 3.5 individuals per 1.6 kilometer (5 mile) route, the highest since 2021, before the emergence of Rabbit Hemorrhagic Disease Virus 2 (RHDV2), but substantially below the 15-year mean of 6.7 (Table 3). Interestingly, the white-tailed jackrabbit index in 2024 was 8 individuals per route, the highest recorded during our study and nearly four times the 15-year mean. The increase in leporid abundance in 2024 may explain the lower incidence of pronghorn, other mammals, and birds in the nesting diet. The higher leporid abundance likely also accounts for the increased golden eagle reproductive rate. Cottontail abundance remains a key to golden eagle reproduction in the Bighorn Basin.

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 (Figure 1), there was a slight increase in 2020. However, in contrast to expectations, cottontail abundance declined each year until 2024. The increase in cottontail abundance may signal a rebound for both cottontails and golden eagle reproduction. 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 the Bighorn Basin Golden Eagle Ecology Program 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, lead poisoning from contaminated carcasses, etc.

Tables and Figure:

Table 1. Golden eagle reproductive performance 2009 - 2024.

Year	Number of Nesting Territories Surveyed	Number and Percentage of Surveyed Nesting Territories Occupied	Number of Occupied Nesting Territories with Known Outcome	Nesting Success: Number and Percentage of Occupied Nesting Territories with Known Outcome Producing at Least One Fledgling	Reproductive Rate: (Number of Fledglings/Occupied Territory with Known Outcome)
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%)	0.30
2023	42	36 (88%)	36	12 (33%)	0.44
2024	55	51 (93%)	48	28 (58%)	0.69
Mean; SD	47.7; SD 11.3	41.0; SD 10.5 85.7%; SD 5.4	39.8; SD 9.1	19.5; SD 10.8 48.1%; SD 22.0	0.68; SD 0.4

Table 2. Summary of prey remains frequency identified from golden eagle nests 2009 – 2024.

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
Total	1891	114	1253 (66%)	152 (8%)	102 (5%)	119 (6%)	243 (13%)	17 (1%)

Table 3. Annual indices to relative abundance of cottontails and white-tailed jackrabbits in the Bighorn Basin, Wyoming 2009 -2024.

Year	Cottontails Roadside Survey[a] (Hunter Harvest[b])	White-tailed Jackrabbit Roadside Survey[a]
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)	8.0
Mean	6.7 (1.4)	2.4

[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).

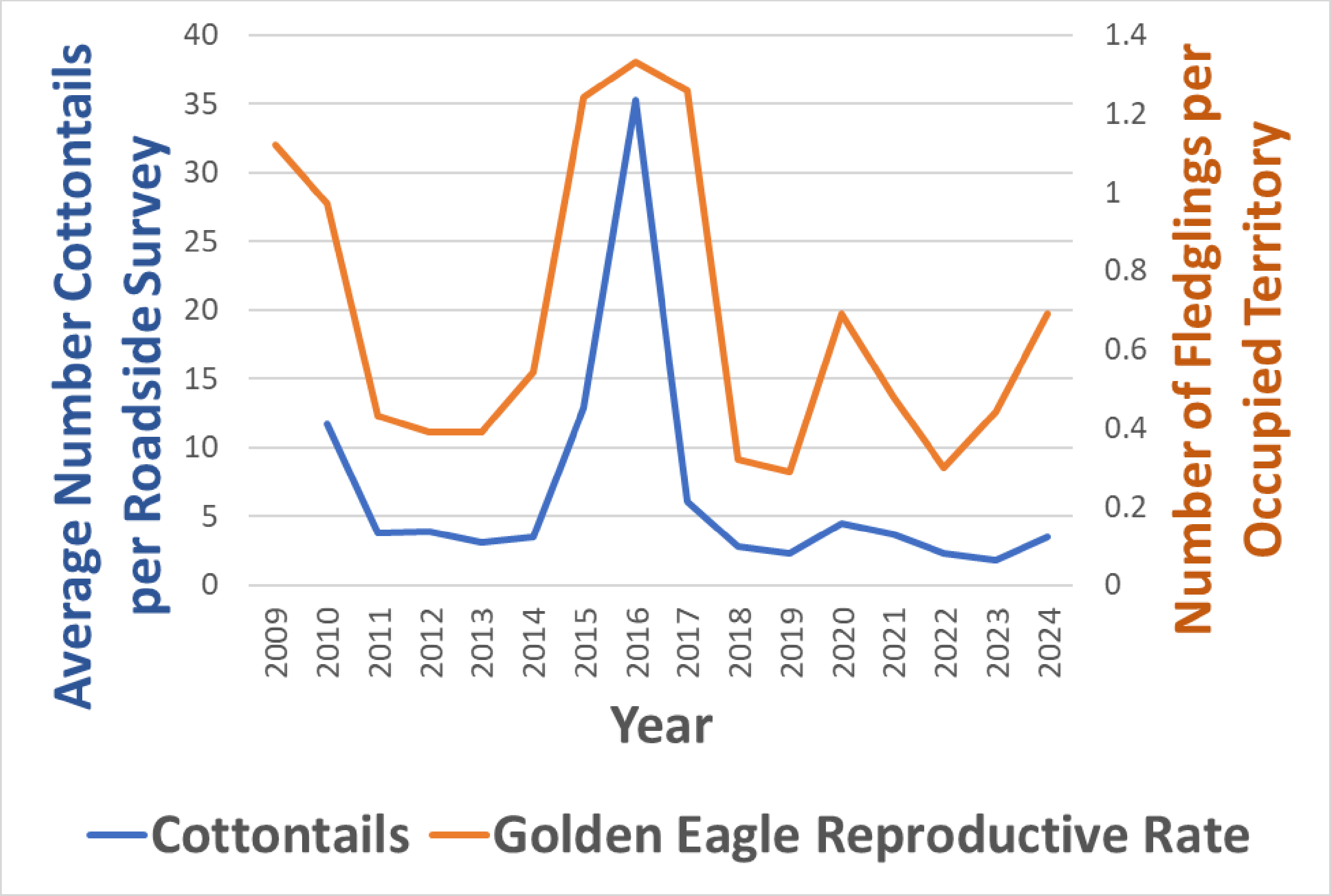

Figure 1. *Relationship between annual cottontail abundance and golden eagle reproductive rate 2009 – 2024.*

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Ferruginous Hawk Habitat Use and Nest Productivity in the NPL Natural Gas Development Field

Project Partners:

Teton Raptor Center

Colorado State University; Sarah Ramirez[1], Liba Pejchar

BLM-Pinedale Field Office; Dale Woolwine

[2]Current Address: USGS

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 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 2024, we continued our annual flight surveys to monitor nest productivity in the NPL Natural Gas Development Field. Flight surveys were conducted on May 14, 2024 and included approximately 816 kilometers flown (Figure 1). Three nests were followed up with one on the ground monitoring check late in the season for territories to determine productivity.

We observed 15 occupied Ferruginous Hawk territories in our 2024 flight surveys (Figure 1). Of those 15 territories only 4 were confirmed to be successful with on-the-ground monitoring. However, we did not check the majority of nests to determine productivity. We determined that the four platform nests we checked were successful, including one that had five nestlings, which we banded. We banded 12 nestlings in platform nests on June 20, 2024.

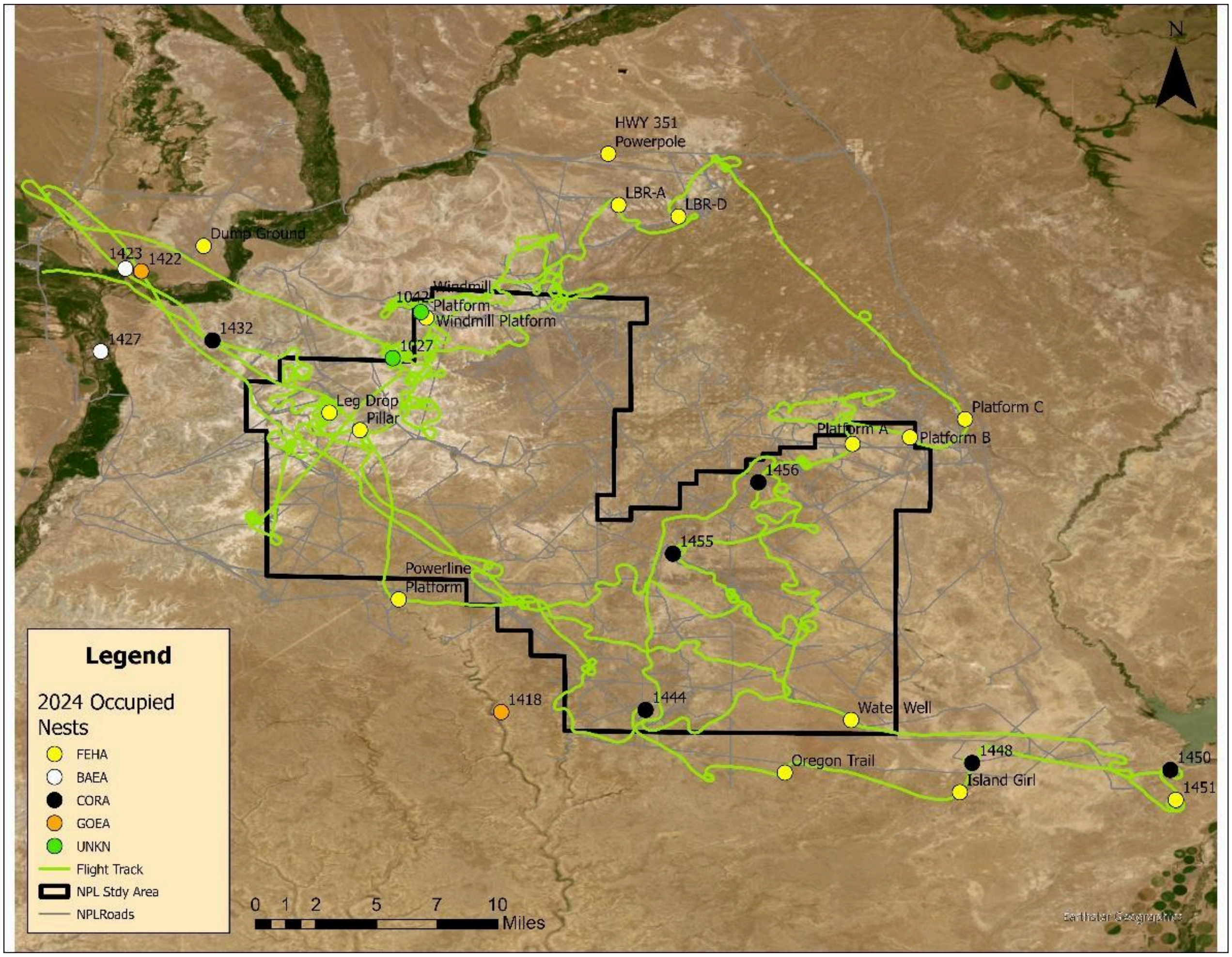

Figure 1. *2024 flight survey data with nest status by species for the NPL study area.*

Table 1. Ferruginous Hawk NPL territories and their status in 2024.

Territory	Status	Outcome	Number of Young	Lat	Long
Powerline Platform	Active	Successful	3	42.34305	-109.899
Dump Ground	Active	Unknown		42.54932	-110.013
Pillar	Active	Unknown		42.44172	-109.922
Windmill Platform	Active	Unknown		42.50737	-109.883
1446	Active	Unknown		42.2419	-109.673
1447	Active	Unknown		42.23052	-109.571
1451	Active	Unknown		42.22603	-109.444
Waterwell	Active	Unknown		42.27271	-109.634
Platform A	Active	Successful	5	42.43371	-109.633
Platform B	Active	Successful	3	42.43761	-109.6
Platform C	Active	Successful	1	42.44812	-109.568
Lower Blue Rim D	Active	Unknown		42.5664	-109.735
Lower Blue Rim A	Active	Unknown		42.57311	-109.77

2018 – 2024 Summary:

Nest productivity information on active Ferruginous Hawk nests in and near the NPL study area was gathered from 2018 – 2024 (Figure 3); 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 documented from 2018 to 2024 ranged from 7 - 15 (mean = 11.1; Figure 4). 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 are not assessing productivity in this report since we had inadequate surveys in the late nesting period to accurately determine nest success. More detail on productivity and habitat selection can be found in Ramirez (2023).

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 2024 (Dump male and Platform A female; Figure 5). 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 2023). Movement data from tagged birds indicated that seasonal movements often involved a northward migration early in the fall before later migrating south of their breeding season range (Figure 6). We are sharing these data with USFS Rocky Mountain Research Station for a broader migration and staging area analysis.

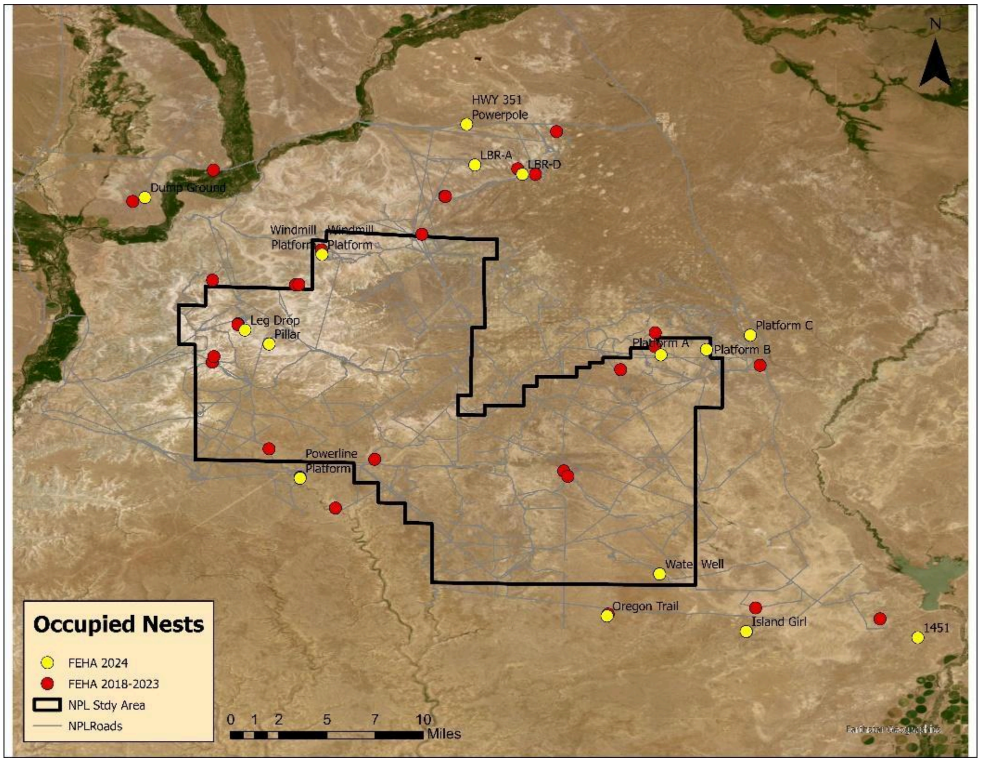

Figure 3. *All active Ferruginous Hawk nest locations in the vicinity of the NPL Study Area from 2018-2024.*

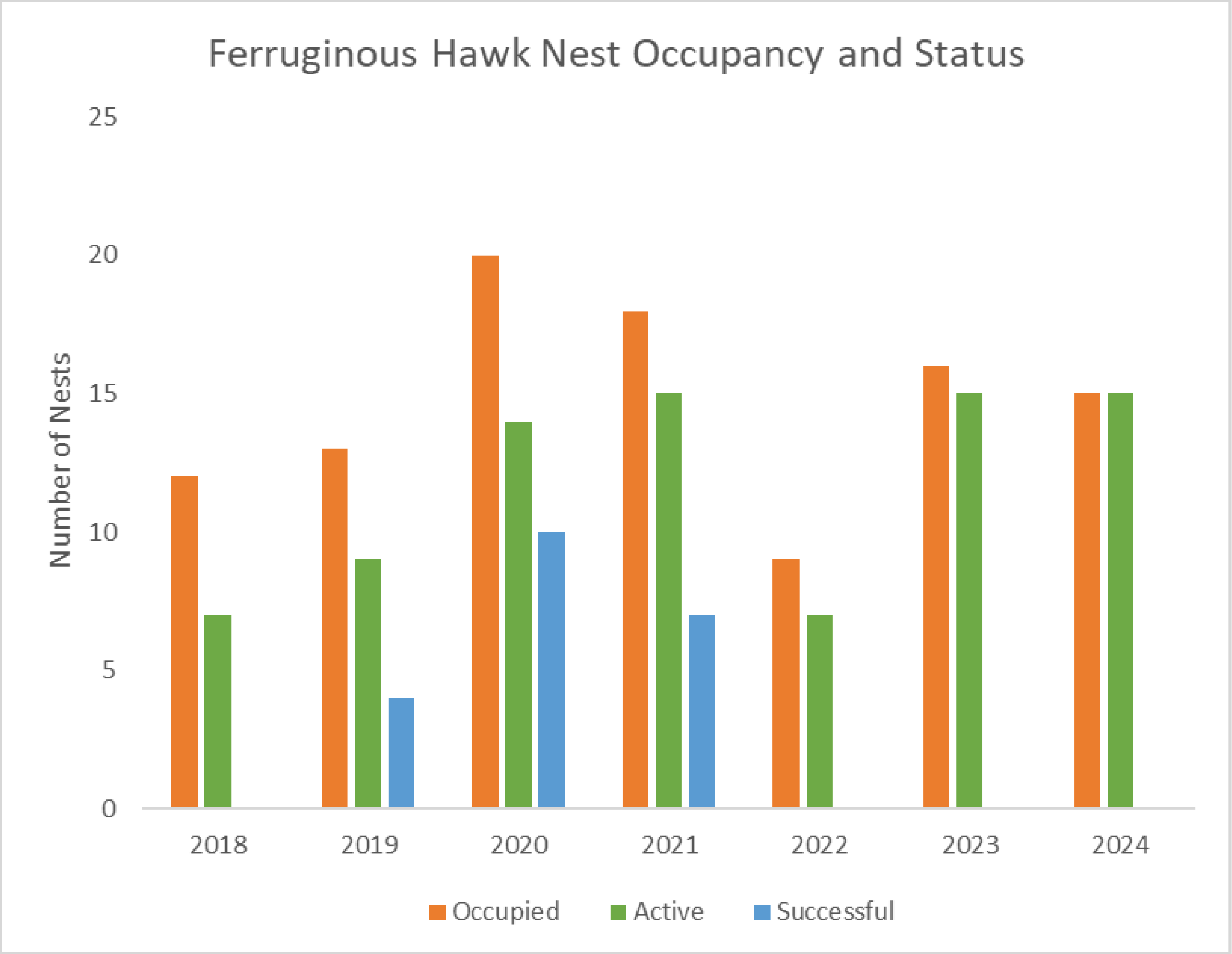

Figure 4. *Number of occupied Ferruginous Hawk territories and active nests by year with nest status for active nests. *note: ground surveys were not conducted in 2022-24 and occupied territories with inactive nests are likely underrepresented. Productivity is only reported for years with sufficient ground surveys to assess success/failures.*

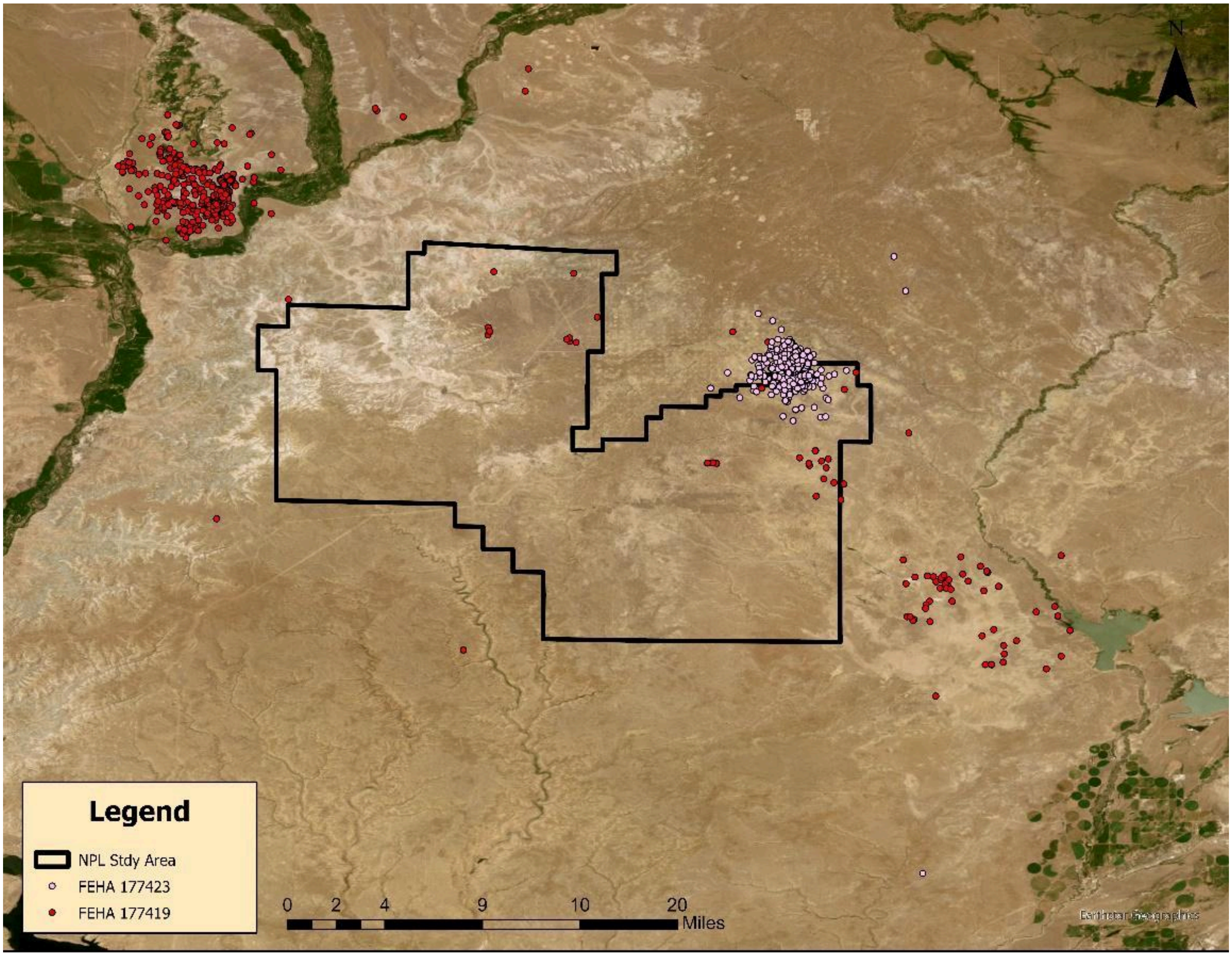

Figure 5. *Location data for three tagged Ferruginous Hawks in the NPL Study Area (2019-2024).*

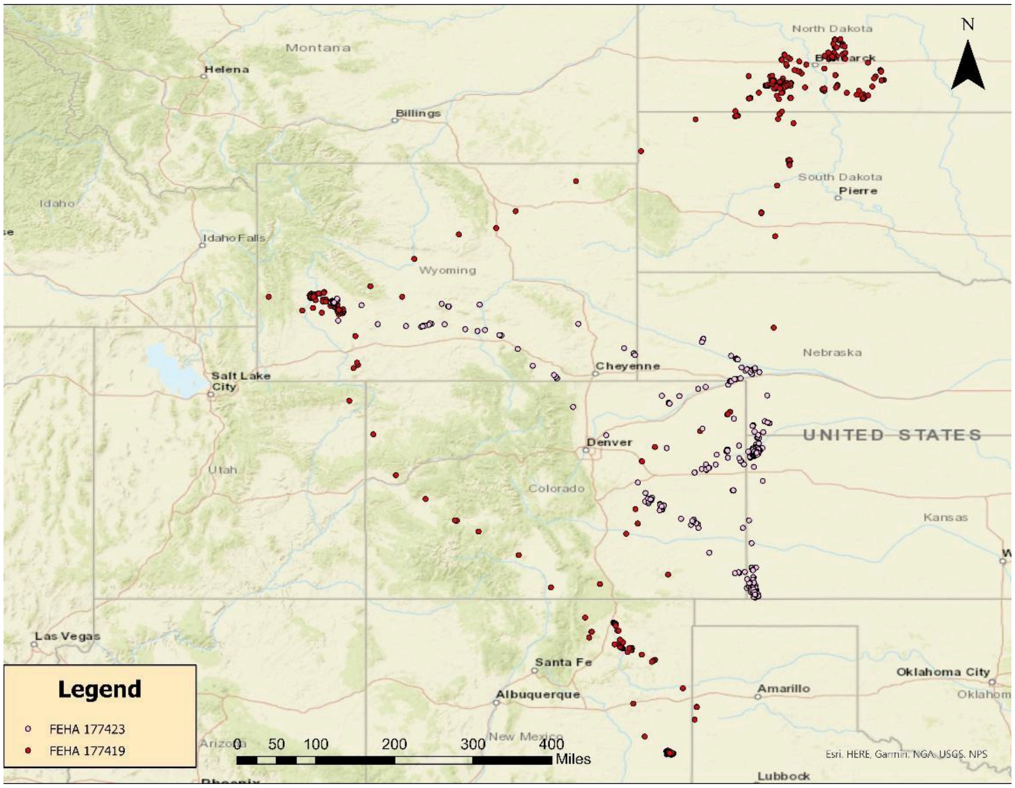

Figure 6. *Movement data for three tagged Ferruginous Hawks on a continental scale (2019-2024) Ferruginous Hawks show an interesting pattern of moving north before south in the fall.*

<u>Artificial Nesting Platforms:</u>

In the fall of 2022, we installed 13 platforms in the NPL study area to provide nesting structures for Ferruginous Hawks (Figure 7). 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 8). 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 platform adjacent to three platforms installed several decades ago (Figure 9). 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) moved and built a nest on the new platform. The pair was captured on camera (Figure 10) 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 the use of three additional new platforms. Powerline 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.

