Behavior and Demography of Breeding Bald Eagles in Colorado's Northern Front Range

November 1, 2020

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The bald eagle (*Haliaeetus leucocephalus*) is a Tier 2 species of greatest conservation need in the Colorado State Wildlife Action Plan (Colorado Parks and Wildlife 2015). Bald eagles have recovered from dramatic population declines and were removed from the federal threatened and endangered species list in 2007. However, there is still concern about the status of local and regional populations, and the potential impacts of land use changes on bald eagles. Bald eagles are a high-profile species with strong interest from the public, and along the Colorado Front Range corridor where bald eagles and humans coexist in close proximity, public awareness of bald eagles is high and citizens closely track individual bald eagles and their nests. With a rapidly expanding human population along the Front Range, development (residential, business, energy, etc.) and other forms of land use change regularly create concerns about impacts on bald eagles, and particularly the loss of nest sites. The U.S. Fish and Wildlife Service is currently developing standards for allowing limited take of eagle nests (U.S. Fish and Wildlife Service 2016) and regularly seeks input from Colorado Parks and Wildlife (CPW) on human-eagle issues.

Historically, bald eagles commonly occurred in northcentral Colorado during migration and winter, but in recent decades a relatively high concentration of breeding pairs has become established in the area (Kralovec et al. 1992, Wickersham 2016). Human activity can negatively impact bald eagles during breeding (Fraser et al. 1985, