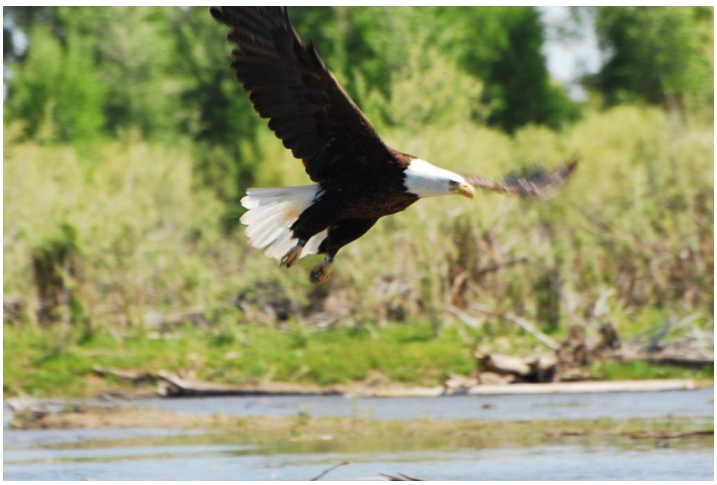
MEG AND BERT RAYNES WILDLIFE FUND
Current Status Report
Bald Eagle Genetics in the Greater Yellowstone Ecosystem—Revealing the Wyoming Connections



Executive Summary

Bald Eagle 22 took her first flight from her natal nest in Wyoming in 1987 when there were few known bald eagle breeding pairs in the Idaho portion of Greater Yellowstone. She traveled thousands of miles as she matured, but since 1994 she and her mates have occupied an Idaho breeding area that she established 66 miles west of her birth place. She has now successfully raised at least 25 young, and some of those young have matured to establish new breeding areas of their own in the GYE and perhaps beyond.

Remnant nesting bald eagles in Jackson Hole were likely a primary source for recovery of the Greater Yellowstone Ecosystem (GYE) bald eagle population. New genetics tools can lead to discovery of the mechanism of that dramatic recovery, the population's boundaries and structure, and thus the foundation for future conservation measures for bald eagles of the GYE and its Upper Snake, Wyoming core area. Research partners have mounted an extensive examination of GYE bald eagle genetics. This project supports one element of that broader study: expanded genetic sampling at key Idaho nest sites to reveal the extent of the Wyoming connections and to better understand the entire GYE bald eagle population. For the Idaho portion of this research, the Meg and Bert Raynes Wildlife Fund provided support to enable sampling at additional Idaho breeding areas to better understand the sources of population recovery, including the Upper Snake in Wyoming, and to better delineate population boundaries and structure.

The overall GYE Bald Eagle Genetics project was initiated in 2016 with a few genetic samples collected, and then broadened in 2017 as sampling expanded into all three GYE states: Wyoming, Montana and Idaho. In Idaho in 2017 and 2018 we collected blood samples from 31 nestlings, 23 from recognized GYE nest sites and 8 from peripheral areas. We also have 73 additional nestling blood samples collected in earlier years at Idaho/GYE nest sites that will be analyzed as part of this study. We also have collected approximately 50 adult feather samples from below nests to aid in genetic analysis from nests that could not be safely entered for collection of nestling blood samples. We intend to extend collection of nestling blood samples for genetic analysis into the 2019 nesting season because weather and river conditions prevented sampling at some sites we had hoped to sample in 2018. The Idaho/GYE Bald Eagle Research Team also completed 2018 productivity monitoring at 90 of the 98 known bald eagle breeding areas within the Idaho portion of GYE. Overall productivity ratios were low relative to past years, largely because of cold, wet spring weather.