Figure 7. *Examples of artificial nesting structures built for Ferruginous Hawks in the NPL area in 2022.*

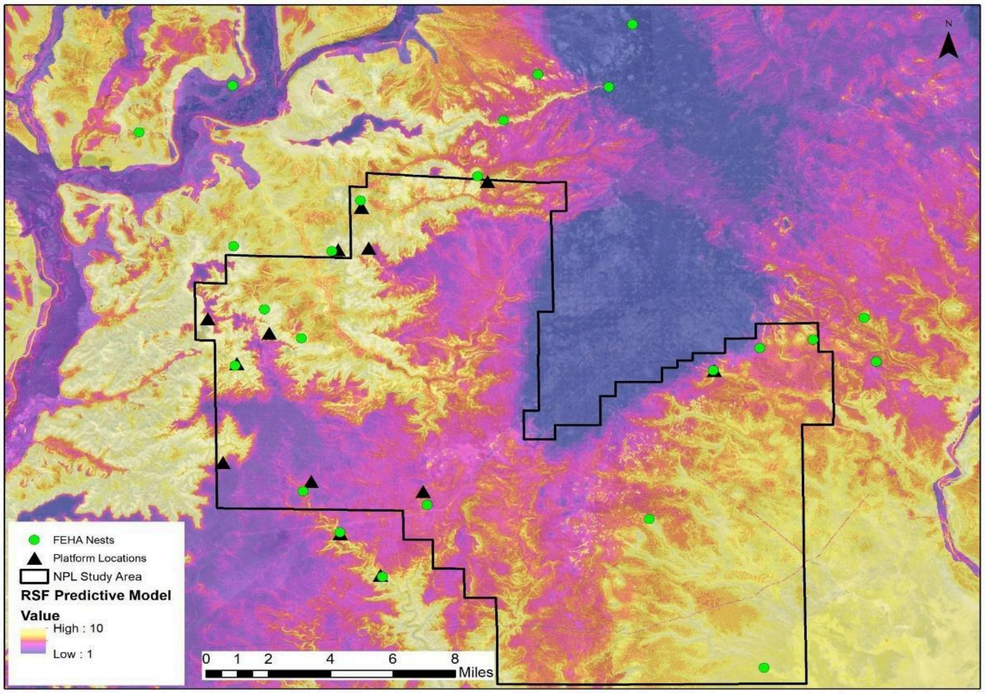

__Figure 8.__ 2024 Ferruginous hawk nests and artificial nesting structures.

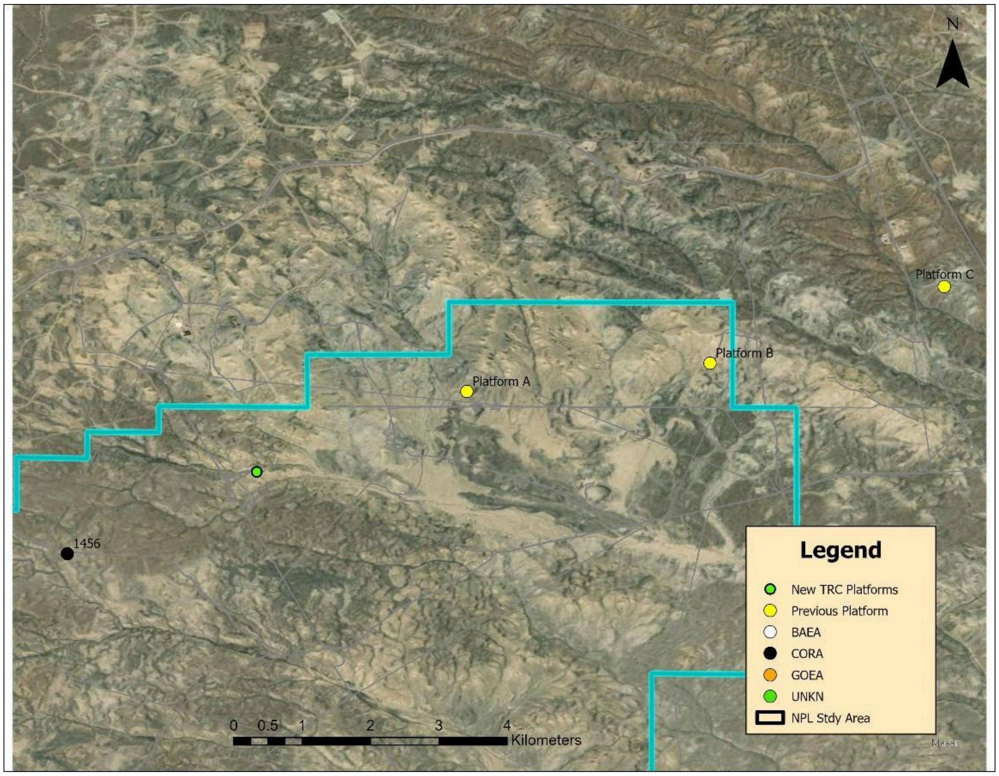

Figure 9. *Platform installed in 2022 (green) that was used in 2023 by pair previously and subsequently occupying Platform A.*

Figure 10. *Two tagged, breeding Ferruginous Hawks nesting on the new SEOW Platform in 2023 (previously and subsequently breeding on Platform A).*

Figures 11 and 12*. Common Raven building a nest on Pipelines Platform in 2024 and an adult, unbanded Ferruginous Hawk checking out the nest shortly after it was completed.*

teton raptor center

American Goshawk Habitat Use in the Greater Yellowstone Ecosystem

Introduction:

Many animal populations are at risk across Wyoming and in the Greater Yellowstone Ecosystem. While agencies are tasked with managing sensitive species, there is often a significant lack of data needed to adequately 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 on 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 county 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 (ARU) 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.

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 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 and Habitat Analysis

In order to determine breeding home ranges for each goshawk we first limited the analysis to goshawks that had a full breeding season of data following deployment. For each of those individuals we filtered the location data to begin on the date of transmitter deployment since all transmitters were deployed between April and July in the breeding season. If it was the second or third year for tracking a tagged goshawk we started the breeding season on April 1, unless we saw obvious indication of a later arrival to the breeding territory in which case we used the arrival date. We typically used either August 31 or September 15 as an end date depending on the latitude of the territory, for the territories located further north we utilized the later date. The exception to this rule is if a bird showed an obvious movement away from the breeding season earlier in the fall. We calculated 95% kernel density estimates (KDE) of breeding home ranges using the adhehabitatHR package in Program R.

We then measured land cover and geomorphic characteristics at goshawk GPS locations (used locations) within mapped 95% KDE breeding home ranges to assess habitat associations across all goshawk territories. We used the National Land Cover Database (NLCD) to determine which land cover categories were most common within breeding home ranges (NLCD 2016). To assess geomorphic characteristics, we obtained elevation, slope, and aspect from a 30 m resolution digital elevation model (DEM).

Results:

For detailed interim habitat modeling results, see the 2023 TRC goshawk annual report. We will be updating these analyses with additional years’ data and preparing a manuscript for publication on habitat use, home ranges, and migration details in the coming 1-2 years. Initial results were presented at the Wyoming TWS meeting in 2024.

From 2019-2024, we have been monitoring goshawk territories for occupancy and nesting (Figure 1). We have monitored between 16 – 23 territories each year, depending on snow conditions, previously known territories and access. Occupancy appears to have dropped over the last six years. However, this apparent trend may be more related to the percentage of new territories located each year. 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. There was a fairly low nest initiation rate within occupied territories, with a 38% mean (range 29 – 57%). For those pairs that did initiate a nest, there was fairly high and consistent success, with a 76% mean (Figure 1).   Successful nests had a relatively consistent productivity rate with a mean of 2 fledglings produced per nest.

This year, we located four previously unknown nests (including three previously unknown territories). Our partners at the BTNF altered us to a nest in Bryan Flats and Konshau Duman located a nesting pair in Coburn Creek. We also located an active nest near Red Top that was a previously known territory where adult goshawks had been observed but no previous active nests had been located. Based on a combination of movement data from previously tagged adults, ARU results, and field visits we also had four territories that were confirmed occupied during the 2024 breeding season but were not believed to have active nests. We also deployed two new transmitters on adult goshawks in 2024. These transmitters were deployed on the adults at the new Redtop territory, but the nest failed prior to the end of the breeding season.

In 2024, we obtained breeding season locations for two previously tagged goshawks and had one transmitter that went down the previous year and we did not obtain data during the 2024 breeding season (Table 1). Of the four goshawks we were able to obtain breeding season ranges for, three of them were males (Mosquito, Trails End, Red Top) and one was a female (Beaver Creek). Interestingly, the female goshawk that successfully bred for the previous two years in the Beaver Creek territory moved north to a new, previously unknown territory on Signal Mountain and successfully nested. Of the three males we monitored in 2024, two nested and it was suspected that the Mosquito male did not by location data and our inability to locate an active nest in the historic nesting stand. The Trails End male was on the same territory it was captured on in 2022, and a female was observed incubating in the same nest as two years prior. However, there were no signs of fledglings later in the season and we suspected the nest failed. The Red Top male had an active nest on a newly discovered territory, but the nest was unsuccessful. Despite nest failure, the Red Top male appeared to stay on territory. The Red Top female immediately moved to the Big Hole Mountains after her nest failed and has remained there through the end of 2024.

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 3).

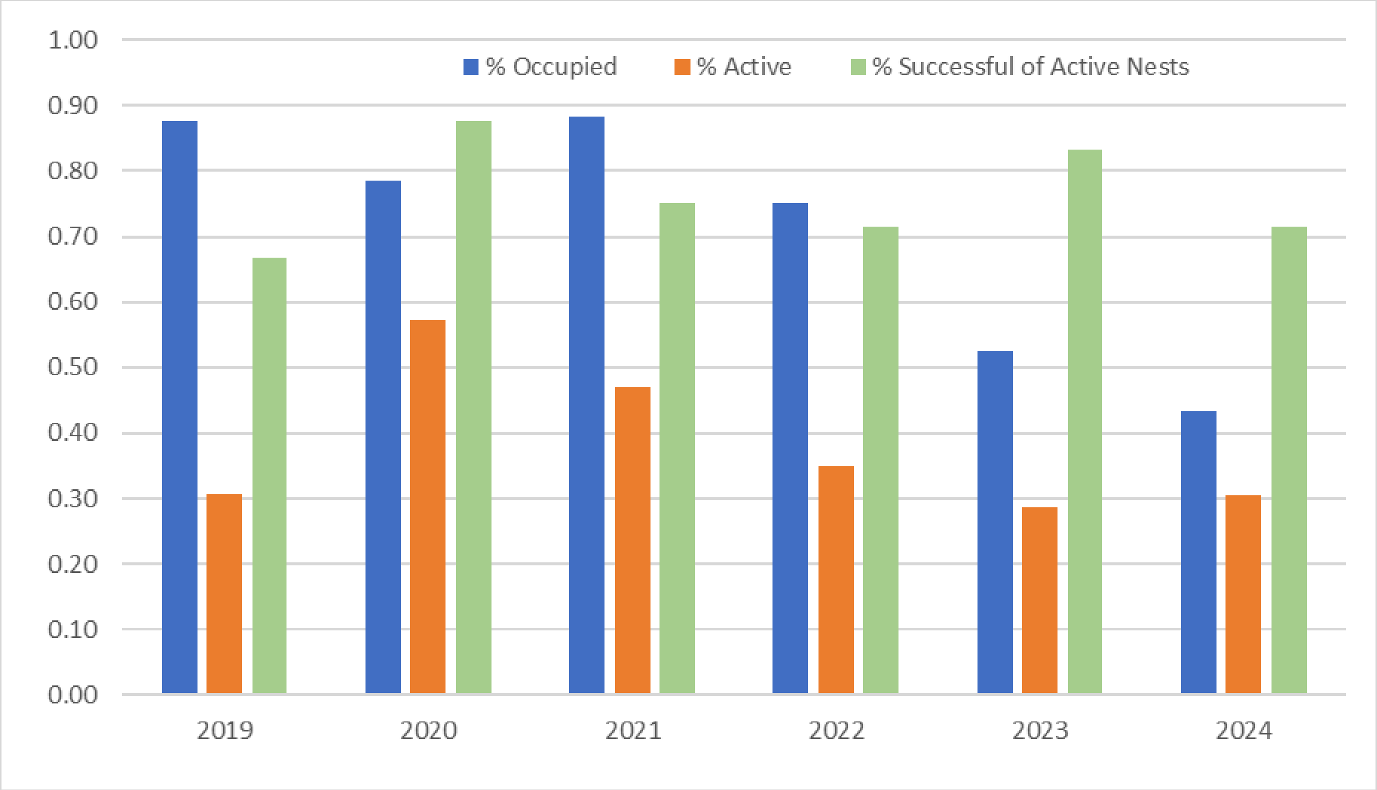

Figure 1. *The percent of territories that were occupied and active of the monitored nests, and the percent of successful nests out of active nests from 2020-2024.*

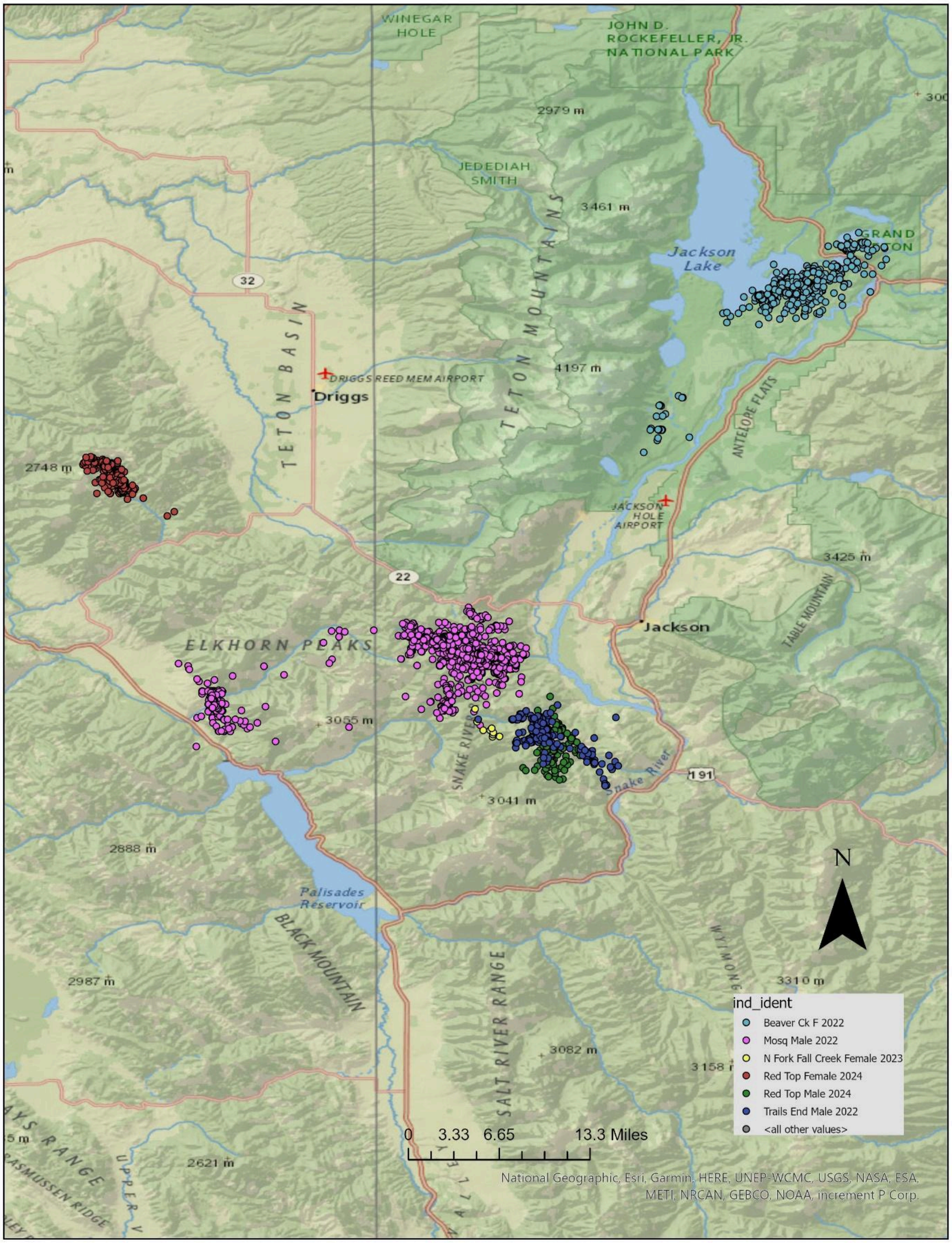

Figure 2. *Goshawk locations in the vicinity of Jackson Hole for four individuals with breeding season location data (April – August) in 2024.*

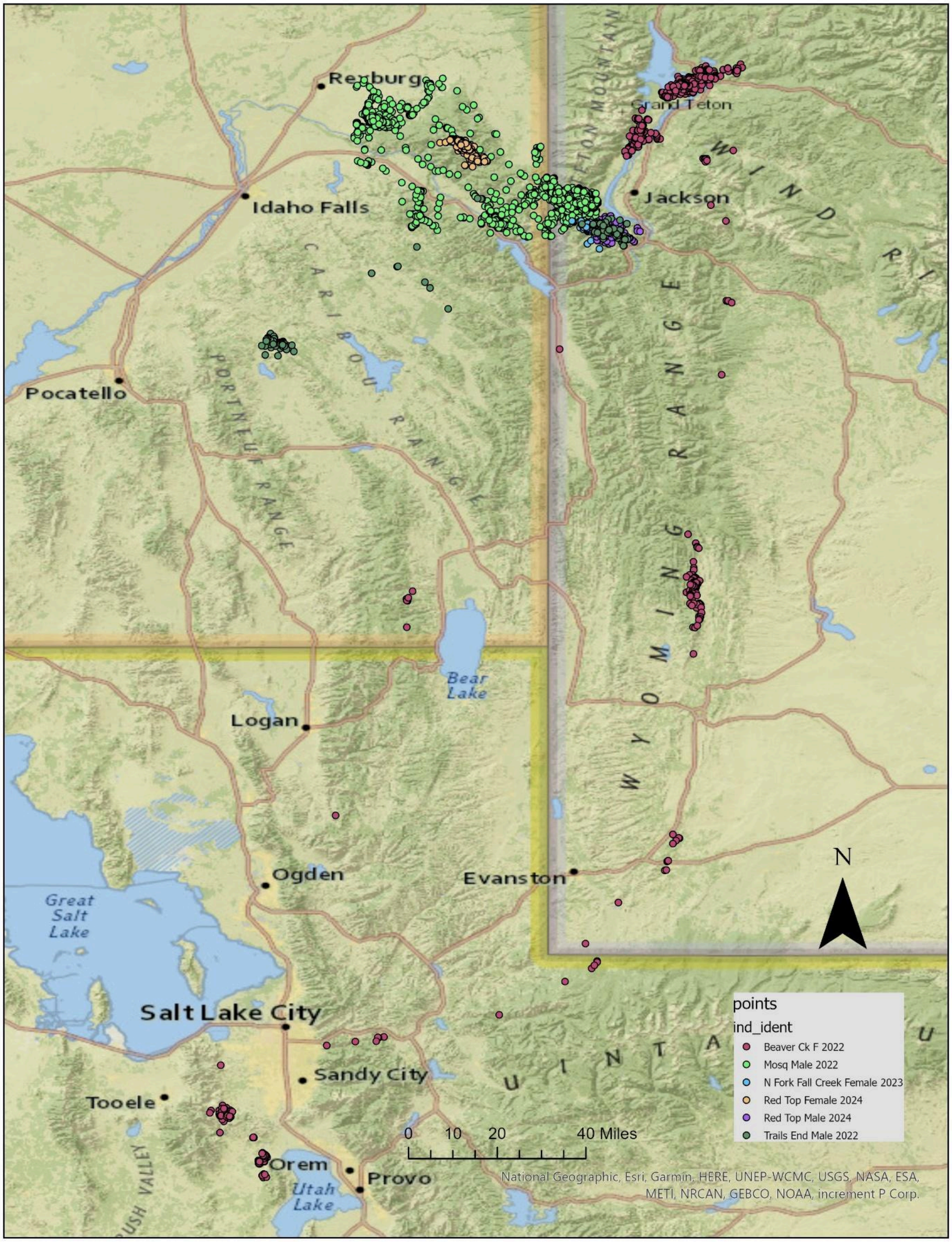

Figure 3. *2024 annual movements of breeding goshawks tagged in Jackson Hole, Wyoming.*

Table 1. Details for goshawks tagged with transmitters in Jackson Hole, Wyoming 2019 – 2024.

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	217	Local	Failed Trans	7/3/2020 – 11/14/2020
5	Beaver Creek	Male	2020	Successful	541	Long	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	7360	Long Distance	Active	6/30/2022 – Current
6	Poison	Male	2020	Successful	49	Unk	Failed Trans	6/7/2020 – 6/8/2020
9	Poison	Male	2021	Successful				
9	Poison	Male	2022	Unsuccessful	1573	Local	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				
12	Taylor - Granite	Male	2023	Unknown	ong Distanc	606	Dropped Trans	6/17/2021 – 6/11/2023
8	Mosquito	Male	2020	Successful	Short	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	9422	Alive	6/23/2022 – Current
10	South Fall Creek	Male	2021	Unsuccessful	ong Distanc	520	Unk	4/20/2021 – 4/19/2022
11	Coal Creek	Male	2021	Successful	hort Distanc	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	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	Alive	6/15/2024 – Current
23	Red Top	Female	2024	Unsuccessful	Short	660	Alive	6/15/2024 – Current

Discussion:

Goshawk territories in the study area appear to have relatively nest success from active territories across years. However, territory occupancy and nest initiation rates appear to be declining across the years of observation. It is difficult 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, although the occupancy rate appears to be declining overall. This suggests we likely did not locate nesting hawks. Goshawks are known to move active nests sites up to 1km from previously active nests. We did not deploy enough ARUs in large enough areas to account for this scale of nest movement. Further, we documented two goshawks completely moving territories across the valley (Beaver Creek to Signal Mtn and Taylor to Granite). 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 a large number of breeding goshawks. We have experienced a large number of 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 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.

In 2025, we plan to reduce efforts for this study, particularly for tagging. Most known territories in the valley have had at least one tagged breeder as part of this study and we have begun developing good models of habitat use. Interestingly, there is a mixture of movement strategies in the winter and we will be investigating that further. We will continue to monitor known territories with ARUs and locate nests, when feasible.

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Golden Eagle Artificial Nesting Structures in the Great Plains

Summary of Accomplishments

We have completed the installment of 10 golden eagle artificial nesting structures. We have worked with Thunder Basin National Grasslands to obtain Categorical Exclusions and permissions to erect these structures. We have completed nest installations in 4 territories where nests were placed in trees and installed 6 poles with nesting baskets in territories devoid of trees. We have also installed remote cameras to monitor eagle use of the nests.

Project Activities & Outcomes

Activities:

Golden eagles (*Aquila chrysaetos*) have recently emerged as a species of conservation concern in North America. In the western United States, threats include mortality and displacement from expansion of domestic energy production. The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d) sets goals to achieve “stable or increasing breeding populations,” and much work has been ongoing to define golden eagle population densities, trends, demographics, risks, and mitigation options to offset losses (e.g., see special issue of Journal Raptor Research 2017:51). Recent data have suggested that golden eagle populations in the conterminous United States are stable-to-declining (Millsap 2013, Neilson et al. 2014, USFWS 2016), leading to a USFWS requirement of no net loss within the regulations of eagle incidental take and take of eagle nests (USFWS 2016 50 CFR 81.242).

The USFWS Western Golden Eagle Team has recently completed risk assessments and conservation strategies for golden eagles across most of Wyoming (Wyoming Basin and Northwestern Plains ecoregions), which include models of relative nesting density (Bedrosian et al. 2019, Wallace et al. 2019, Dunk et al. 2019). These strategies and models help spatially identify conservation opportunities and priorities, such as the loss of cottonwoods for nesting habitat in the Northwestern Plains. These conservation assessments also identify that Wyoming hosts the densest populations of breeding golden eagles in the West. Within the Northwestern Great Plains, NE Wyoming has the highest relative golden eagle nest density (Dunk et al. 2019).

The number of eagle nesting territories are, in-part, a function of available nesting substrate in NE Wyoming (Bedrosian et al. 2019). Unlike much of their range, eagles in the Northwestern Plains are heavily reliant on trees for nesting. While up to 98% of eagle nests are located on cliffs in the Wyoming Basin (Preston et al. 2017), the converse is true in NE Wyoming, with up to 82% of nests located in trees (Phillips and Beske 1990). Nests in this area primarily occur in plains cottonwoods (*Populus deltoides*) and these trees are typically large enough to support eagle nests when they are ca. 25 years old and live <100 years.

Loss of cottonwoods and/or lack of regeneration can significantly affect the ability of local eagle pairs to nest. Many small stands and single cottonwood trees occur across the region because of current and remnant agriculture. Early homesteads planted and irrigated cottonwood trees as shade and windbreaks but those historic plantings are being lost due to natural attrition. Additionally, irrigation ditches from agriculture in the early half of the 1900s provided moisture and soil disturbance that led to cottonwood growth in some areas. Many of those irrigation channels have been abandoned over the years, limiting contemporary regeneration. Finally, livestock grazing can significantly reduce seedling densities by foraging (Crouch 1979, Auble and Scott 1998), cause soil compaction that limits germination, and girdle larger saplings and pole trees. In areas such as Thunder Basin National Grasslands, young cottonwood galleries now only exist in washes too steep and deep for cattle to regularly graze (T. Beyer, pers comm). As those remnant cottonwoods are lost and not replaced, this functionally loses golden eagle nesting habitat. Further, not all cottonwoods have the branch structure to support an eagle nest.

Objective and Solution:

Our objective is to create and restore golden eagle nesting habitat in areas with no or limited nesting substrate and directly increase eagle populations in Wyoming.

Methods:

We will accomplish our objective by providing nesting platforms in cottonwoods that cannot support a nest or erect artificial nesting trees within high-quality eagle habitat that is devoid of nesting substrate *and* outside of an existing eagle territory. Golden eagles have been known to nest on artificial platforms and other similar structures; such as powerlines, transmission towers, GSM towers, oil and gas infrastructure, and others. In northern Montana, golden eagles nest on platforms in areas otherwise devoid of nesting structures (Randy Matchett, UWFWS, personal observation). Nesting platforms are regularly used in the Powder River Basin (e.g., McKee 2018) and active nests are successfully moved from power lines to platforms (T. Jones, personal observation) or when mining conflicts occur (McKee 2018). Active nests blown out of trees or when trees have fallen during the nesting season, new nests have been created and immediately used when moved to platforms in northern California (B. Woodbridge, personal communication). Our project is designed to find high quality eagle nesting habitat in northeast Wyoming that is unoccupied because there are no cottonwoods or cottonwoods that do not have the branch structure to support an eagle nest. In the former, we will erect an “artificial nesting tree” that consists of a utility pole, nesting platform/nest, and an attached real, reclaimed or artificial cottonwood branches to maximize probability of colonization. In unoccupied habitat that has cottonwood(s) unable to support an eagle nest, we will place a platform, with a man-made nest, in the tree. Both efforts will result in “creating” a territory in high quality habitat that would not be available for nesting otherwise.

Outcomes:

Overview:

TRC utilized existing nest location data, modeled high quality breeding habitat for golden eagles (referred to as "GOEA" here on out), Greater Sage-grouse Lek location data and aerial imagery to identify potential areas to search for potential platform areas (Fig. 1)

On-the-ground reconnaissance of these areas was conducted in 2021 to search each area for historic GOEA nests and identify suitable areas for placing nesting platforms either on a pole or within an existing cottonwood tree; seven platform areas were identified (Fig. 2)

All proposed platform areas are located > 1 mile from existing GOEA nests and within areas of high quality breeding habitat for GOEAs

All proposed areas avoid sage-grouse priority or core areas after consultation with T. Byer.

All proposed areas avoid existing ferruginous hawk territories to minimize potential competition after consultation with T. Byer.

Proposed locations include areas where platforms would be placed on poles designed to resemble trees (n = 3) as well as areas where platforms would be placed in existing old cottonwood trees (n = 4) that lack suitable branching for supporting GOEA nests

We completed the initial assessment of the project area via GIS and previously collected data in the area. This allowed for the initial site selection in the initial areas identified in the figure 2. We then completed fixed-wing aerial surveys of the area to 1) ensure that the identified areas were not occupied by nesting golden eagles and 2) to identify any other territories where nests and/or nest trees were no longer present. From these efforts, we identified four additional areas that were suitable for nesting structures (Figure 3). We then worked with USFS biologists to create and submit a Categorical Exclusion within an Environmental Assessment (EA) for the project since it will occur on federal lands. The EA was submitted in January 2022. After initial review, an archaeologist clearance was required and we conducted site visits with the USFS archaeologist in May to all the sites. We did locate a new ferruginous hawk nest at one of the sites and moved the platform location to avoid that nest but got clearance for final locations at all other sites. The Categorical Exclusion was finally granted in August 2022 to allow us to continue with the project and install artificial nesting structures at 10 sites (six pole structures and four in-tree platforms). We have also secured retired power poles from our partners at PreCorp and are working to schedule those installations. Following the pole installations, we will create the branching and nest structures.

The main goal of 2023 was to work with power pole installation contractors to get poles moved to Thunder Basin National Grasslands and install them. We had lined out one crew to install poles during the winter of 2022/23 but weather and snow precluded them from accessing the remote locations. We had difficulty scheduling the crew in spring/summer of 2023 due to high work loads and demands of contractors.

As part of other collaborative studies in the area, we did fly the majority of the area again in the spring of 2023 to locate active golden eagle nests. This step is important to identify locations of old territories and confirm that we will not be placing nesting structures in existing territories. One new Golden Eagle nest was located 1.3 miles from an identified nesting structure location (Site 7 – Jenne Trail), so we will work with Thunder Basin National Grassland biologists to locate a new site that is outside this active territory. All other sites were confirmed as outside existing territories, so we can proceed as planned.

Following a long period of inability to install poles due to a backlog of work by installers, we have successfully installed 10 artificial nesting structures in 2024. We installed 6 nesting structures on retired power poles with the help of installers (Figure 4). Further, we completed building 4 artificial nests in existing trees (Figure 5). Locations of poles and trees were predetermined through a rigorous analysis of the landscape and existing eagle territories. In short, we used historical and new aerial flight data to identify locations where eagle territories previously existed but no longer do. This excluded sage-grouse core areas and areas of other sensitive species (e.g., ferruginous hawks). We worked with USFS biologists to get Categorical Exclusions of the exact locations for our work within the EIS framework.

When building nests, we placed a remote camera adjacent to the nest to determine if nests are found and occupied. In trees, we located territories with at least one tree and erected an eagle-sized nest within the lower canopy, typically where golden eagle nests would be located. In all instances, the tree lacked proper support and branching structure to hold an eagle nest and therefore this is additive to the population of eagle territories in the Great Plains. For pole installations, no trees were present in the potential territory and we provided elevated nesting structures for eagles to use. Currently, we have only installed the poles and a custom welded bracket to hold a golden eagle nest. We returned to the study area on Nov 11-13, 2024 to complete the nests and create a branching structure on the poles to mimic cottonwood trees (Figure 6). We used a pull-behind lift to erect branching structures, nests, and remote cameras at this time.

We will continue to monitor the artificial nesting structures and surrounding territories via aerial and ground surveys for at least 5 years. We will also annually replace batteries and SD cards in remote cameras to gather use data.

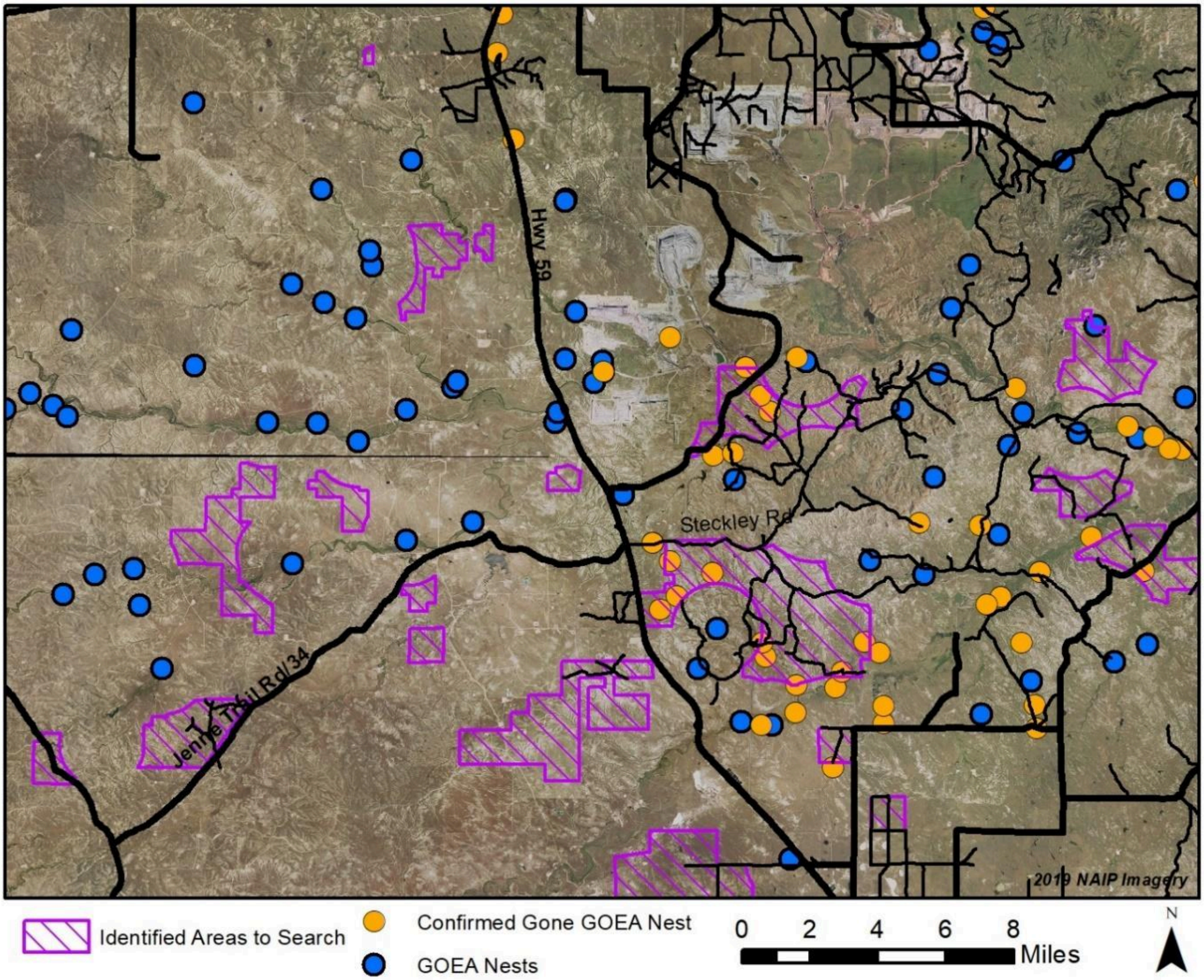


Figure 1. *Areas identified utilizing existing GOEA nest data and modeled high quality breeding habitat to search for potential platform locations.*

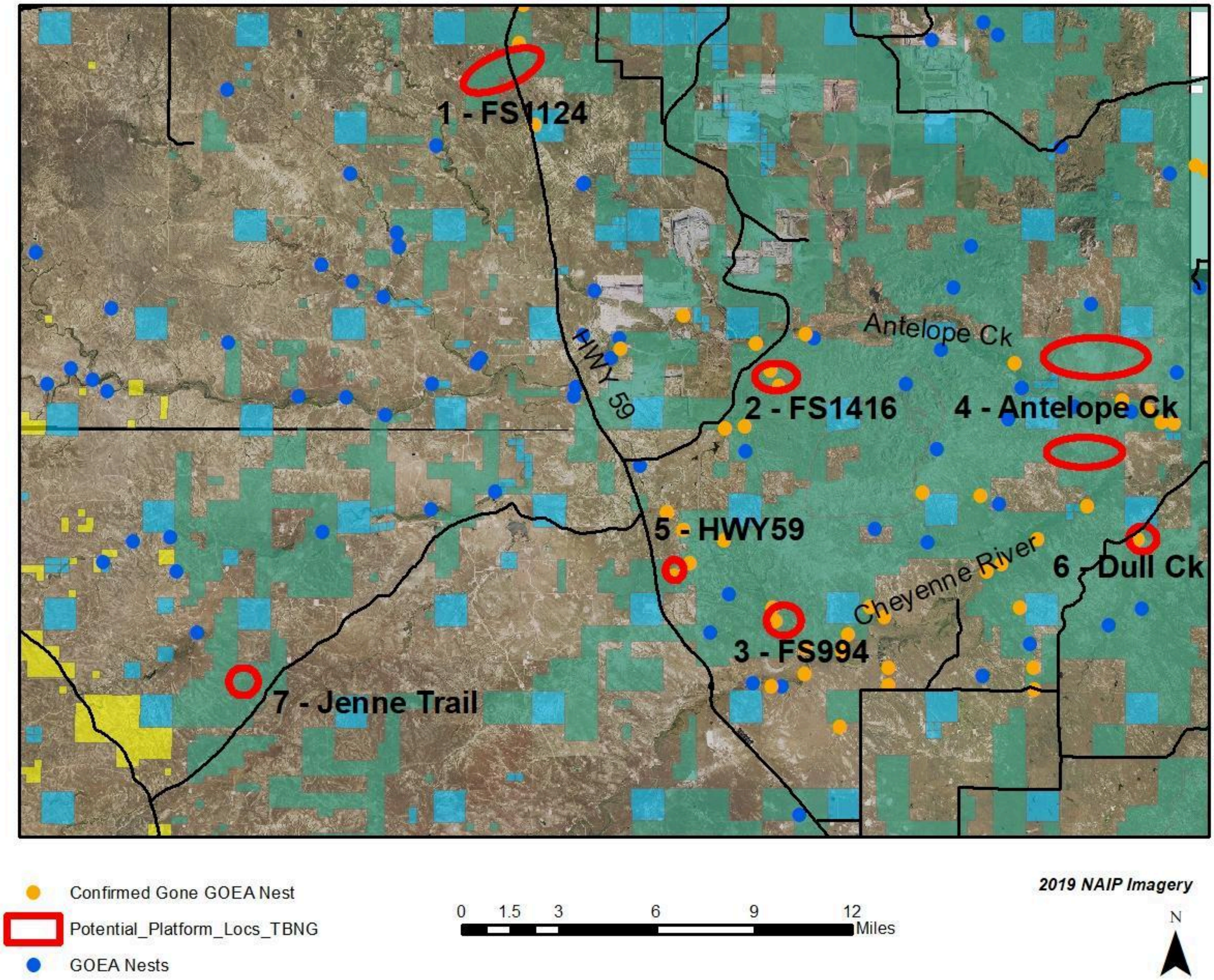


Figure 2. *Potential platform areas identified in Thunder Basin National Grassland from an on the ground reconnaissance conducted by TRC in July 2021.*

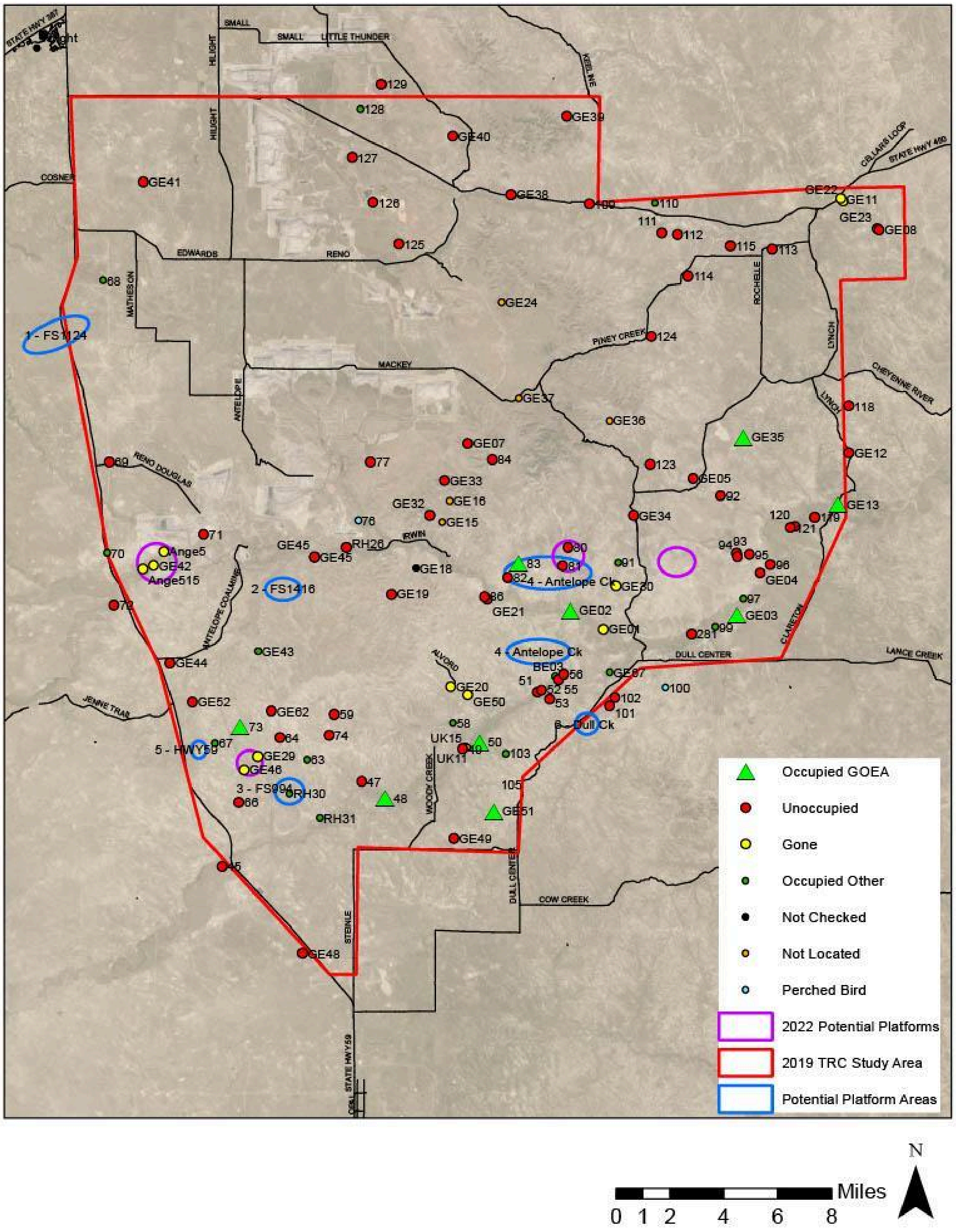


Figure 3. *Locations of golden eagle nests, GIS identified potential platform areas (blue), and additional sites identified after aerial surveys of the study area (purple).*

Figure 4. *Examples of initial pole installation for artificial nesting structures placed in the Great Plains for golden eagles (left). Golden eagle flying over pole during installation process (right).*

Figure 5. *Examples of nest building process of artificial golden eagle nests in the Great Plains. Nests were permanently erected in trees lacking proper nest support to host a golden eagle nest.*

Figure 6. *Examples of artificial nest structures (and their final installations) using retired utility poles.*

Teton-to-Snake Raptor Monitoring

Project Partners:

Teton Raptor Center

Bridger-Teton National Forest

Introduction

The Bridger Teton National Forest (BTNF) has been implementing a longstanding forest treatment project along the urban-wildland interface along the Fish and Fall Creek roadways on the western edge of Jackson Hole. Several sensitive raptor species are known to occur within and adjacent to most treatment areas and Teton Raptor Center has partnered with BTNF to survey these raptors to achieve two major objectives. First, we are surveying all potential treatment areas for at least two years prior to implementation to document the presence of nesting Great Gray Owls, American Goshawks, Boreal Owls, and Flammulated Owls, all of which are BTNF and Wyoming Game and Fish designated sensitive species. We are working with the implementation team at BTNF to identify key nesting habitat for these species for potential adjustments to the treatment plans to ensure the persistence of these raptors as part of their adaptive management planning process.

The second main objective of this work is to determine any potential effects of mechanical and/or prescription burning treatments to raptor occupancy. There are few studies documenting both pre- and post- treatment occupancy of raptors and mixed results regarding selection or avoidance of these areas. Some studies have suggested that thinning and burning may increase small mammal abundance in the area, therefore increase the abundance of species like Great Gray Owls. Conversely, other studies suggest avoidance of treatment areas by some raptors. This study is designed to help gather unique and critical data to inform immediate management actions as well as data on the long-term effects of management on raptors.