Bald Eagle Genetics in the Greater Yellowstone Ecosystem—Revealing the Wyoming Connections

Project Collaborators

Meg and Bert Raynes Wildlife Fund—a direct sponsor of this project and therefore acknowledged as the catalyst for completion of key data collection
The Idaho bald eagle work is led by Michael Whitfield – Research Associate, Northern Rockies Conservation Cooperative, Driggs, ID and Director, Idaho/GYE Bald Eagle Research Team
The Idaho work is a key element of a larger Greater Yellowstone Ecosystem research project. For this larger project, our research partners are:
Bryan Bedrosian– Senior Avian Ecologist; Roger Smith – Co-Founder and Chair, Teton Raptor Center, Jackson, WY
Susan Patla, – Non-Game Biologist, Wyoming Game and Fish Department—Jackson, WY
Ron Van Den Bussche – Associate Vice President for Research, Oklahoma State University
Megan Judkins – Graduate Student, Oklahoma State University and Assistant Aviary Manager, Grey Snow Eagle House

Project Description:

Project Summary and Current Status:

Remnant nesting bald eagles in Jackson Hole were likely the source of much of the recovery of the GYE bald eagle population. New genetics tools can lead to discovery of the mechanism of that dramatic recovery, the population's boundaries and structure, and thus the foundation for future conservation measures for bald eagles of the GYE and its Upper Snake, Wyoming core area. Research partners have mounted an extensive examination of GYE bald eagle genetics. This project supports one element of that broader study: expanded genetic sampling at key Idaho nest sites to reveal the extent of those Wyoming connections.

We initially proposed to complete genetic sampling in 2018 and analysis early in 2019. However wet, cold spring weather in 2018 resulted in a relatively high level of nesting failure at Idaho nest sites and high water during critical periods prevented access to some targeted nests. Funding for the genetic analysis was also delayed beyond expectations. We now intend to extend sample collection into the 2019 bald eagle nesting season to allow sampling at additional sites. Funding for analysis of approximately 200 GYE related bald eagle genetic samples has been obtained and this analysis will soon be underway.

Project Background

A highly significant nesting population of bald eagles (Haliaeetus leucocephalus) occurs in the Greater Yellowstone Ecosystem (GYE) located in the tristate region of northwest Wyoming, eastern Idaho, and southwest Montana. When bald eagles gained greater attention as an endangered species in 1967 (and in the ESA of 1973), the GYE population was small and geographically isolated from other remnant populations. Enhanced management and protection of bald eagles and the banning of DDT led to rapid recovery of this population from very low levels in the mid-1900s. Research over the past 35 years suggests that a primary source for this population recovery was remnant nesting adults in the Upper Snake watershed in Wyoming.

The GYE bald eagle population's federal and state status and concern for its recovery led to the formation of the Greater Yellowstone Bald Eagle Working Team in 1981. This collection of agency representatives and bald eagle researchers developed a management plan for the GYE bald eagle population in 1983 (updated in 1995). This plan identifies goals for management and monitoring of bald eagles and their habitats in 3 GYE bald eagle subpopulations: Snake, Continental and Yellowstone, with 3 management sub-units in each (GYE Bald Eagle Management Team 1995). The Management Plan was informed by ongoing bald eagle research (Harmata and Oakleaf 1992; Whitfield 1993). Although these management units have provided a useful framework for planning and implementation of bald eagle conservation measures, they were delineated by administrative and ecological attributes rather than bald eagle biology.

Recent advances in genetics have the potential to greatly advance our understanding and management of the GYE bald eagle population. A key first step in the conservation of a wildlife population is delineation of the biologically relevant boundaries for that population's range. This critical step informs wildlife managers and policy makers of the geographic units they are attempting to conserve or manage while also setting the biological and theoretical foundations for future decisions. We now have an opportunity to better establish that foundation for conservation of bald eagles in the GYE. Our partners at Oklahoma State University have developed a reference genome for bald and golden eagles plus a comprehensive set of genetic markers for eagle conservation and management. These advances in genetics enable us to better delineate population boundaries and evaluate population structure, gene flow, parentage, relatedness, and genetic and adaptive variation. Genetic markers can thus aid in management and conservation efforts which are critical in light of increased anthropogenic stressors, such as climate change, heavy metal poisoning, habitat loss and fragmentation, electrocutions, and collisions with wind turbines. Ultimately this genetic information can strengthen conservation management planning to ensure the sustained health of the GYE bald eagle population and its core area in Jackson Hole.