Project Goals

1. Conduct surveys for sensitive raptors for two years pre- and two years post-treatment, when possible.
    a. *March 15 – April 5th:* Autonomous Recording Unit (ARU; SoundScout) surveys for boreal owls, great gray owls, and American goshawks, simultaneously
    b. *April 6 – April 28th:* Follow-up ARU surveys at locations of positive detections that also have ambiguity in nesting forest stand
    c. *May 15 – June 15:* ARU surveys for flammulated owls

2. Nest search for target species, when possible

    a. *May 1 – June 15:* Great gray owls and American goshawks in areas with positive detections

    b. *June 15 – July 15:* Flammulated owls in areas with positive detections

Survey areas for 2024:

-Mechanical treatment areas: T-33, T-35, T-36

-Prescribed fire: PF-26, PF-34, PF-30

Methods:

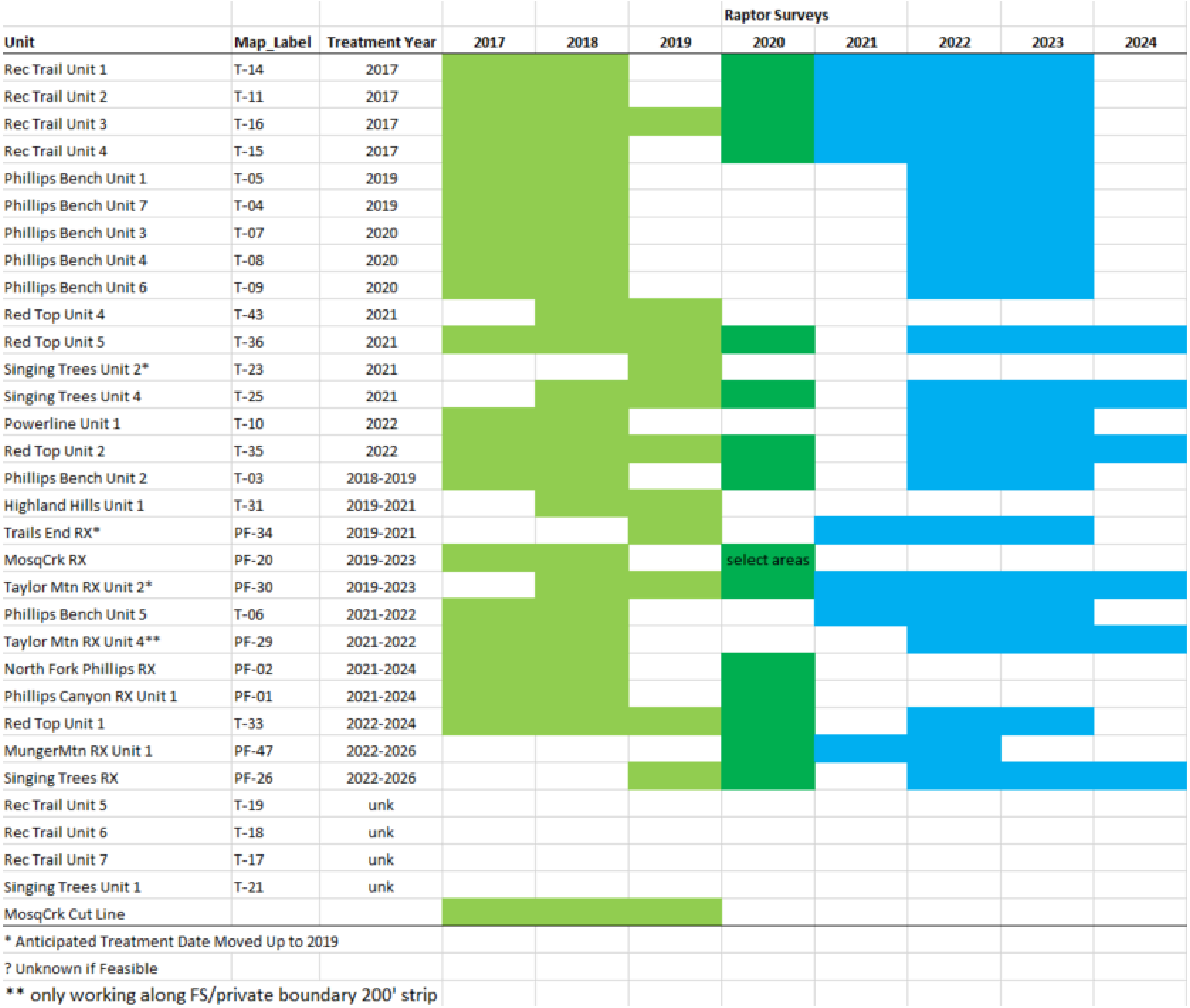
To document the occurrence of all target raptors across the study area, we are surveying forest patches using autonomous recording units (ARUs). Auditory surveys are standard for owl species during the courtship period and our previous studies have found that ARUs are roughly twice as effective as traditional call-back surveys for species like Great Gray Owls. Similarly, passive pre-dawn surveys for American Goshawks have been shown to be more effective at determining territory occupancy than call-back surveys but conducting in-person surveys significantly limits the areas that can be surveyed. Deployments of ARUs during the courtship period provides a method for pre-dawn surveys over multiple days.

Survey locations were predetermined in a GIS using a 300m detection radius of the ARUs within potential treatment areas within the T2S project areas. Our long-term goals were to survey each treatment area for at least two years prior to treatment and will conduct follow-up surveys two years post-treatment (Table 1). Topography, access, and safety were all considered when placing survey locations. Areas of unsuitable raptor nesting habitats were not included, and all potential nesting habitat was covered with survey locations. Survey locations were divided into three groups, depending on safety and seasons, 1) a low-slope (safely accessible in spring), 2) high slope (inaccessible for spring surveys) and 3) late-season surveys for flammulated owls.

Recorders were each deployed for six consecutive nights, once during the early call period (Objective A). Flammulated owls were surveyed for ARUs beginning mid-May after arriving on breeding grounds (Objective C). We conducted targeted nest searching, when possible, in nest stands with positive detections of great gray owls and American goshawks. Fieldwork looking for flammulated owl nesting cavities in 2017 and 2018 indicated that nest searching was not feasible for this survey given the time needed and low rates of finding nest locations. Recordings from the late season were reviewed for fledgling great gray owls and American goshawks in areas with previously positive detections to determine if the nesting territory was successful (Objective D). In many instances, we combined recorders for objectives C and D for efficiency.

We used the acoustic analysis program Kaleidoscope to help analyze all the recordings. We had previously built a detector in Kaleidoscope using a library of verified great gray owl, boreal owl, American goshawk, and flammulated owl calls from Teton County to identify territorial, begging, and wail calls for each species. Each species had its own cluster analysis and we reviewed each recording separately for each species. Kaleidoscope ranks any potential calls based on the likelihood that the potential call matches the set of verified calls that the detector was built from. It also ranks the potential match to our predefined categories (e.g., “alarm,” “begging,” Begging + alarm,” and “Other”). Kaleidoscope may identify >30,000 potential calls within one week from one recorder for each species, but the probability of a true call significantly decreases as you get down the list of potential calls. To maximize our efficiency, we made the assumption that the 300m area surrounding the recorder was unoccupied if we did not verify any calls within the first 1,000 output potentials for each category (4,000 total potential calls). We also documented the number of verified calls within the first 1,000 output potentials to obtain a relative gauge of occupancy. For example, if only one territorial call was found within the first 1,000 outputs, it is likely an owl or goshawk simply flew over the area once while calling. Therefore, if we identified ≥50 individual calls within the week we considered the patch as definitively occupied. If 1-49 calls were verified within the first 1,000 calls, we reviewed all outputs of the recorder to determine occupancy.

Table 1. Sensitive raptor monitoring schedule for Teton-2-Snake fuels reduction project. Schedule is designed for two years pre- (green) and post-treatment (blue; when possible).



						Raptor Surveys				
Unit	**Map_Label**	**Treatment Year**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Rec Trail Unit 1	T-14	2017	🟩	🟩		🟢	🟦	🟦	🟦	
Rec Trail Unit 2	T-11	2017	🟩	🟩		🟢	🟦	🟦	🟦	
Rec Trail Unit 3	T-16	2017	🟩	🟩	🟩	🟢	🟦	🟦	🟦	
Rec Trail Unit 4	T-15	2017	🟩	🟩		🟢	🟦	🟦	🟦	
Phillips Bench Unit 1	T-05	2019	🟩	🟩				🟦	🟦	
Phillips Bench Unit 7	T-04	2019	🟩	🟩				🟦	🟦	
Phillips Bench Unit 3	T-07	2020	🟩	🟩				🟦	🟦	
Phillips Bench Unit 4	T-08	2020	🟩	🟩				🟦	🟦	
Phillips Bench Unit 6	T-09	2020	🟩	🟩				🟦	🟦	
Red Top Unit 4	T-43	2021		🟩	🟩					
Red Top Unit 5	T-36	2021	🟩	🟩	🟩	🟢		🟦	🟦	🟦
Singing Trees Unit 2*	T-23	2021			🟩					
Singing Trees Unit 4	T-25	2021		🟩	🟩	🟢		🟦	🟦	🟦
Powerline Unit 1	T-10	2022	🟩	🟩				🟦	🟦	
Red Top Unit 2	T-35	2022	🟩	🟩	🟩	🟢		🟦	🟦	🟦
Phillips Bench Unit 2	T-03	2018-2019	🟩	🟩		🟢		🟦	🟦	
Highland Hills Unit 1	T-31	2019-2021		🟩	🟩					
Trails End RX*	PF-34	2019-2021			🟩		🟦	🟦	🟦	
MosqCrk RX	PF-20	2019-2023	🟩	🟩		🟢 select areas				
Taylor Mtn RX Unit 2*	PF-30	2019-2023		🟩	🟩	🟢	🟦	🟦	🟦	🟦
Phillips Bench Unit 5	T-06	2021-2022	🟩	🟩			🟦	🟦	🟦	
Taylor Mtn RX Unit 4**	PF-29	2021-2022	🟩	🟩				🟦	🟦	🟦
North Fork Phillips RX	PF-02	2021-2024	🟩	🟩		🟢				
Phillips Canyon RX Unit 1	PF-01	2021-2024	🟩	🟩		🟢				
Red Top Unit 1	T-33	2022-2024	🟩	🟩	🟩	🟢		🟦	🟦	
MungerMtn RX Unit 1	PF-47	2022-2026				🟢	🟦	🟦		
Singing Trees RX	PF-26	2022-2026			🟩	🟢		🟦	🟦	🟦
Rec Trail Unit 5	T-19	unk								
Rec Trail Unit 6	T-18	unk								
Rec Trail Unit 7	T-17	unk								
Singing Trees Unit 1	T-21	unk								
MosqCrk Cut Line			🟩	🟩	🟩					

* Anticipated Treatment Date Moved Up to 2019

? Unknown if Feasible

** only working along FS/private boundary 200' strip

Results:

This was the eighth year of our surveys in the T2S project area. From 2017-2024, we have collectively deployed 860 recorders across the study area, effectively surveying 20,539 acres in total (Figure 1). We continued post-treatment monitoring surveys at Red Top, Singing Trees, and Taylor Mtn Units. We worked with the Bridger-Teton Fuels team to identify likely future treatment areas to survey in 2025. This resulted in us surveying points in the Red Top, Taylor, and Singing Trees treatment areas.

We surveyed for forest raptors during 36 deployments in 2024 (Figure 2). We deployed ARUs in 23 locations from 15 March – 24 April to survey for great gray owls, boreal owls, and American goshawks, and 12 locations from 15 May – 8 June for flammulated owls.

We detected great gray owls calling at 87% of the locations (n = 20) that we surveyed in 2023 with detections occurring throughout the Red Top, Taylor Mtn and Singing Trees Units (Figure 3). We detected duets at ten of these locations (Figure 4). We found Great Gray Owl nests and found active nests in the vicinity of detected duets on previously known territories. Only one Great Gray Owl pair was successful in 2024 in the vicinity of the treatment area. These findings, coupled with data collected as part of a concurrent study in which we found six active nests in 2024, suggest that great gray owls may have experienced a year of low productivity in 2024, following a year of high productivity in 2023. It was also noteworthy that our nest searching efforts were not as intensive in 2024 due to staff constraints. The detections of great gray owls in the Red Top, Taylor Mtn, and Singing Trees Units is consistent with previous years. We are uncertain if we are missing an additional territory in Taylor Mtn or if the owls from one of the ARUs that recorded a duet in that area are from the adjacent known territories.

It is still unclear how calling patterns relate to nest sites. For example, if a raptor travels to a territory edge to defend its territory by calling, detections at that site may not be indicative of the nest itself. Or, transient individuals may be detected but not indicate a nest site. To further investigate this, we tallied the number of calls detected at each site as a general indicator of habitat use (Figure 4). While we still have yet to determine how many calls per night occur at known nest sites, our knowledge of some nest sites in conjunction with the number of calls detected near those nests can help us determine occupied habitat patches for nesting great gray owls.

We did not detect any boreal owls at any of the locations surveyed in 2024. Boreal owls are known to experience boom and bust cycles directly related to vole abundance, their primary food source. In years of low vole abundance, boreal owls will rear smaller broods or not breed at all, instead becoming more nomadic in search of prey. Comparing data from the past six years, it appears 2017, 2019, 2020, 2022, and 2023 may have been good years for boreal owl productivity, while in 2018 very few boreal owls were detected and in 2021 no boreal owls were detected, perhaps relating to prey availability. 2024 appears to have been another “bust” year based on the absence of any boreal owl detections during the study.

We detected American goshawks at 4% (n = 1) of the survey locations in 2024 (Figure 7). Goshawks were detected on ARUs near Red Top at an ARU placed near a known goshawk territory (Figure 8). The new territory we identified in 2022, located west of the Trails End Unit, was occupied in 2024 and the goshawk pair did nest in 2024 but we failed to get productivity on that nest. The low number of goshawk detections is consistent with past T2S observations, as well as a concurrent study in which we had only a few active territories in 2024.

In 2024, we detected flammulated owls at 33% of survey locations (n =4); the number of detections this year was higher than previous years (Figure 9). Most flammulated owl detections were within the Taylor Mtn Units and one Flammulated Owl detection occurred near the Red Top Unit, with multiple locations having greater than 50 calls detected within a week. This indicates nest territories are likely present in those areas (Figure 10). The detections in 2024 within the Taylor Mtn and Red Top Units are consistent with where we have detected flammulated owls annually even in years when they are not detected elsewhere in the study area.

Multi-Year Detections

The ability to identify nesting territories greatly increases with multiple detections over multiple years in the same habitat patch for raptors since they typically have discrete territories that they defend for their lifetimes (except Boreal Owls). While we did not survey all the same locations every year from 2017–24, there are areas with multiple detections that can help differentiate areas where raptors may occur but is not necessarily a nesting territory.

We identified areas that were surveyed ≥2 years and overlaid all detections and our previous knowledge of occurrence/nest sites for each species to help deductively identify potential territories (Figures 11-14). This does not preclude raptors from having other territories within the study area, particularly in areas that were only surveyed in one year. This method simply helps identify areas with the highest likelihood of nesting occupancy, given the data collected thus far. It also helps identify which areas should be surveyed a second year to help confirm the presence of nesting forest raptors in the study area.

For **great gray owls**, we have not identified any potential territories in the northern T2S treatment areas. However, we have identified several territories in the southern portion of T2S and have been working with BTNF personnel to protect some of these areas (e.g., Red Top). We have also identified nesting territories in Singing Trees and Taylor Mtn areas (Figure 11). The design has already been mitigated for nest sites at Taylor Rx4 and Trails End Rx.

Boreal owls can be nomadic between years and have multiple nest sites each year. Therefore, identifying key habitat patches for this species can be problematic. We detected many calling boreal owls in 2017, 2019, 2020, 2022, and 2023, but few in 2018 and none in 2021. Due to the widespread distribution of boreal owls across the project area and the high occurrence rate, it is difficult to identify territories based on multi-year detections. It appears that the Powerline, Phillips Bench, Red Top, TaylorMtn and Singing Trees areas are likely important breeding areas for multiple pairs based on having detections during at least two years, with some variation in terms of when those territories are used (Figure 12).

American goshawks are the least abundant raptor species detected during this study. We have consistently detected goshawks in Red Top Mx1. We have also documented several alternative goshawk nests in Red Top Mx2. Additionally, in 2017 and 2018 we detected goshawk alarm calls at survey points along Mosquito Creek Road. It is likely that these detections are associated with the territory south of the Mosquito Rx where an active nest was located outside of treatment areas in 2020. A new goshawk territory that was found in 2022 and is located west of the Trails End Rx Unit had an active nest in 2024. Multi-year goshawk detections occurred in TaylorMtn Unit 2 but no active nests have been found in that unit (Figure 13).

Flammulated owls are a newly discovered owl species on the Bridger-Teton. We have detected a relatively large number of individuals from this species over the past six years (Figure 14). Across areas with multi-year surveys, we have identified one territory adjacent to the Powerline Unit, but likely far enough not to be influenced by the treatment. As with other species, the Red Top Mx appears to host several pairs. The Taylor Rx4 and small parts of the Taylor Rx2 both host territorial pairs, with this area having the most consistent use by flammulated owls on an annual basis. The MungerMtn Rx, Singing Trees Rx, and Mosquito Creek North Rx also all have locations where flammulated owls were detected during at least three years of surveys.

Conclusions and Continued Work:

We found that recorders and automated detectors worked well to effectively survey for calling raptors within the extensively large area of the Teton-to-Snake project areas. In 2017, we surveyed for flammulated owls using both call-back surveys and autonomous recorders. In 2018-2024 we only used recorders to eliminate the possibility of drawing flammulated owls outside of their nesting territories to respond to callbacks, as has been shown in other studies and may erroneously affect results. Additional years of data collection will help us better understand the territory centers for these owls.

This was the third year of post-treatment follow up surveys at Red Top Units. In Red Top, there were many fewer Flammulated Owl and Boreal Owl detections during post treatment surveys than pre-treatment (Fig. 15 and 16). Nighttime playback surveys were utilized in 2017, possibly contributing to higher detection rates of Flammulated Owls that year.

The Red Top Mx areas have high use by all BTNF sensitive raptors and should be avoided for treatments based on our results. Similarly, great gray owls, boreal owls, American goshawks, and flammulated owls were all detected within the Taylor Mtn Rx Unit 2 in 2022, and three of the four species were detected in 2023 suggesting this is an area of high use and important habitat of forest raptors. In 2024, only Flammulated and Great Gray Owls were detected within the Red Top treatment area. While we did not find evidence to suggest that treatments within the Singing Tree Mx would affect nesting raptors, the Singing Trees Rx certainly would. Any potential Rx design should avoid the north-central forest patch where we have identified great gray owl and goshawk nest sites.

We will seek additional funding from BTNF for subsequent years and strongly urge managers to continue the original goals of surveying areas for two years post-treatment to gather critical and novel information on potential treatment effects on the sensitive forest raptors. We will also use information summarized in this report to identify areas with raptor detections and only one year of survey for additional surveys in 2025. This information can greatly benefit future treatments across the forest.

Acknowledgements:

We could not have completed this work without the significant investment and support of Andy Hall, Jason Wilmot, Andy Norman, Randy Griebel, Kerry Murphy, Ashley Egan, and Dave Wilkins. ARU deployments were completed by Julie Polasik, Adrian Rouse, Georgia Coleman, and Julie Calandrella. Julie Polasik ran and validated automated analysis software for this project. Julie Polasik, Adrian Rouse, Skyler Bol, Georgia Coleman, and Julie Calandrella reviewed recordings for species detections.

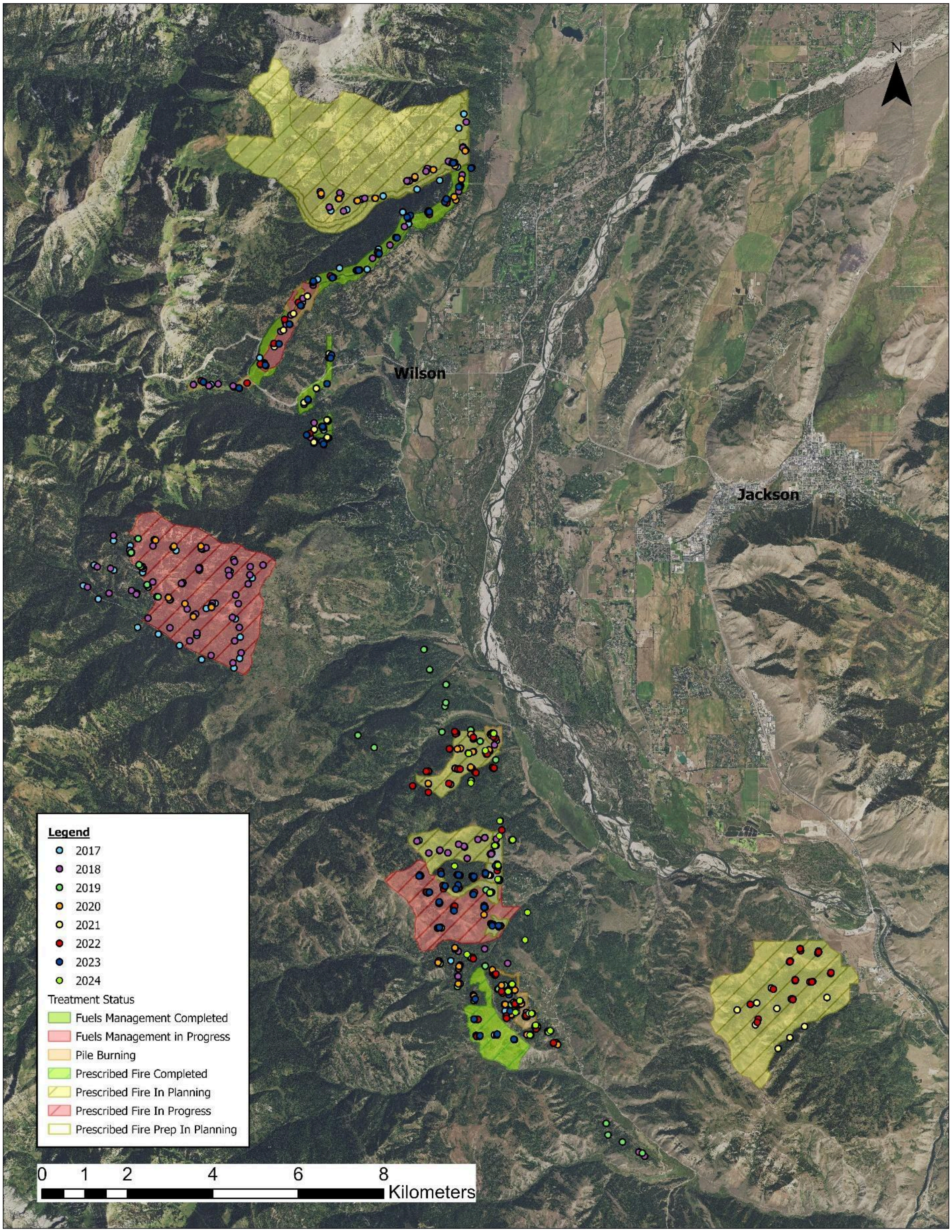


Figure 1. *Locations of all surveys conducted in the Teton-2-Snake project area from 2017-2024 and treatment status as of 2023.*

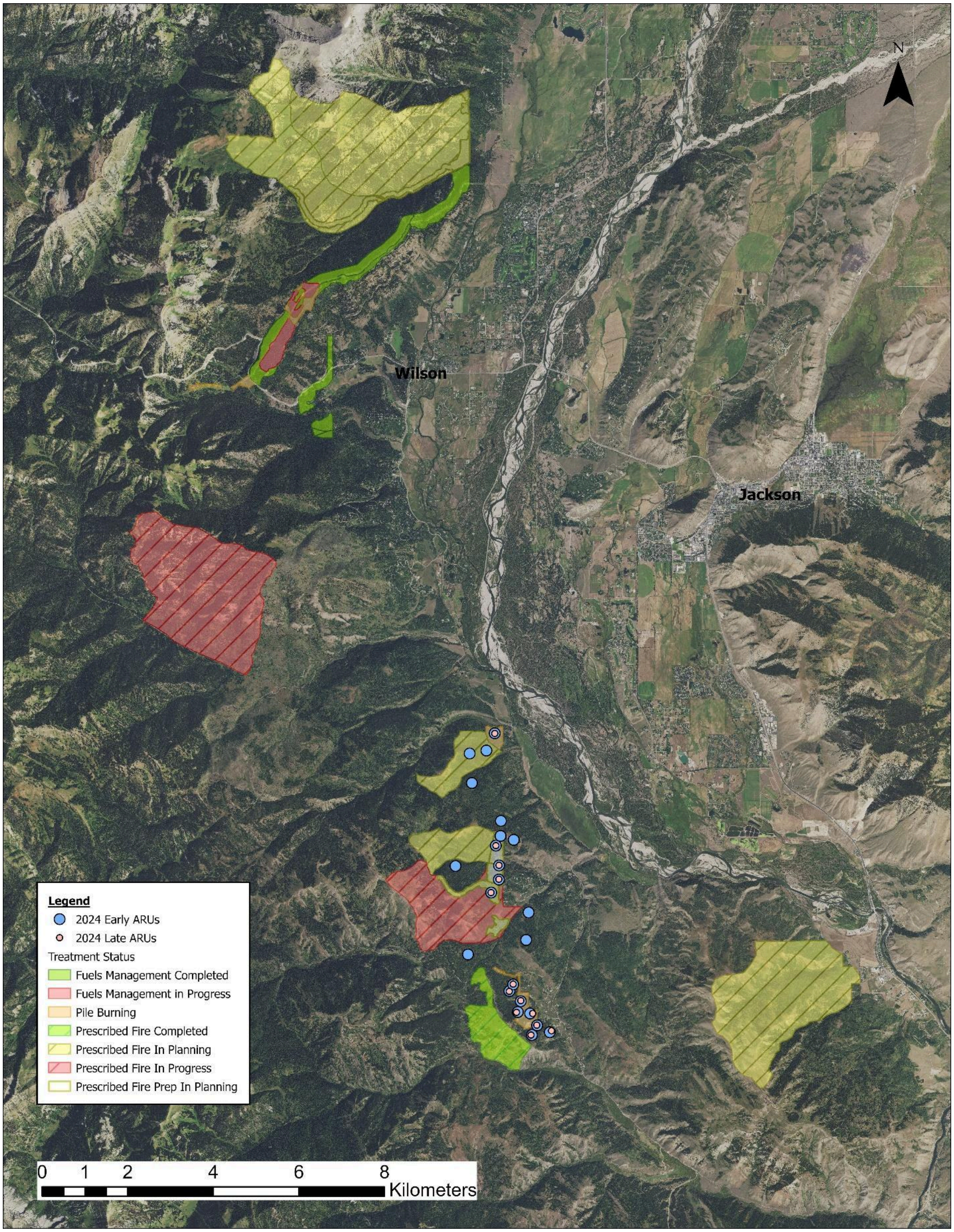


Figure 2. *Locations of deployed automated recording units for early and late season surveys and treatment areas in 2024.*

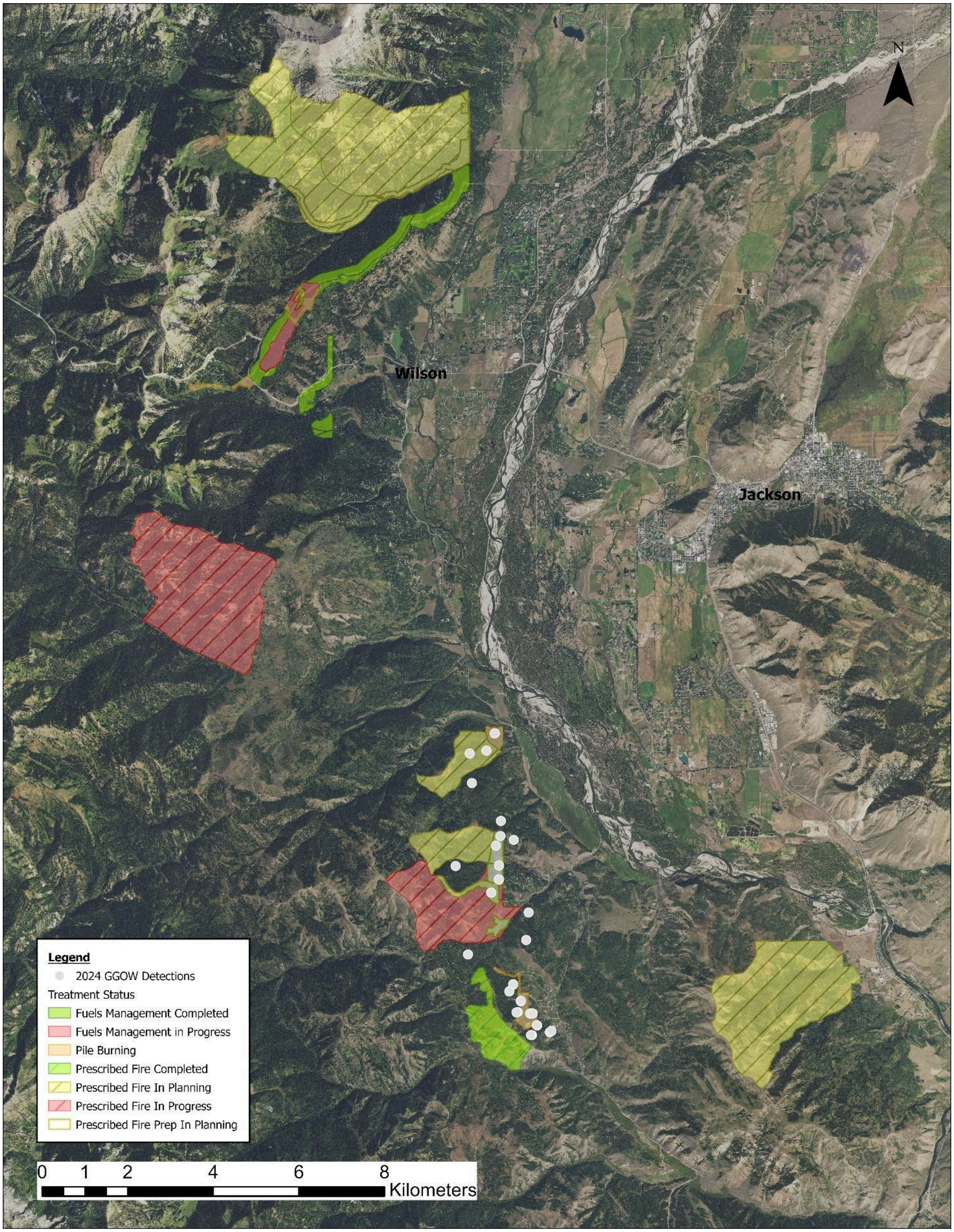


Figure 3. *Locations of 2024 great gray owl (GGOW) detections.*

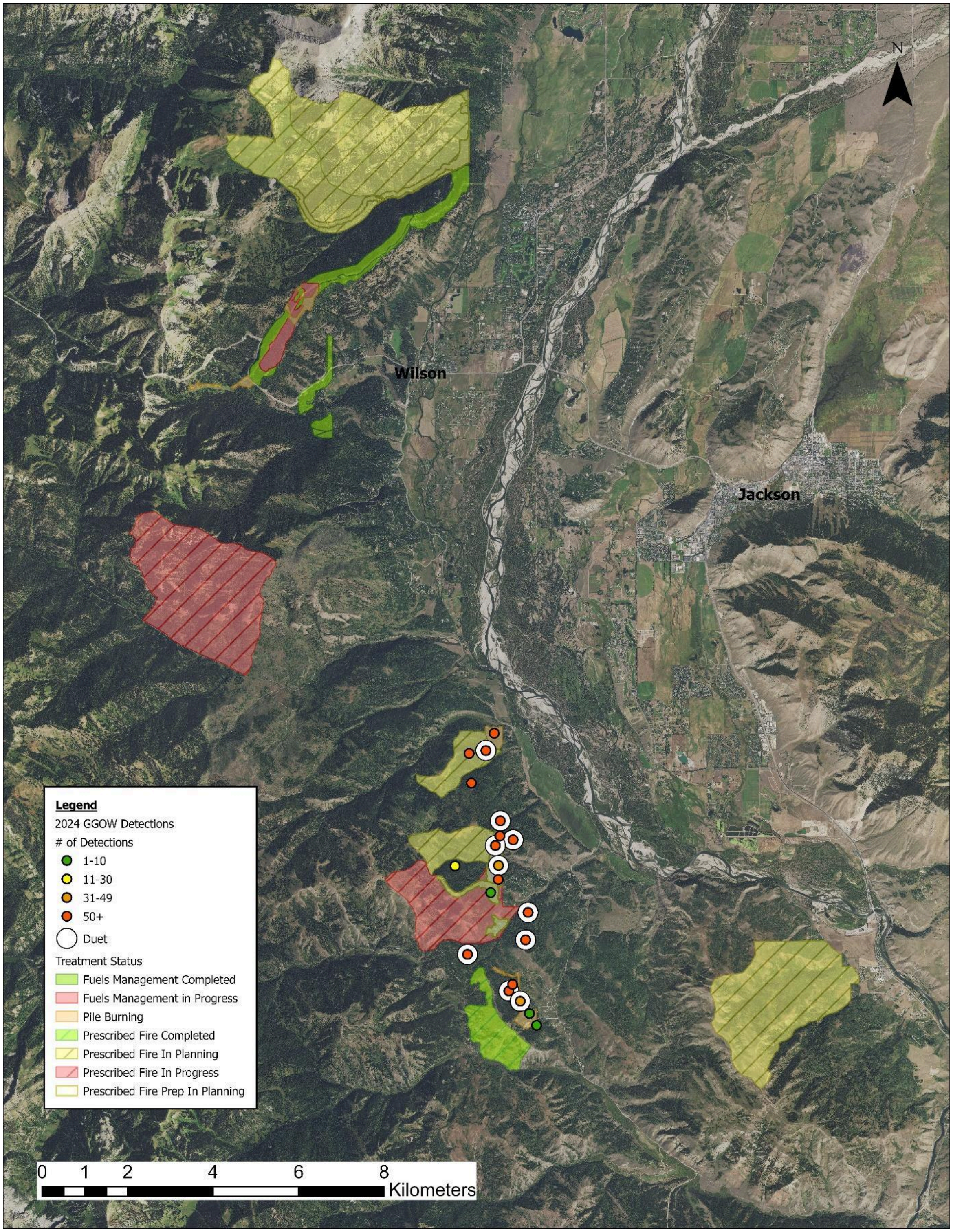


Figure 4. *Number of great gray owl calls detected during one week of recorder deployment in 2024. Locations with two great gray owls calling simultaneously (duets of presumably breeding pairs) are outlined in white.*

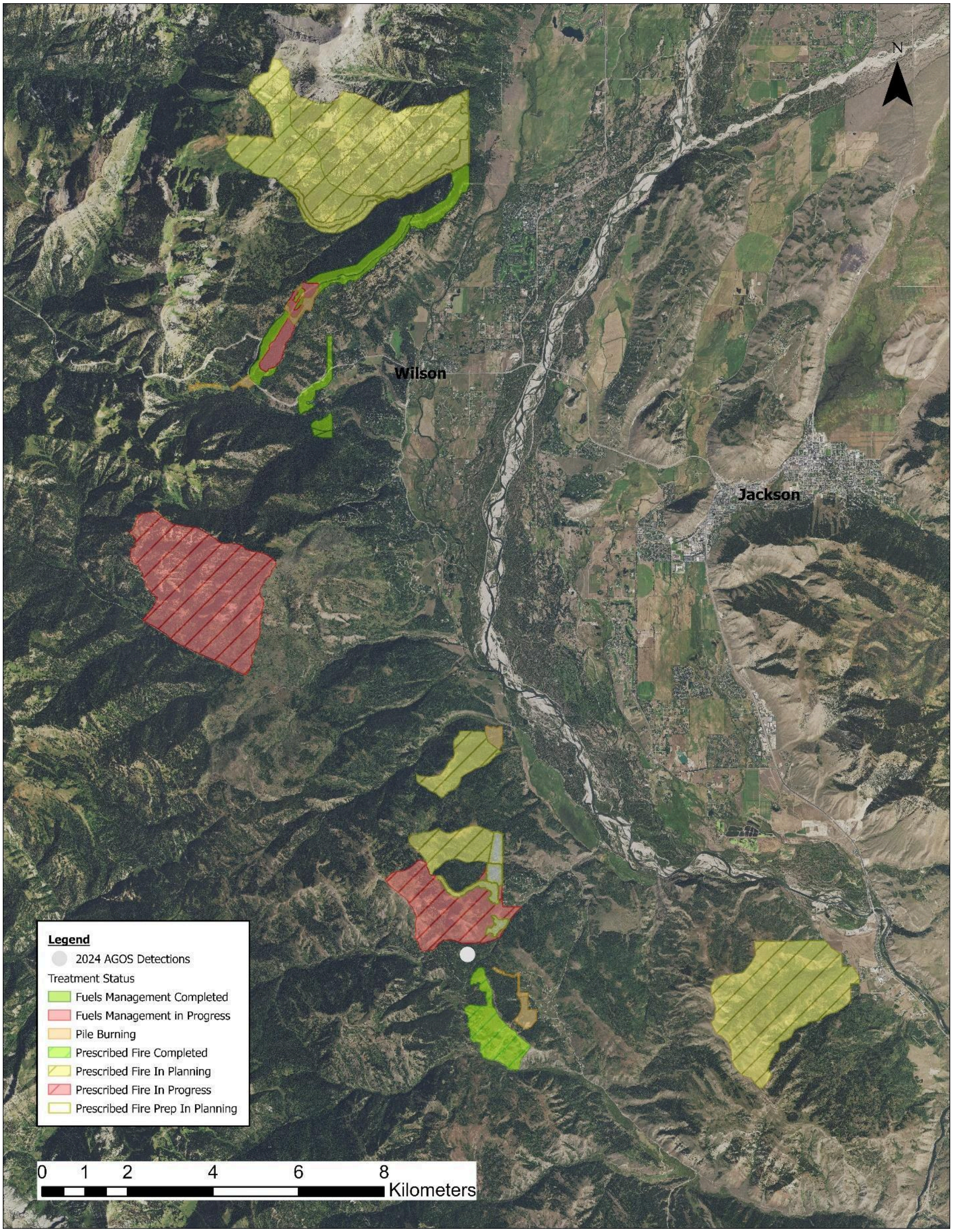


Figure 7. *Locations of 2024 American goshawk (AGOS) detections.*

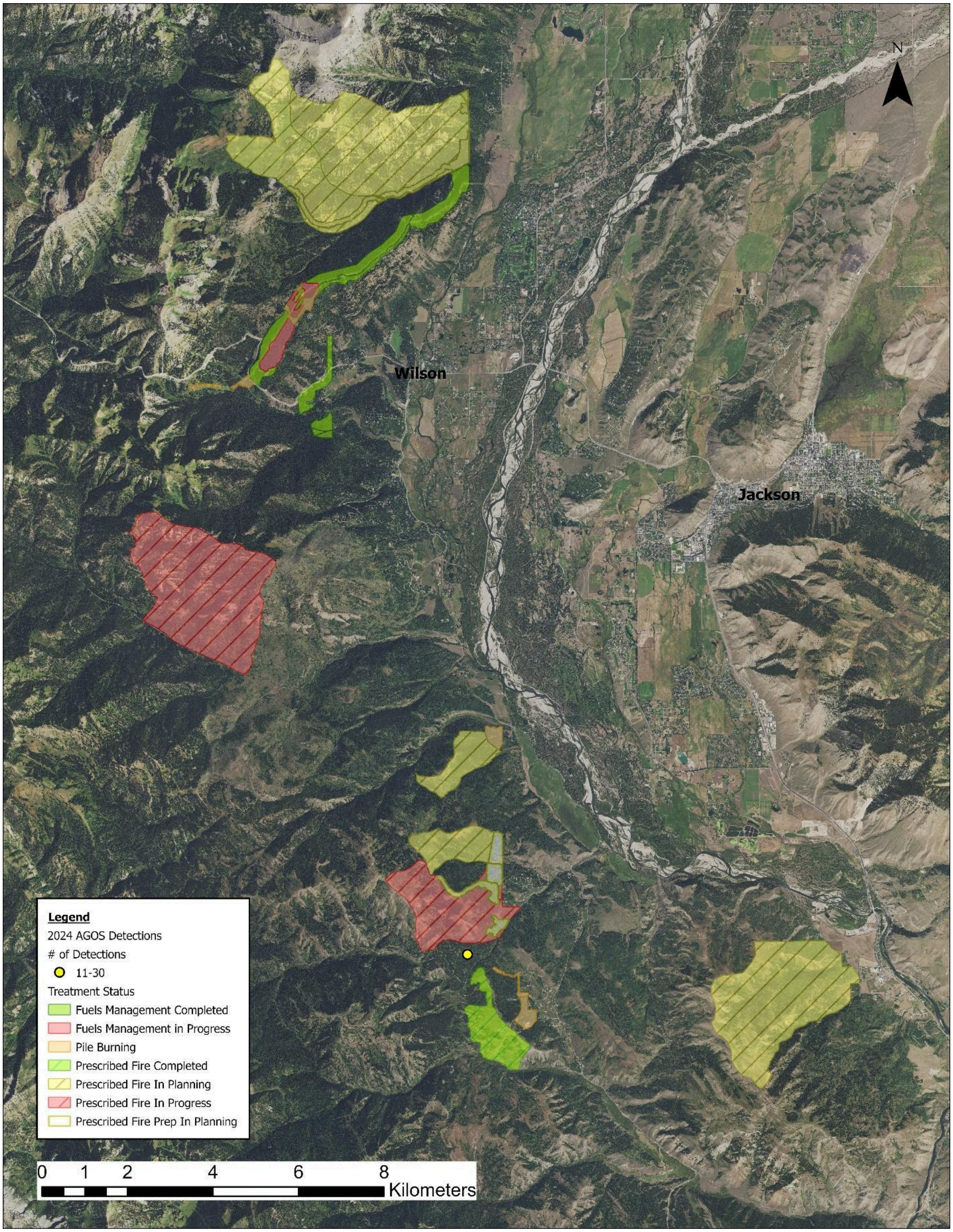


Figure 8. *Number of American Goshawk calls detected during one week of recorder deployment in 2024.*

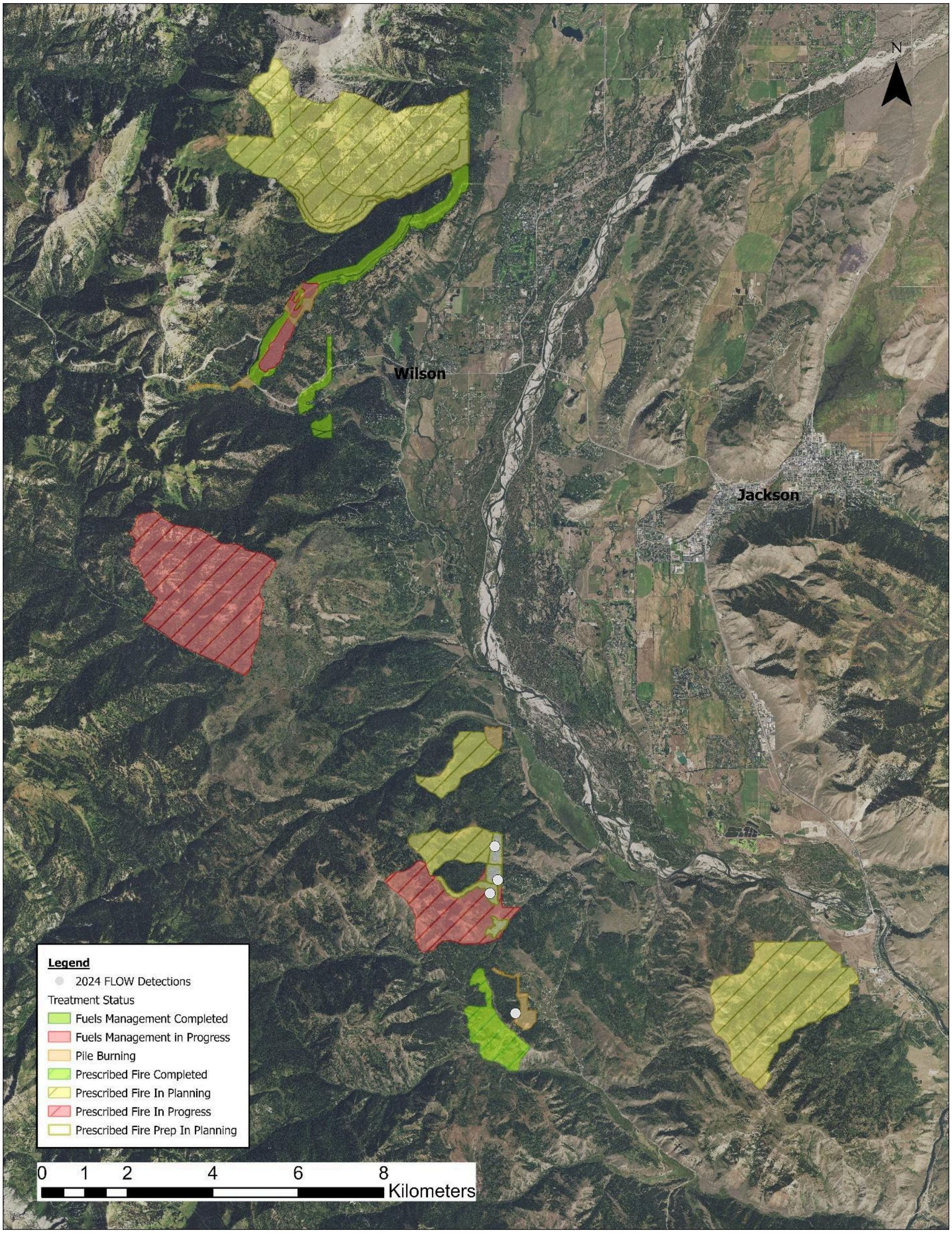


Figure 9. *Locations of 2024 flammulated owl (FLOW) detections.*

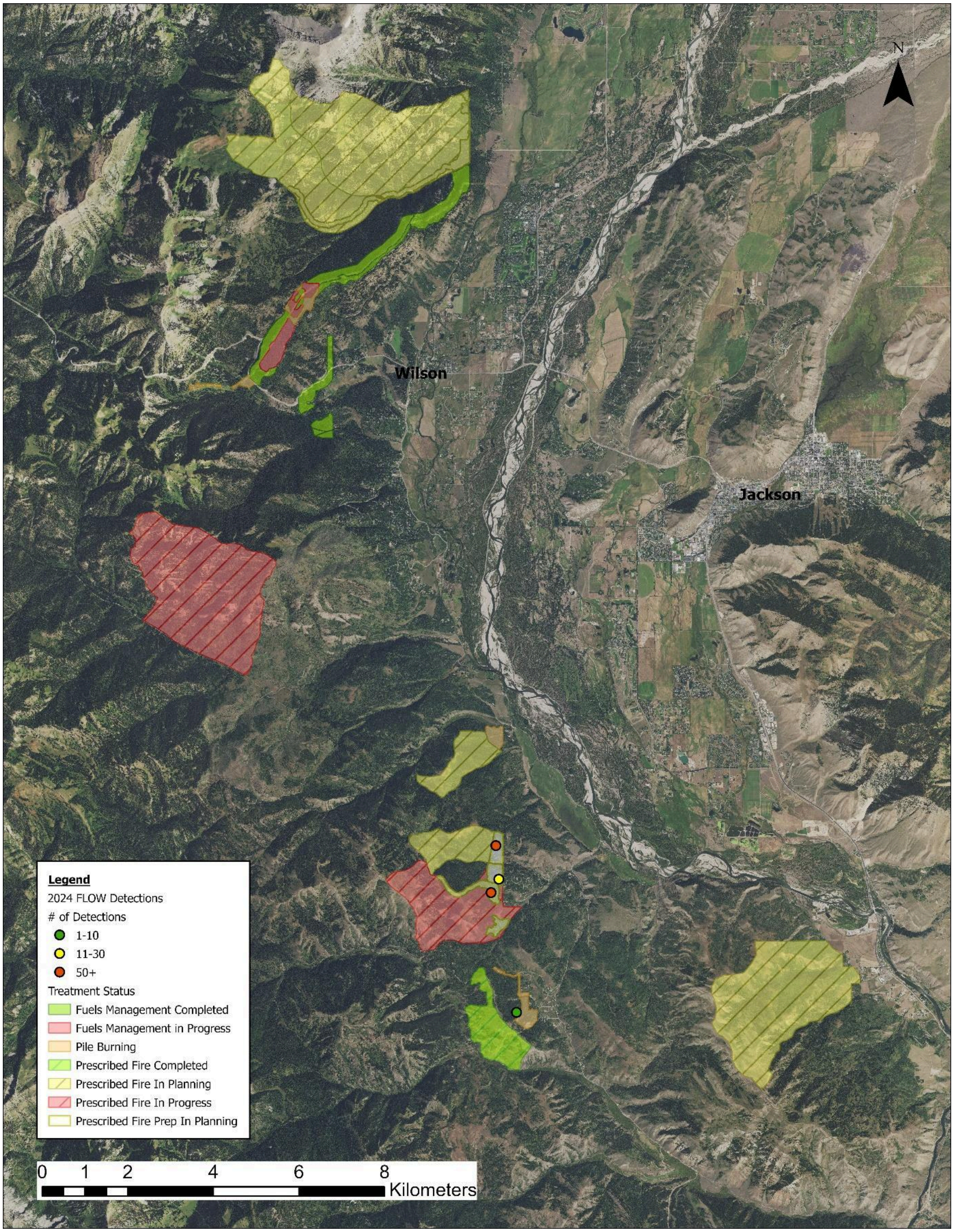


Figure 10. *Number of flammulated owl calls detected during one week of recorder deployment in 2023. Locations with two flammulated owls calling simultaneously (duets of presumably breeding pairs) are outlined in white.*