Bald eagles represent an important element of the river dependent wildlife in the Upper Snake River Watershed and the entire GYE. As top of the food chain predators, bald eagles are also excellent indicators of overall watershed health for many species. Bald eagles have long been a protected species in the continental United States. One of the first species to receive protections under the precursor to the Endangered Species Act in 1967, the bald eagle was removed from the Federal List of Endangered and Threatened Wildlife and Plants in 2007. Bald eagles continue to be protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. As K selected, top of the food chain predators that produce relatively few, slowly developing young and long-lived nesting adults, bald eagles will continue to require careful protection in the face of growing environmental threats. Those adults that do survive to productive age are highly valuable to population sustainability and their nesting habitats warrant continued conservation vigilance. The monitoring and genetic research proposed here can greatly inform conservation measures and also provide tremendous information for use in conservation education.

<u>Why new genetic sampling in Idaho is relevant to conservation of Jackson Hole bald eagles.</u>
In March 2016, the recovery of an injured nesting adult near the National Elk Refuge in Jackson Hole, Wyoming that was banded in 1982 prompted the U.S. Fish and Wildlife Service, among others, to encourage this genetics research. Much of this interest was to better understand the role

that long-lived, productive nesters like this adult played in the dramatic growth in this region's bald eagle population. GYE bald eagles can teach us much about species recovery under the Endangered Species Act. Banding efforts during the 1980's and 1990's within the GYE resulted in hundreds of nestlings being tagged. These past banding studies reveal that similarly long lived adults with Wyoming origins have established nests in the Idaho portion of Greater Yellowstone, where the known nesting population has grown from just 1 known nesting pair in 1960 to 98 breeding pairs in 2018 (Whitfield 2018). It appears that recovery of the bald eagle population in the Idaho portion of GYE emanated from those remnant nesting pairs in the Upper Snake in Wyoming, a theory that this genetic research can refine. Band observations also reveal that some of the current GYE Wyoming and Montana nesting adults were fledged from nests in Idaho where the currently most productive GYE bald eagle breeding areas are found—the GYE population is tightly linked.

Discussions between the U.S. Fish and Wildlife Service and our partners at the Teton Raptor Center in Jackson Hole led to learning of the advanced genetics tools that have been developed by our partners at Oklahoma State University. Ongoing monitoring of several banded adults in the Idaho portion of the GYE that are near (or beyond) 30 years of age, several of which were fledged from Wyoming nests, prompted our partners to reach out to M. Whitfield and the Idaho/GYE Bald Eagle Research Team for further collaboration. Abundant evidence of population mixing across the state boundaries coupled with suggested high overall nesting fidelity to the GYE region further prompted interest in understanding the contribution of these long-lived adults to the population recovery of bald eagles in the GYE and nearby regions.

Since the 1980s the Bureau of Land Management and U.S. Forest Service have partnered with the U.S. Fish and Wildlife Service and Idaho Department of Fish and Game to sponsor productivity monitoring in the Idaho portion of the GYE by the Idaho/GYE Bald Eagle Research Team. However under the current federal administration there is no funding available for productivity monitoring or any expansion of the genetics work. In 2016-2017 research partners completed initial sampling in Wyoming, Montana and Idaho. In 2018 Teton Raptor Center (TRC) expanded sampling to some areas of Wyoming that were missed in 2017. TRC will collect some further samples in Yellowstone and other Wyoming areas as feasible in 2019. M. Whitfield and the Idaho/GYE Bald Eagle Research Team monitored GYE Idaho bald eagle productivity on a volunteer basis in 2018 and will continue to do so in 2019. The Meg and Bert Raynes Wildlife Fund provided financial support in the amount of $4,500 to hire climbers to enable completion of targeted genetic sampling in some key Idaho areas. We used half of this grant in 2018 and will use the remainder to complete sampling in 2019.