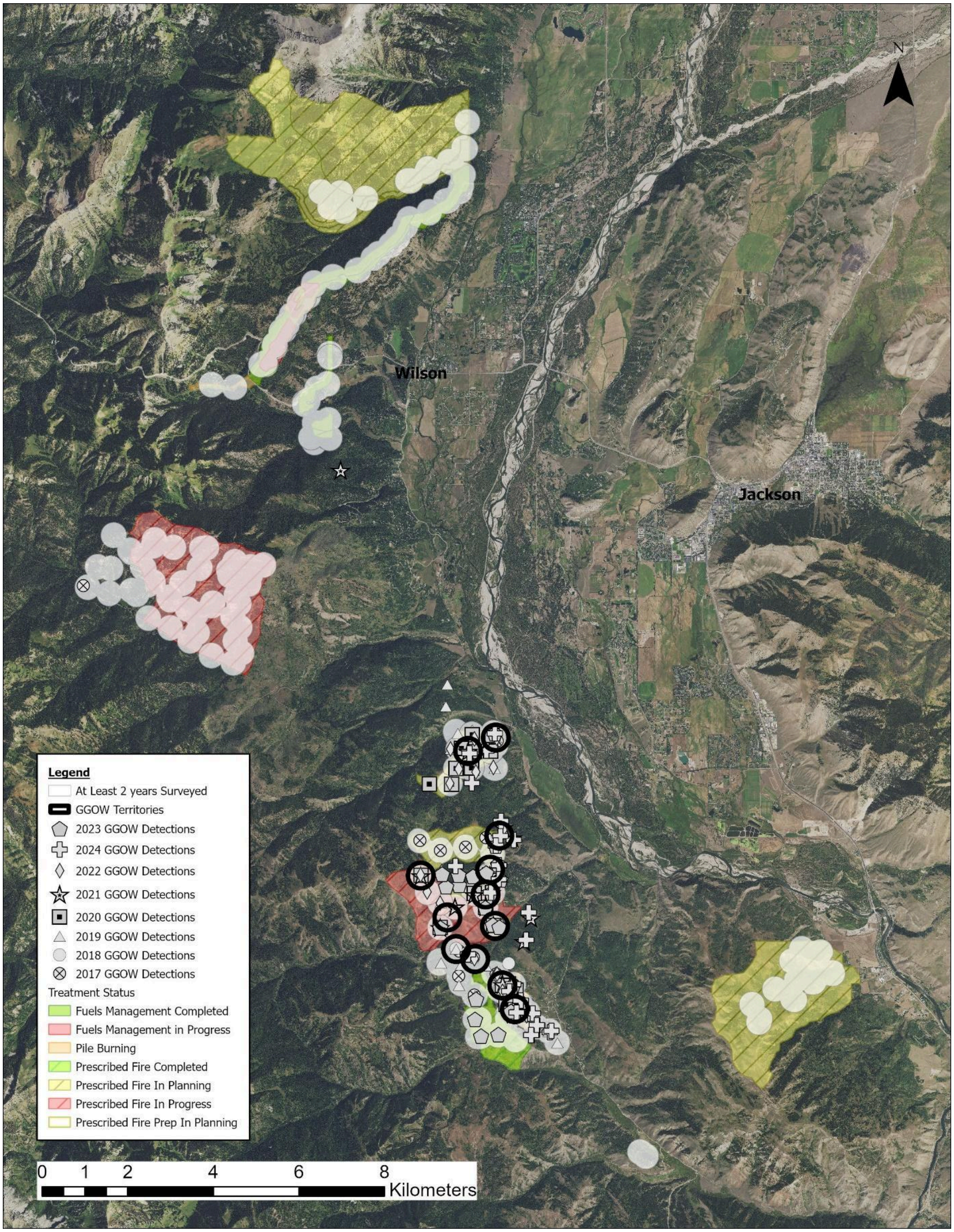


Figure 11. *Areas within the T2S project area that have been surveyed ≥2 years between 2017–23 (shaded white), positive great gray owl detections (points) and deductively assumed territories with 300m radius (circles).*

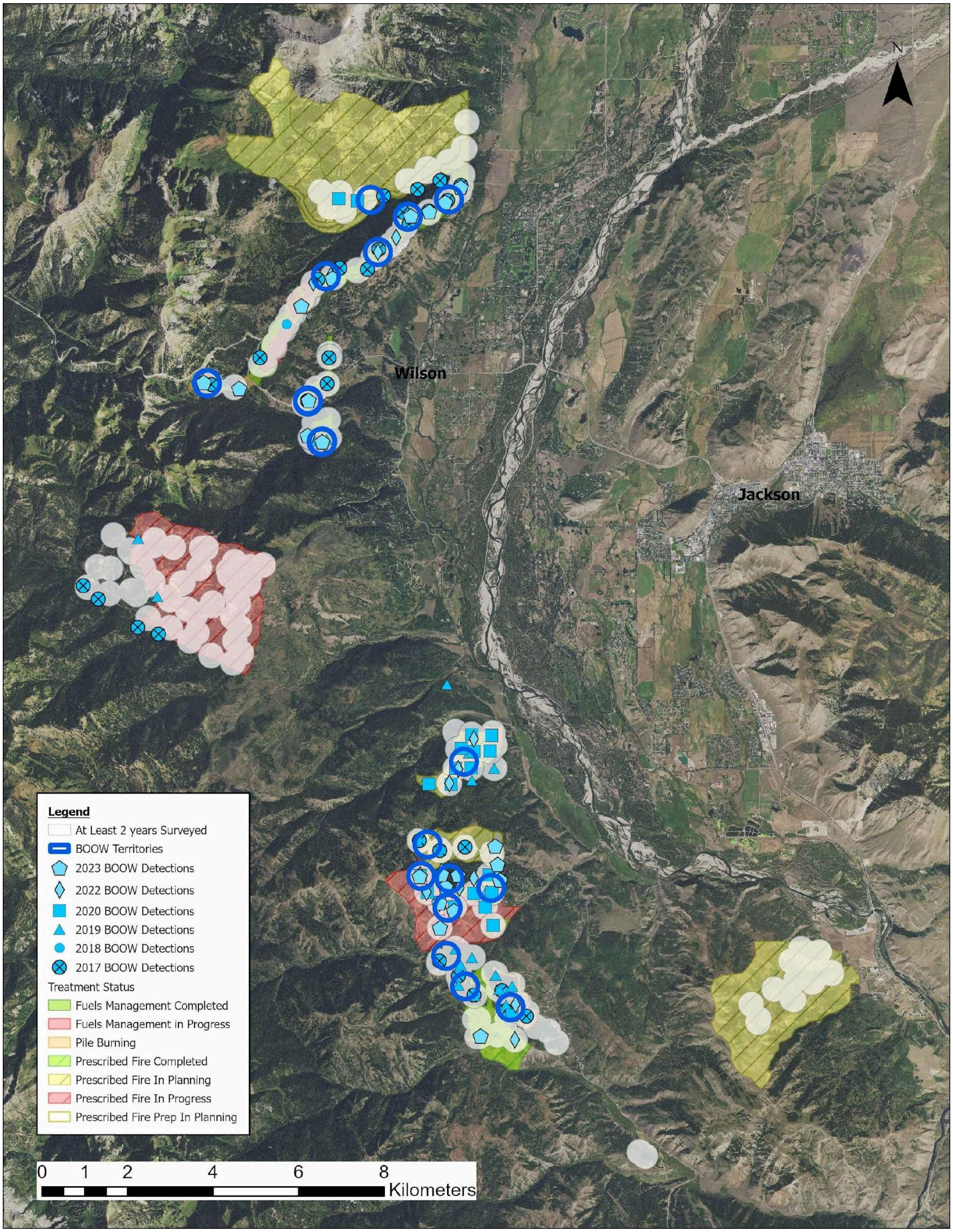


Figure 12. *Areas within the T2S project area that have been surveyed ≥2 years between 2017–24 (shaded white), positive boreal owl detections (points) and deductively assumed territories with 300m radius (circles). There were no BOOW detections in 2024.*

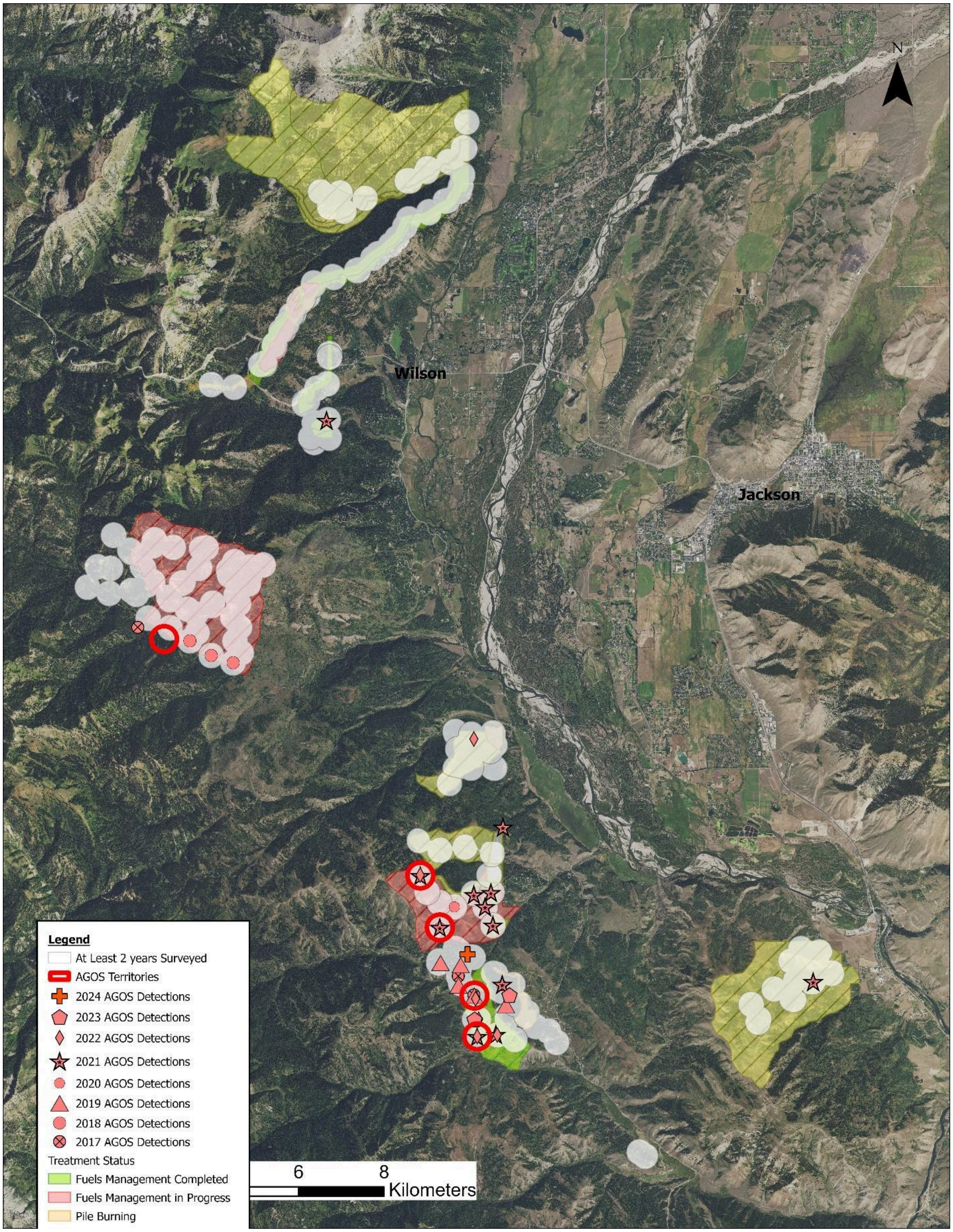


Figure 13. *Areas within the T2S project area that have been surveyed ≥2 years between 2017–23 (shaded white), positive American goshawk detections (points) and deductively assumed territories with 300m radius (circles).*

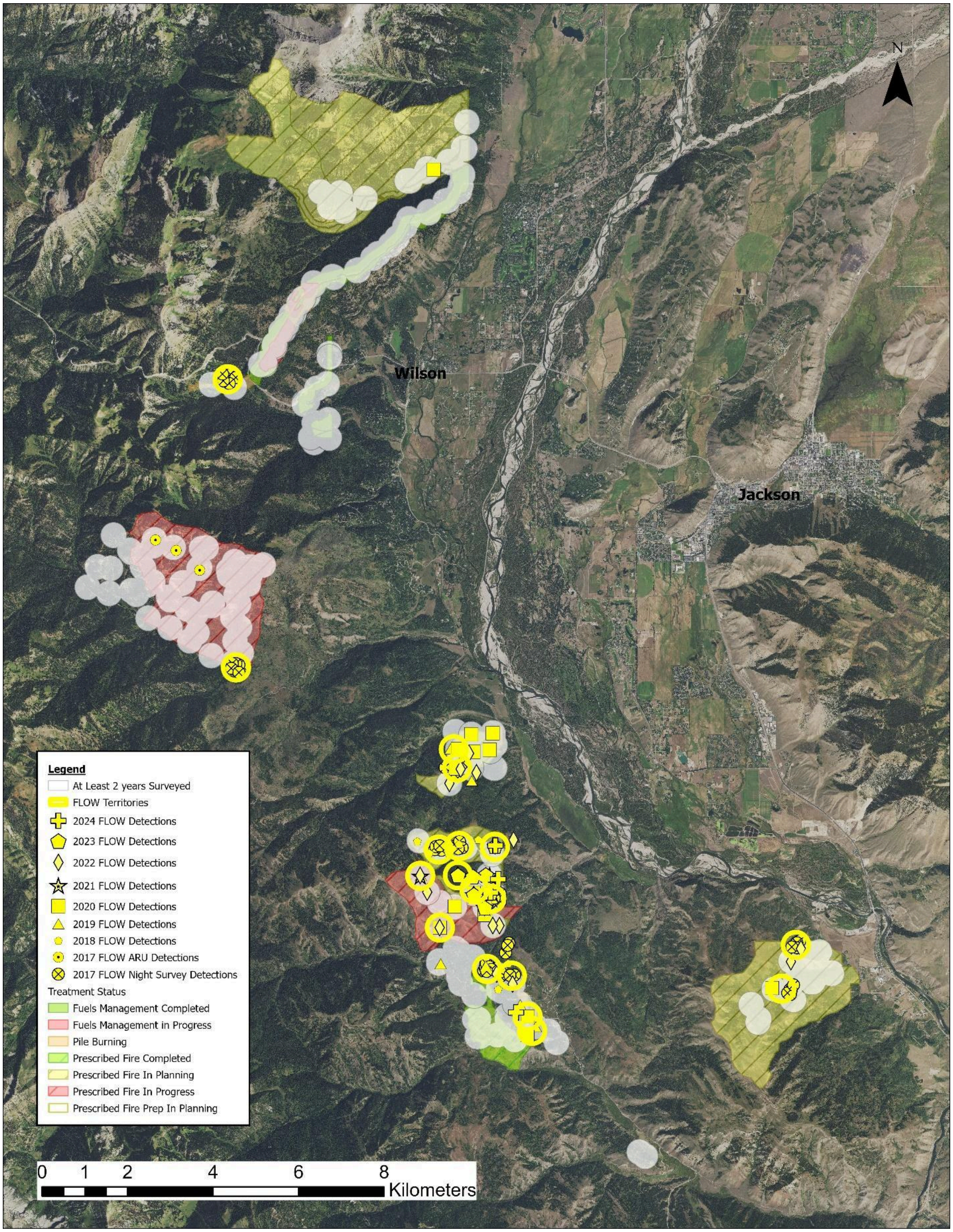


Figure 14. *Areas within the T2S project area that have been surveyed ≥2 years between 2017–23 (shaded white), positive flammulated owl detections (points) and deductively assumed territories with 300m radius (circles).*

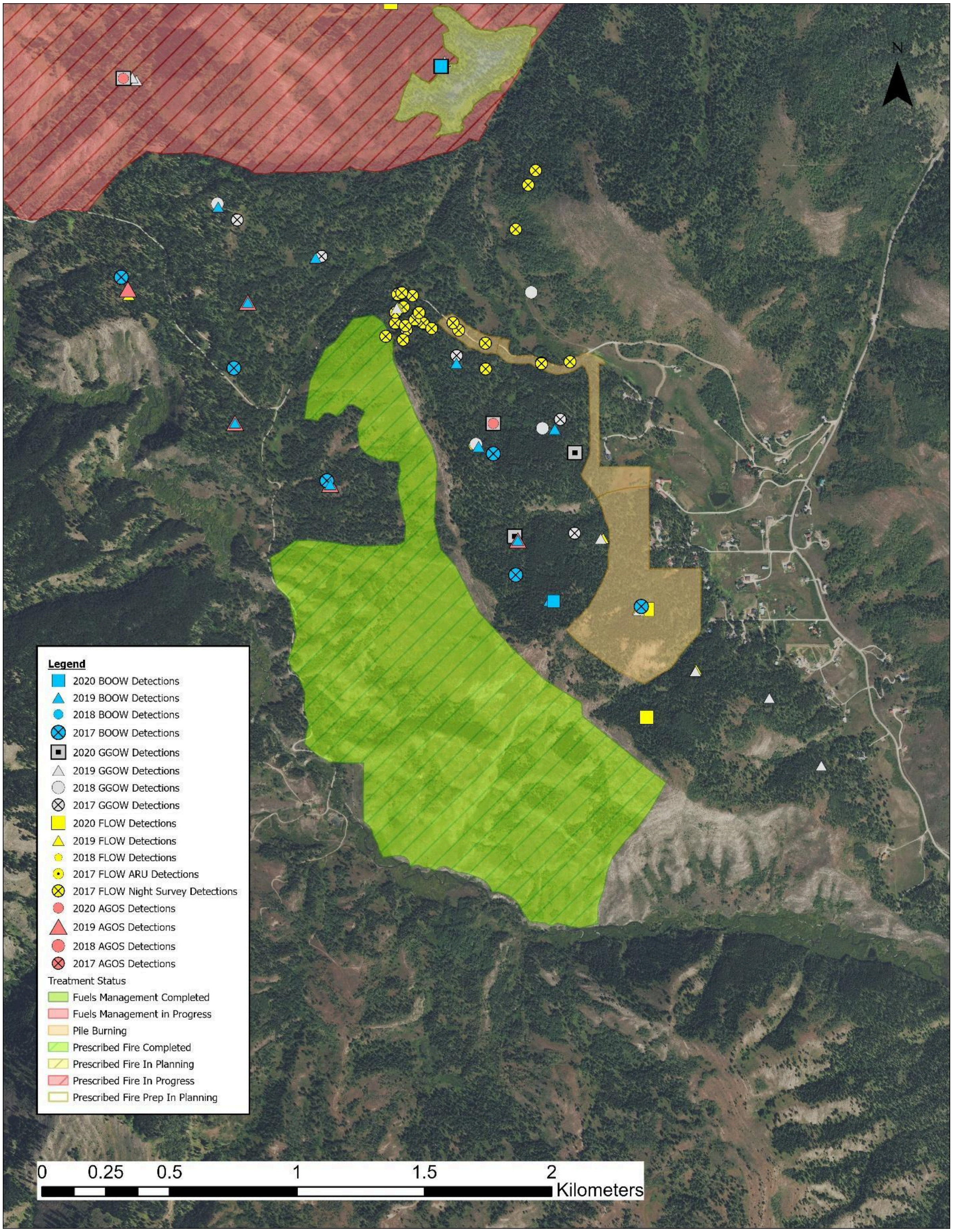


Figure 15. *Pre-treatment survey results (2017-2020) for completed treatments in the Red Top and Trails End Units.*

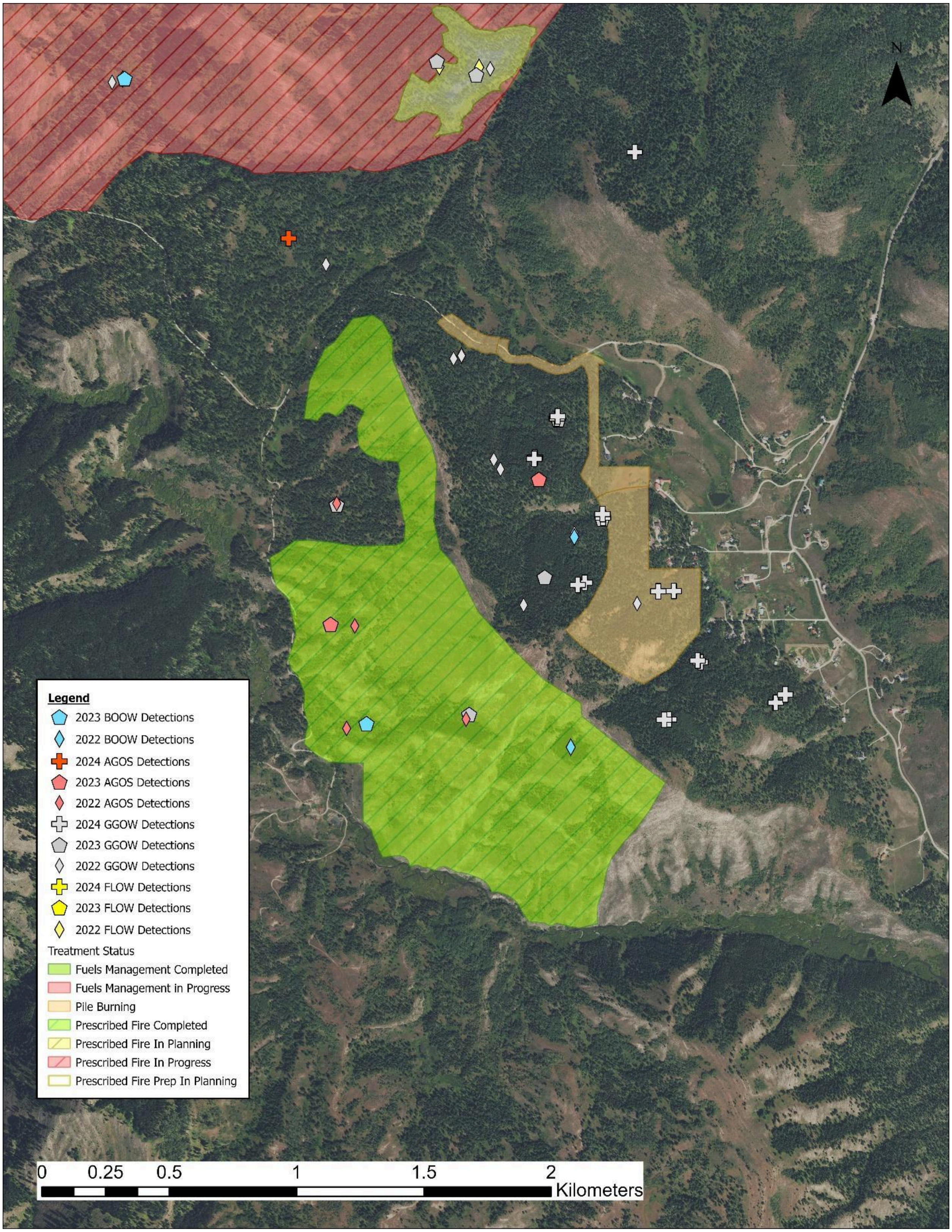


Figure 16. *Post-treatment survey results (2022-2024) for completed treatments in Red Top and Trails End.*

Osprey Nest Platform Monitoring

Teton Raptor Center Project

In 2024, Teton Raptor Center Ambassadors monitored approximately 34 potential Osprey (OSPR) territories which contain 64 artificial nest platforms in Jackson Hole, WY for occupancy and nest productivity during the breeding season. 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 Osprey at least once during the breeding season in 20 of the territories (59%). Seven platforms were occupied by nesting Canada Geese but in two instances, platforms within a single Osprey territory were occupied by Canada Geese resulting in five Osprey territories having platforms that were only occupied by geese (12%). In one case a monitor observed an Osprey within a territory where a goose had nested on a platform and never found an Osprey nest on a platform in that territory. In another case, a monitor observed a goose nesting on a platform in a territory where there was an active Osprey nest. The Osprey nest in that territory failed. An additional ten Osprey territories contained platforms that were not used for nesting by either species this year throughout the study area (29%; Figure 1).

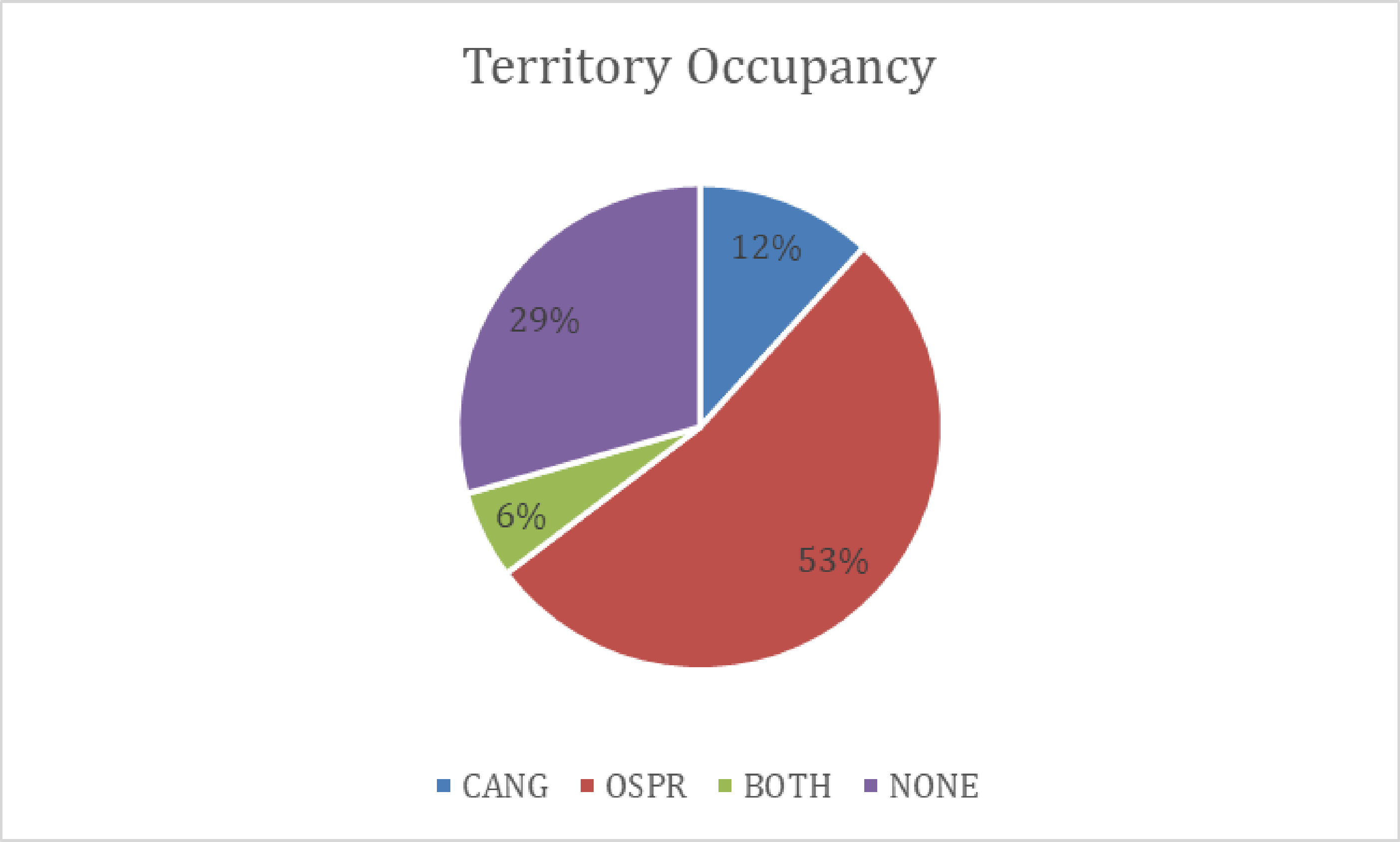


Figure 1. *The proportion of occupied territories within the Osprey study area in Jackson Hole, WY. Twenty territories were occupied by Osprey (53%), four territories were occupied by Canada Geese (12%), two territories were occupied by both species (6%), and ten territories were not occupied by either species (29%).*

Nest Productivity:

There are 64 platforms throughout the study area (Figure 2).

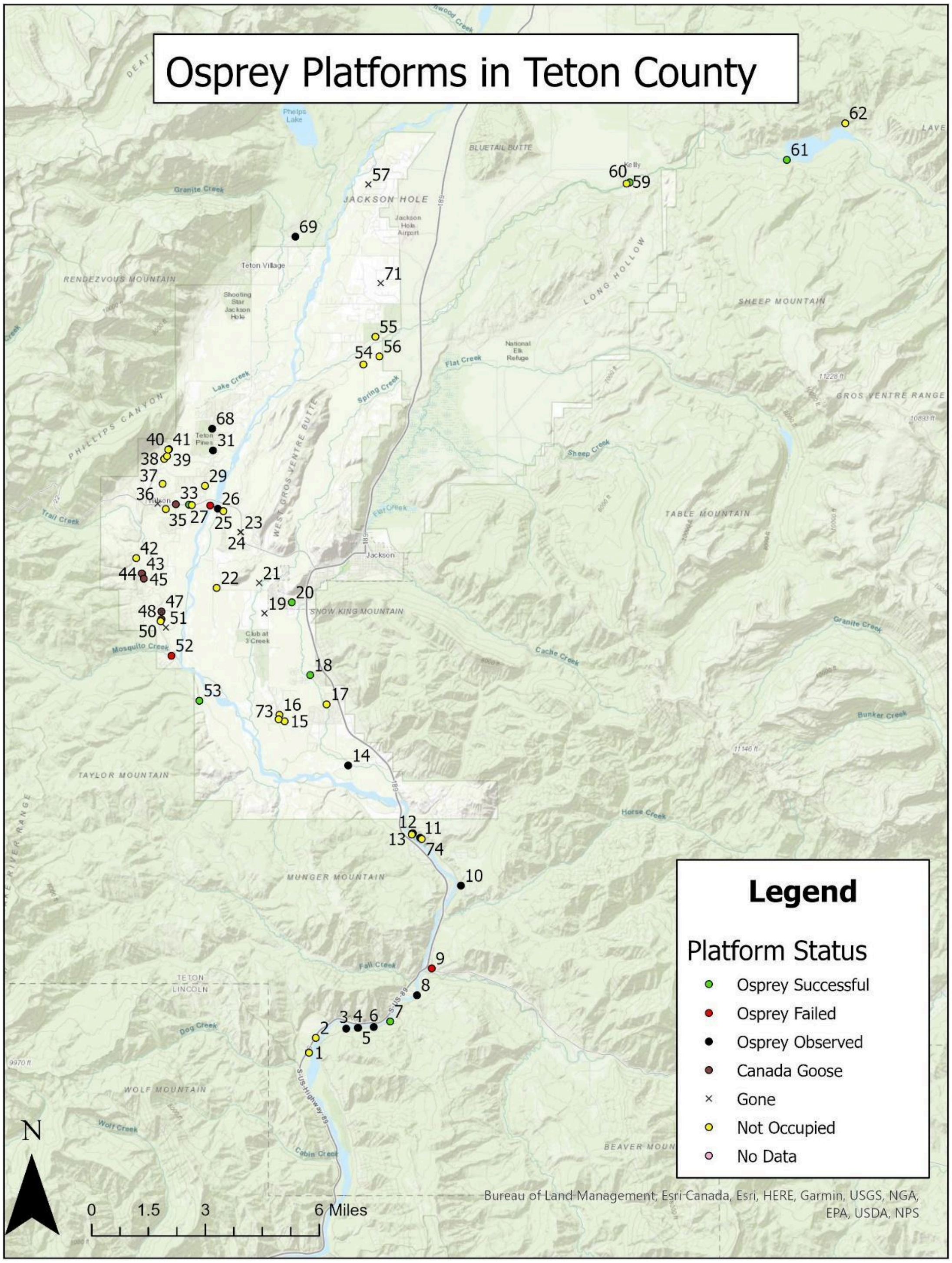


Figure 2. Osprey nesting platform status across the Jackson Hole Valley in 2024.

We monitored 100% of the study area platforms this year and observed Osprey at 27 platforms. Fifteen platforms had active Osprey nests this year and ten of the active nests reached the nestling stage. Eight of the nests were successful and in total, they produced 14 fledglings. Additionally, eight 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. Forty platforms had no nesting activity and 12 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.

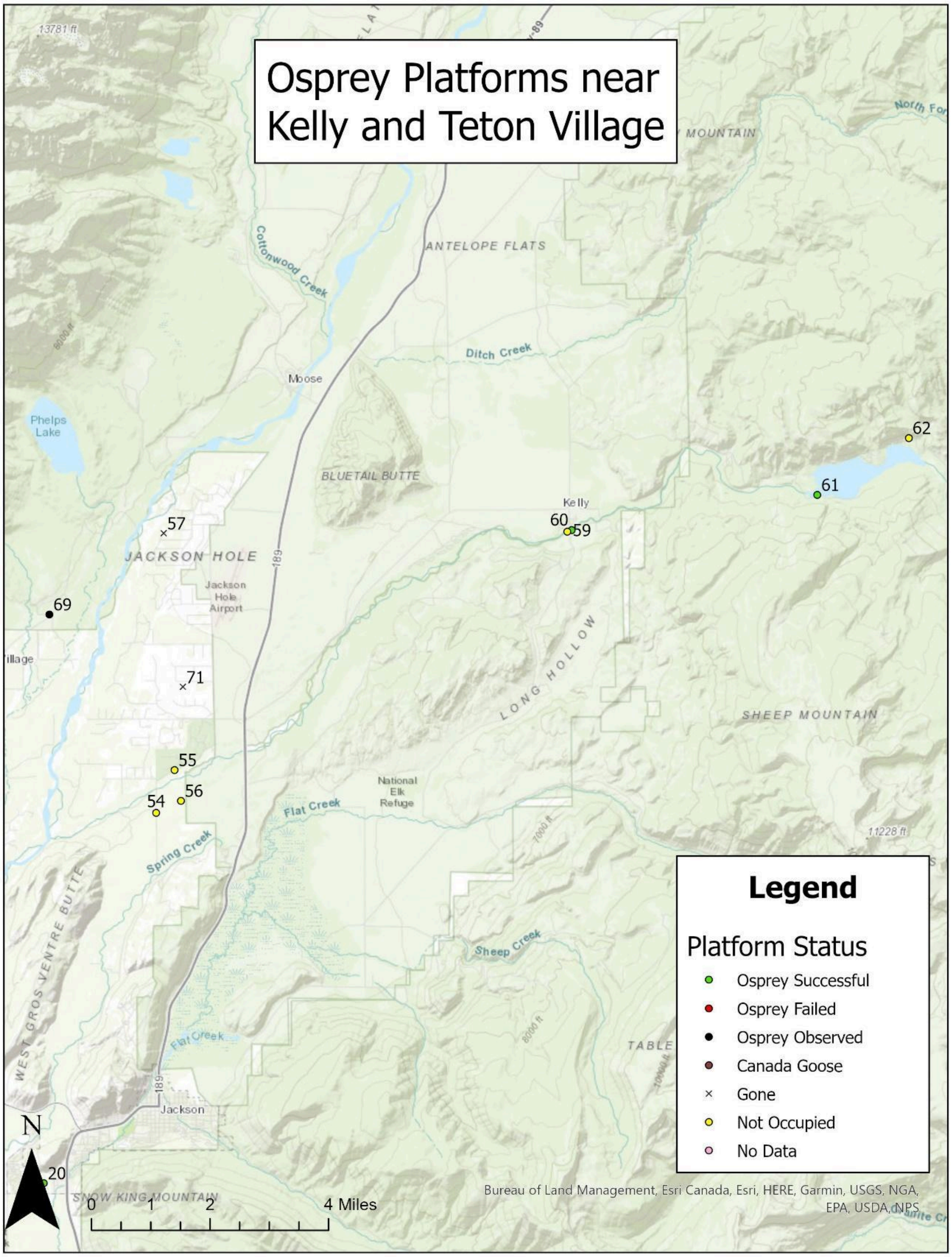
	ACTIVE	NSTL	SUCCESS	#FLDG
CANG	8	8	8	UNK
OSPR	15	10	8	14
NONE	40	*n/a*	*n/a*	*n/a*
GONE	12	*n/a*	*n/a*	*n/a*

Ospreys were observed at one of the nesting platforms by Moran and one Osprey platform was occupied by Canada Geese in 2024 (Figure 3). Near Kelly, one platform was occupied by an Osprey and produced one fledgling. A platform near Lower Slide Lake also produced two fledglings. Ospreys were observed at a platform near Teton Village, but that platform did not have an active nest (Figure 4). At platforms near Wilson, Ospreys were observed throughout the summer, but only one nest was active. Platform 33 produced two fledglings, continuing the success of this platform throughout years, despite the construction and commuter traffic along this stretch of Wyoming Highway 22 (Figure 5). Platforms along Fall Creek Road were dominated by Canada Goose nests (platforms 43, 45, 46, and 48). An active Osprey nest on platform 44 failed before reaching the nestling stage and platform 53 successfully fledged one Osprey (Figure 6). Osprey platforms south of Jackson were largely unoccupied, but there were successful Osprey nests at platforms 18, which produced two fledglings and 20, which produced one fledgling (Figure 7). In the Hoback area, Ospreys 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.

Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Figure 3. *One of the platforms near Moran had Ospreys observed nearby and one platform was occupied by Canada Geese in 2024 .*



Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Figure 4. *Platforms 60 and 61 produced fledglings in 2023 and Osprey were observed at 69 but there was never an active nest there.*

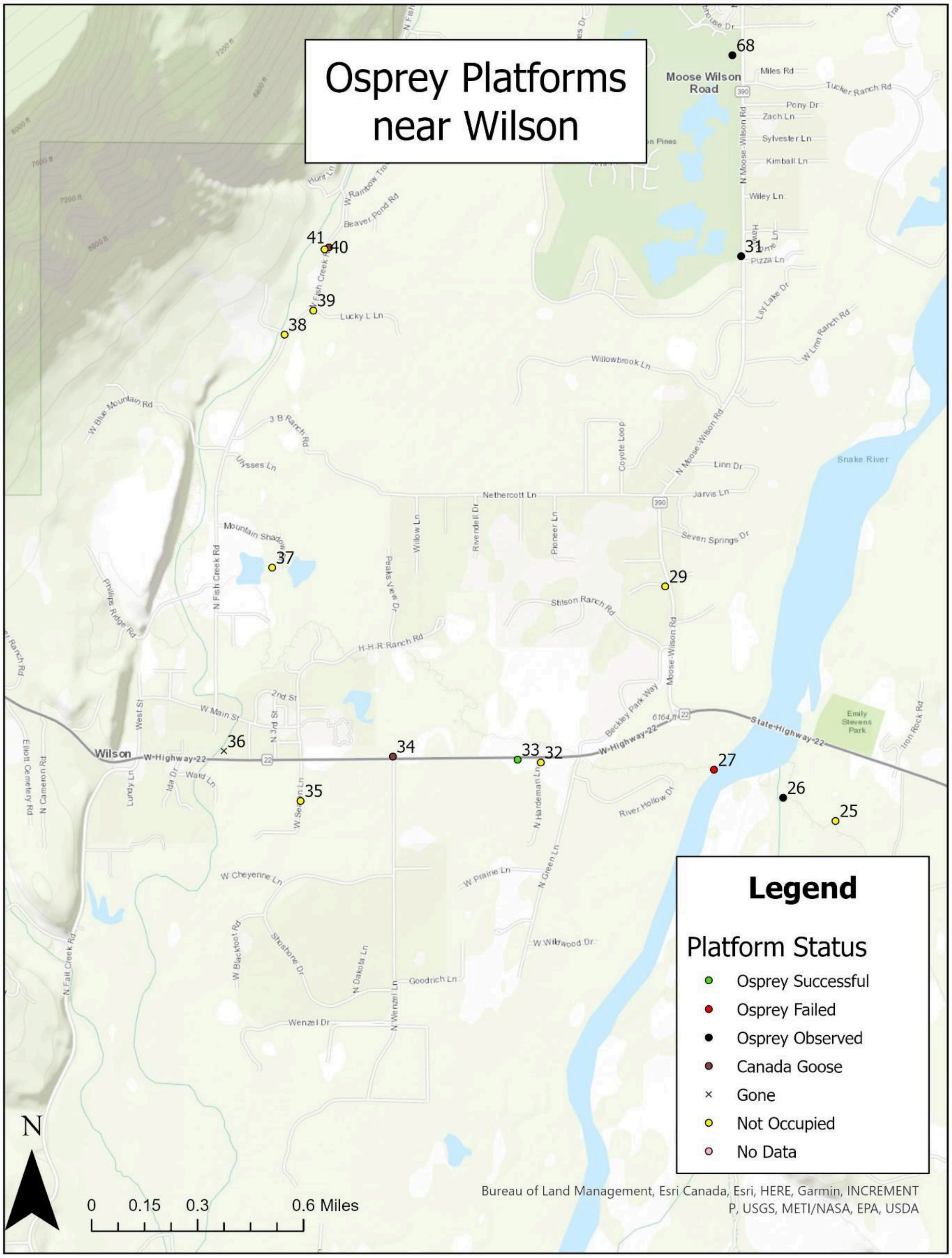


Figure 5. *Ospreys were observed near three of the platforms near Wilson, but there was only one successful nest – on platform 33 near Teton Raptor Center! That nest produced two fledglings.*

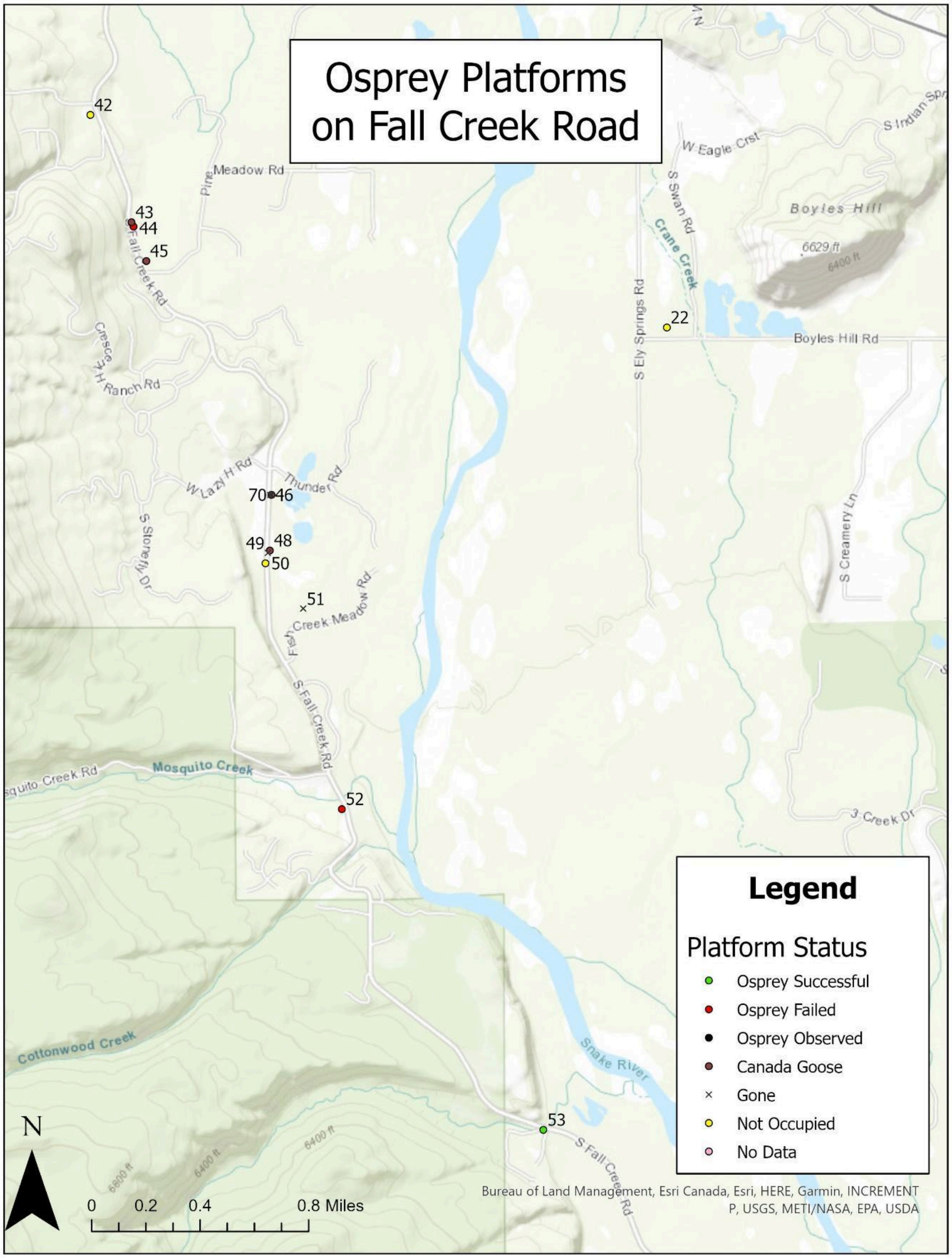


Figure 6. *Fall Creek Road was dominated by Canada Goose nests (platforms 43, 45, 46, and 48). An active Osprey nest on platform 44 failed before reaching the nestling stage and platform 53 successfully fledged one young.*