Project Goals and Objectives:
In our overall GYE research partnership, we proposed analysis of historic genetic samples and new samples from nestlings and known-aged eagles with known banding locations to investigate the following objectives:

- Understand the degree to which the Upper Snake Wyoming and GYE populations acted as genetic sources for bald eagle recovery in the broader region
- Assess the effects of population bottlenecks due to very low population numbers in the mid-1900s due to eagle persecution, habitat loss, and use of DDT

- Delineation of GYE population and Snake Wyoming and other sub-population boundaries to understand regional population structure
- Assess gene flow, genetic connectivity, natal origins and individual relatedness, and inbreeding coefficients
- Evaluate relative genetic success and dispersal distances of individuals within and surrounding the GYE
- Examine parentage and territory adult turnover rates; multiple paternity at nest sites
- Further understanding of adaptation and the impacts of anthropogenic stressors on eagle populations

For the Idaho portion of this research, the Meg and Bert Raynes Wildlife Fund provided support to enable sampling at additional Idaho breeding areas to better understand the sources of population recovery, including the Upper Snake Wyoming connections, and to better delineate population boundaries and structure. In 2018 we expanded sample density among breeding areas within the GYE as well as sites at the ecosystem boundaries, and we intend to continue this effort in 2019. Identification and monitoring of sample nests in Idaho has been and will be completed by M. Whitfield and team on a volunteer basis. Wildlife Fund funding covers the costs of hiring climbers to enter nests to enable nestling banding and collection of genetic samples.

Methods and Approach:
We will analyze blood and feather samples collected in earlier years in Idaho and Wyoming and augment these with nestling blood samples from accessible nests and feather samples collected below or in nest sites from Wyoming, Montana and Idaho. Our focus is on Snake River WY and Snake River ID as our core sampling effort, and collection of material from nests within 120 miles for dispersal and relatedness sampling. To investigate adult turnover and multiple paternities, we also sample selected nests for a minimum of two years. Nests with known-aged banded breeders are a priority for sampling.

We enter nests when the chicks are 5.5 to 7 weeks old to minimize impacts to the young eagles, band the eagles, and take a 2ml blood sample from the brachial vein (stored in lysis and EDTA storage tubes). Molted feathers from adults are collected from within and below the nest for further DNA analysis. Banding is completed with bands issued by the federal Bird Banding Laboratory.

Recent advances in genetic research technology enable much more refined assessment of population demography than was earlier possible. DNA will be extracted from feathers and blood. Our DNA samples will be genotyped by our colleagues at Oklahoma State University using their recently developed SNP (single nucleotide polymorphism) chip containing >50,000 genetic loci (SNPs; approximately 25,000 of these loci are "neutral" whereas the remainder were chosen because they fall in ecologically relevant genes or upstream or downstream regions of these genes). Genotypes will be assessed for relationship among samples using super-computer analysis of all pairwise comparisons.

Results to Date
The overall GYE Bald Eagle Genetics project was initiated in 2016 with a few genetic samples collected, and then broadened in 2017 as sampling expanded into all three GYE states:

Wyoming, Montana and Idaho. In Idaho in 2017 and 2018 we collected blood samples from 31 nestlings, 23 from recognized GYE nest sites and 8 from peripheral areas. We also have 73 additional nestling blood samples collected in earlier years at Idaho/GYE nest sites that will be analyzed as part of this study. We also have collected approximately 50 adult feather samples from below nests. Feather samples will be analyzed where they represent targeted nest sites that could not be safely entered for collection of nestling blood samples. Our Teton Raptor Center (TRC) project partners have collected 43 blood samples from Wyoming nest sites including Jackson Hole, Grand Teton National Park, Yellowstone National Park, and the Green River area near Pinedale. The TRC partners have also collected 20 blood samples from Montana GYE nest sites. The TRC partners have also collected 45 feather samples from below nests to augment coverage of genetic sampling from areas where nests could not be entered.