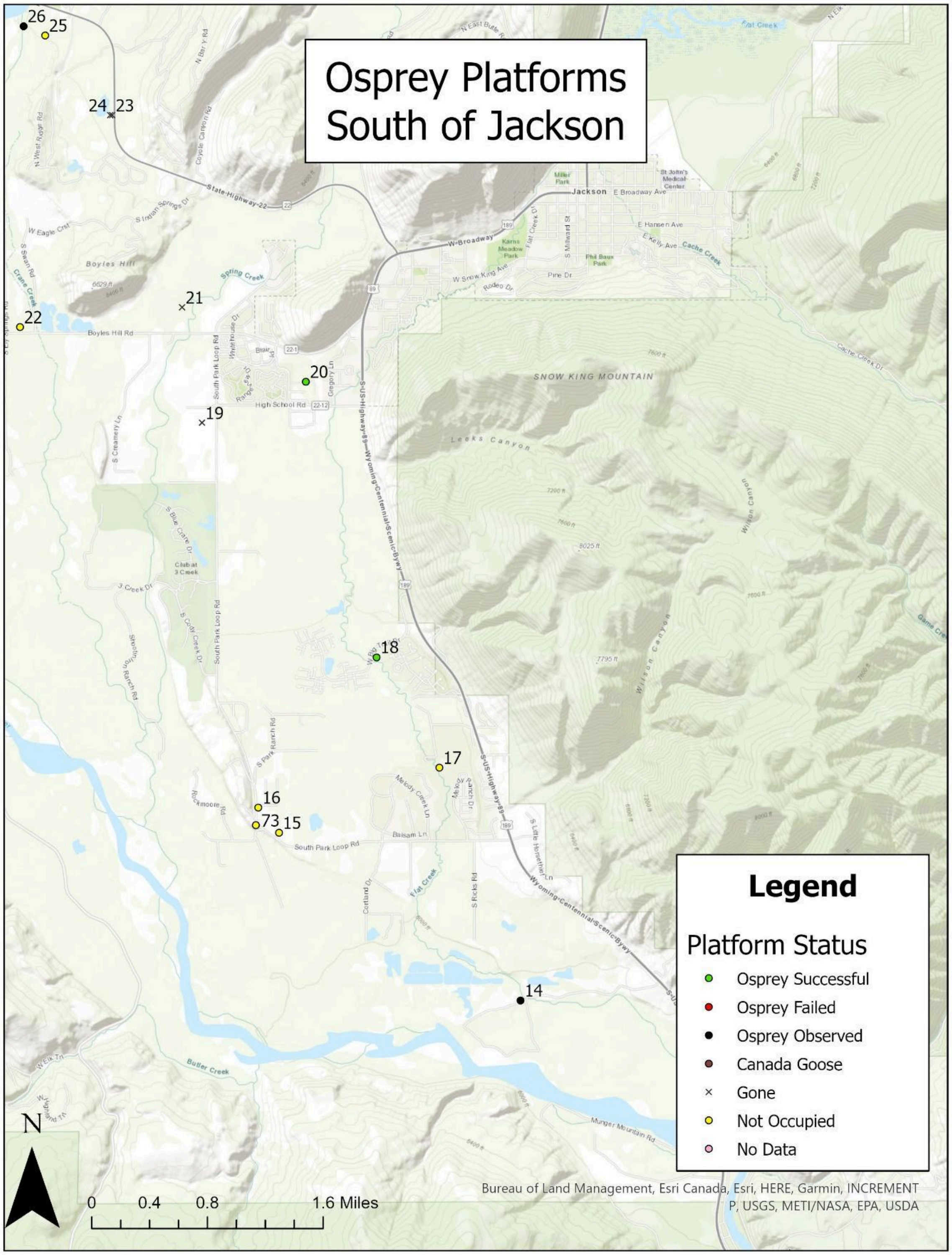


Figure 7. *Osprey platforms south of Jackson were largely unoccupied, but there were successful Osprey nests at platforms 18 and 20, which fledged a total of three chicks between them.*

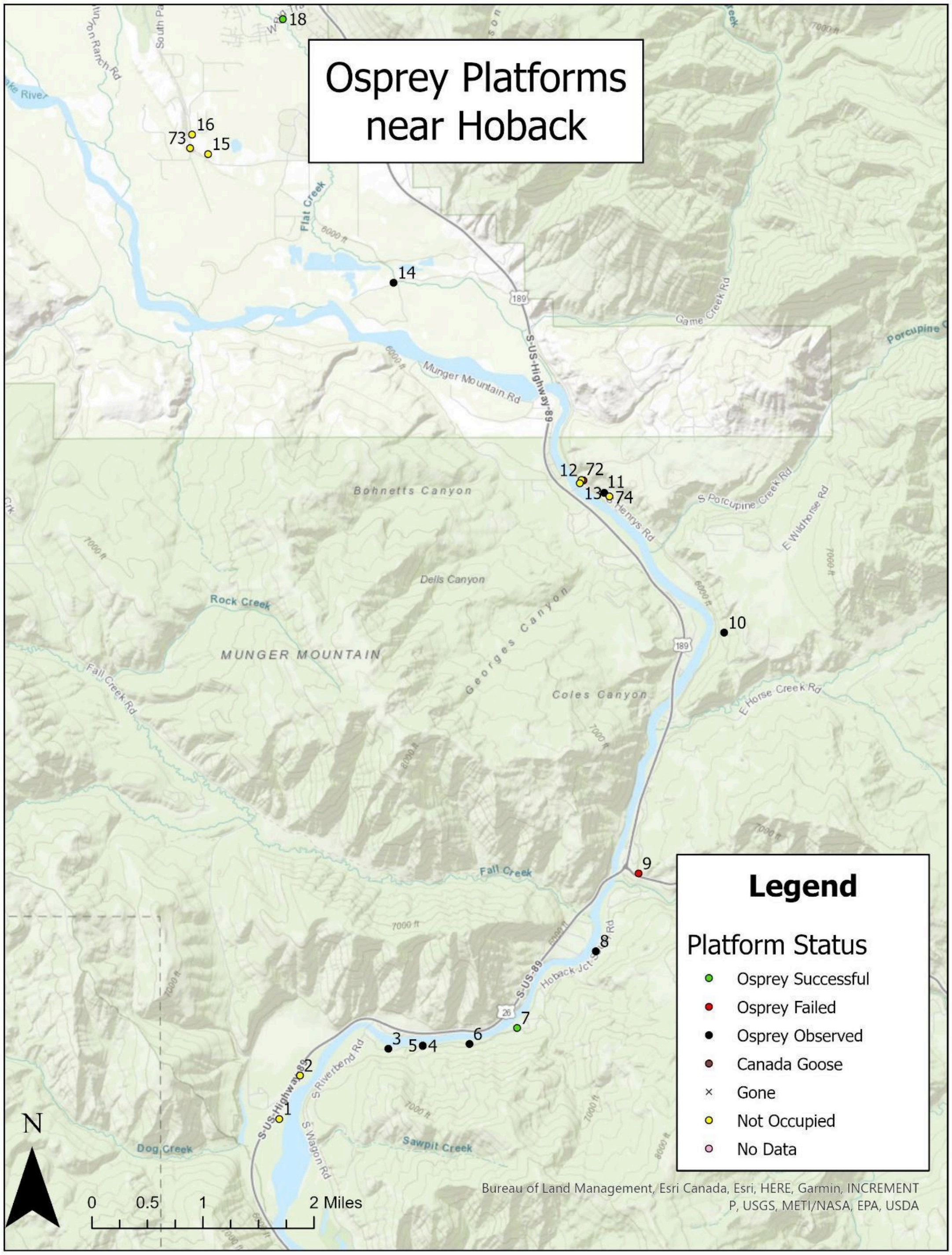


Figure 8. *In the Hoback area, Ospreys were observed near or on many of the platforms along the Snake River. There were three active nests in 2023 (7, 9 and 72). Nests on platforms 9 and 72 failed before the nestling stage and platform 7 fledged three young!*

Table 1. 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	N	No nest
4	OSPR	N	No nest
5	OSPR	N	No nest
6	OSPR	Y	Failed
7	OSPR	Y	Fledged
8	OSPR	Y	Failed
9	OSPR	Y	Failed
10	OSPR	U	Unknown
11	OSPR	N	No nest
12	NONE	N	
13	NONE	N	
14	OSPR	N	No nest
15	NONE	N	
16	NONE	N	
17	NONE	N	
18	OSPR	Y	Fledged
19	GONE		
20	OSPR	Y	Fledged
21	BROKEN	N	
22	NONE	N	
23	GONE		
24	GONE		
25	NONE	N	
26	OSPR	N	No nest
27	OSPR	Y	Failed
28	GONE		
29	NONE	N	
30	GONE		
31	OSPR	N	No nest
32	NONE	N	
33	OSPR	Y	Fledged
34	CANG	CANG	CANG
35	NONE	N	
36	GONE		
37	NONE	N	
38	NONE	N	
39	NONE	N	
40	NONE	N	
41	CANG	CANG	CANG
42	NONE	N	
43	CANG	CANG	CANG
44	OSPR	Y	Failed
45	CANG	CANG	CANG
46	GONE		
47	CANG	CANG	CANG
48	CANG	CANG	CANG
50	NONE	N	
51	GONE		
52	OSPR	Y	Failed
53	OSPR	Y	Fledged
54	NONE	N	
55	NONE	N	
56	NONE	N	
57	GONE		
58	NONE	N	
59	NONE	N	
60	OSPR	Y	Fledged
61	OSPR	Y	Fledged
62	NONE	N	
63	GONE		
64	OSPR	Y	Fledged
65	OSPR	N	No nest
66N	NONE	N	
66S	NONE	N	
67	CANG	CANG	CANG
68	BOTH	CANG	CANG
68A	OSPR	N	No nest
69	OSPR	N	No nest
70	GONE		
71	GONE		
72	OSPR	Y	Failed
73	NONE	N	

74	NONE	N	
75	OSPR	U	Unknown

Osprey Observation Summary 2018-2024:

From 2018 to 2024, 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 2). From 2018-2024 Ospreys were observed at between 33% (2023) and 50% (2022) of monitored platforms. In 2024, 41% of monitored platforms had at least one Osprey observed on or near them at least once throughout the season (Figure 7). From 2018-2024 an average of ten active Osprey nests produced chicks and an average of 17% of platforms monitored produced chicks. In 2024, 14 Osprey fledglings were produced from ten active nests.

Table 2. Number of Osprey platforms monitored each year with results for platforms with Osprey observed, Osprey incubating, and Osprey chicks observed from 2018-2024.

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

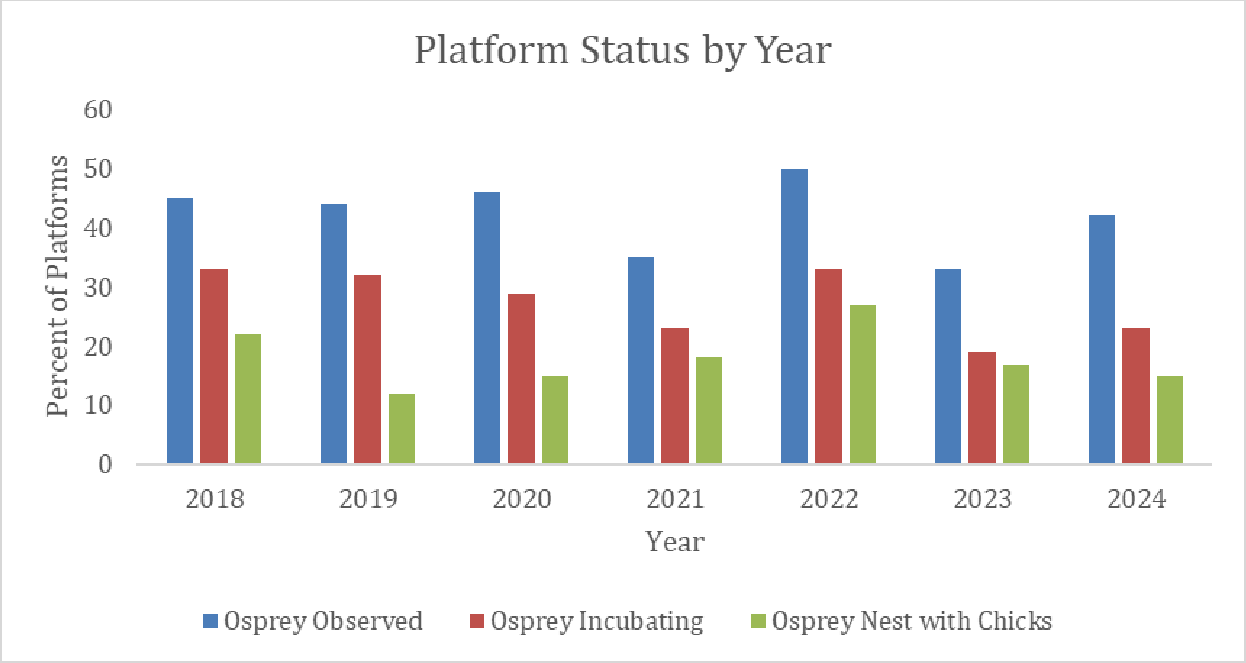


Figure 9. *Osprey platform status by year based on percent of monitored platforms. 2024 was similar to previous years in all three categories. Note that these values will not add to 100% as a platform may have had osprey observed, then subsequently have Osprey incubating and then chicks in the nest and 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.

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 42% of the monitored platforms. Additionally, an average of 28% of monitored platforms have had Osprey incubating with 18% having had chicks observed on the nest.

Continued monitoring of these platforms will help provide long-term productivity information that is essential towards understanding population trends of Osprey in the area. We also plan to continue monitoring efforts of nest platforms in 2025.

Acknowledgements:

This monitoring effort could not be completed without the volunteer time and dedication of Teton Raptor Center Ambassadors. We acknowledge Anne Hare, Bev Boynton, Ray White, Phil Dupuis, Nick Smith, Maggie Hagen, Becky Hawkins, Linnea Gardner, Phil Leeds, and Tom Stanton for monitoring nest platforms in 2024, as well as dozens of other Teton Raptor Center Ambassadors who have spent countless hours monitoring platforms over the last ten years. If you are interested in monitoring Osprey nests next year, please reach out to hilary@tetonraptorcenter.org

Understanding hematological values for raptors to improve rehabilitation diagnosis

Background:

Wildlife rehabbers in North America annually care for thousands of raptors after they have been injured or poisoned by anthropogenic causes. Blood chemistry values can be helpful in diagnosing illnesses in wildlife, but there is 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.

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 but will include both resident and migratory populations. Sample acquisition began in 2022 and is targeted to be complete by fall 2025. The study is monitored by a combination of Teton Raptor Center staff including Bryan Bedrosian (Conservation Director), Dr. Salene Freeman (DVM, Medical Director), Hilary Turner (Research Biologist) and Connor Hartnett (Clinic Coordinator).

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 2024, we collected samples from 46 raptors, representing 13 species (Figure 1). Species captured and sampled included FEHA, SSHA, COHA, AGOS, SWHA, MERL, Red-tailed Hawk (RTHA), Prairie Falcon

(PRFA), American Kestrel (AMKE), Northern Harrier (NOHA), Peregrine Falcon (PEFA), Broad-winged Hawk (BWHA), and Bald Eagle (BAEA). We collected samples from both NSTL samples from FEHA and BAEA and the rest of the samples were collected from non-NSTL individuals.

Since the study commenced in 2022, we have collected and analyzed 113 blood samples from 17 raptor species in Wyoming and Montana (Figure 2). 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, and SWHA. We only sampled NSTL FEHA and GGOW and the rest of the species are only represented by non-NSTL individuals.

Of the 113 samples, 92 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, we aim 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. We don't have any non-NSTL samples for FEHA or GGOW and have minimal GOEA and AGOS NSTL samples.

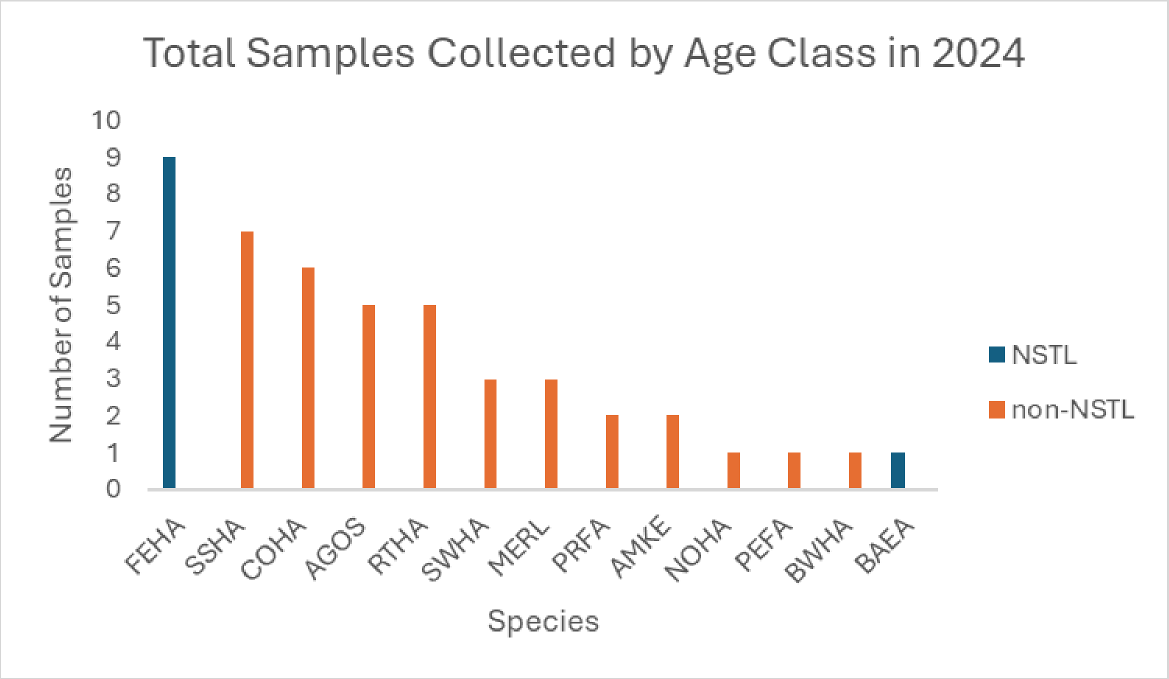


Figure 1. *In 2024, we collected blood samples from 9 FEHA, 7 SSHA, 6 COHA, 5 AGOS, 5 RTHA, 3 SWHA, 3 MERL, 2 PRFA, 2 AMKE, 1 NOHA, 1 PEFA, and 1 BAEA. All FEHA and BAEA sampled were nestlings or fledglings and the rest of the individuals sampled were fully flighted.*

Figure 2. *The number of samples per species collected since the start of the study by age class.*

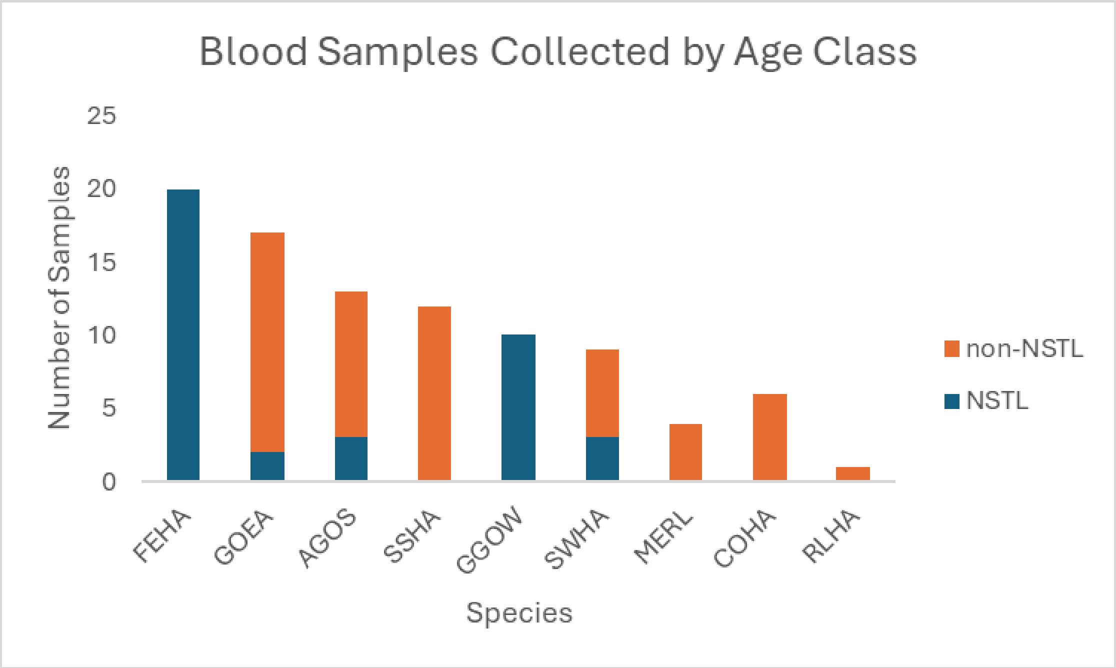


Figure 3. *The total number of blood samples collected from study species by age class since the study started in 2022. We collected 20 FEHA NSTL samples, 15 GOEA NON-NSTL and 2 GOEA NSTL samples, 10 AGOS NON-NSTL and 3 AGOS NSTL samples, 12 SSHA NON-NSTL samples, 10 GGOW NSTL samples, 3 SWHA NON-NSTL samples and 6 SWHA NSTL samples, 7 MERL NON-NSTL samples, 6 COHA NON-NSTL samples, and 1 RLHA NON-NSTL sample.*

Next Steps:

We will continue the project to augment sample sizes for those with fewer than ten samples per species. We were unable to sample sufficient Rough-legged Hawks at our migration site so we will target them via road trapping with bal-chatris during winter 2024-2025 and we will aim to wrap up data collection at our migration site in fall 2025.

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.

Bile Acids (BA)
BA are produced in the liver, excreted in the bile, and reabsorbed in the small intestines (SI). BA values test liver FUNCTION as they are produced in the liver. Low to normal values should be appreciated in healthy individuals as they should be reabsorbed in the SI.

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 glycogen 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 is 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)
Comprising 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).