The Idaho/GYE Bald Eagle Research Team reported 2018 productivity monitoring results for the 98 known bald eagle breeding areas within the Idaho portion of the Greater Yellowstone Ecosystem (GYE), the Idaho portion of U.S. Fish and Wildlife Service Bald Eagle Management Zone 18 (M. Whitfield et al 2018). In 2018, activity monitoring surveys were completed for 66 of the now 73 breeding areas found in the Snake Idaho population sub-unit. The research team was not able to monitor many of the lower Snake River nests owing to lack of river access during the nesting season. The team monitored 24 of 25 breeding areas found in the Continental Idaho sub-unit. Overall productivity ratios were low relative to past years, largely because of cold, wet spring weather at times when nestlings were most susceptible. In 2018, 1 new breeding area was confirmed in the Snake sub-unit, the Conant Landing breeding area at a nest site thought to have been a possible alternate for the Conant Valley breeding area in 2017, but clearly documented as a separate breeding pair in 2018. There were 50 known advanced young produced at 62 occupied breeding areas with known outcome in the Snake Idaho unit in 2018. In the Snake Idaho population sub-unit, active nesting was detected at 53 of the 62 occupied breeding areas with known outcome. For breeding areas with known productivity, 32 of 62 occupied breeding areas successfully produced 50 young for a productivity ratio of 0.81 young/occupied breeding area with outcome known. The nesting failure rate in the Snake Idaho sub-unit was 45.3% (24 of 53 active nests with known outcome failed). In the Continental Idaho sub-unit, active nesting was detected at 14 of the 24 occupied breeding areas with outcome known. In the Continental Idaho sub-unit, 7 of 24 occupied breeding areas with known outcomes successfully produced 10 advanced young for a productivity ratio of 0.42 advanced young/occupied breeding area. In this sub-unit, 7 of 14 active nests failed for a failure rate of 50.0%.

In 2018, productivity monitoring was not completed as a whole in Idaho areas peripheral to the GYE in southern Idaho and the Salmon River area although M. Whitfield completed nesting activity observations at 8 southern Idaho breeding areas outside of the GYE and banded at one successful site.

Future work

We intend to extend collection of genetic samples from bald eagle nestlings at selected sites into the 2019 nesting season in our ongoing effort to fully sample both GYE nesting areas and bald eagle nests from areas peripheral to Greater Yellowstone. Our partners at Oklahoma State University (OSU) have obtained funding to analyze approximately 200 genetic samples and are now preparing to initiate this work with samples that GYE partners have provided. The OSU

team will complete genetic analyses later in 2019 and the partnership will prepare data for publication and sharing of results in late 2019. The Idaho/GYE Bald Eagle Research Team will continue to monitor bald eagle productivity at Idaho/GYE breeding areas.

Anticipated benefits for wildlife:
Understanding gene flow and relative contribution of individual eagles within a population is an important aspect to long-term management of k-selected species like bald eagles. With a maximum lifespan of over 30 years and a first breeding age of 5 years, some bald eagles have the potential to produce a large number of progeny that can perpetuate a local or regional population. Traditionally, it is expected that in raptor species less than 20% of individuals within a population contribute more than 80% of the genetic material due to high juvenile and sub-adult mortality. We are in a very unique position to test this theory as we seek to delineate population boundaries and better understand GYE population dynamics and structure, gene flow, parentage, relatedness, and genetic and adaptive variation. These analyses can thus aid in management and conservation efforts which are critical in light of increased anthropogenic stressors for bald eagles and many associated fish and wildlife species. Ultimately this genetic information can strengthen conservation management planning to ensure the sustained health of the GYE bald eagle population and its core sub-population in Jackson Hole.

Project Budget Update (Idaho portion only):
The Meg and Bert Raynes Wildlife Fund provided a grant of $4,500 to hire climbers for sampling at Idaho nest sites as a key element of this overall project. The Idaho banding team spent half of this grant in 2018 and will spend the remainder in 2019.

In 2018 the Idaho/GYE Bald Eagle Research Team contributed 406 hours of volunteer time (295.5 hours by M. Whitfield) in productivity monitoring and documentation. Additionally M. Whitfield contributed 4,971 vehicle miles in completion of the project, and leftover U.S. Forest Service funds covered an additional 929 vehicle miles at the federal reimbursement rate.

The Northern Rockies Conservation Cooperative (NRCC), as a 501(c) (3) non-profit organization, received the MBRWF funds and monitors and controls their use by serving as project bookkeeper. NRCC provides for payroll control to pay hired climbers. The MBRWF funds are the sole source for hiring climbers to assist in collection of genetic samples at the selected Idaho bald eagle breeding areas.

The **MEG AND BERT RAYNES WILDLIFE FUND** will be acknowledged as the funder who enabled collection of genetic samples through this project in locations that could not otherwise be sampled in Idaho. Further, the **FUND** will be acknowledged as a catalyst for achievement of research goals for the broader regional effort.

Funding for the broader study in Wyoming and Montana and the genetic analysis at Oklahoma State University has been and will be funded from other sources.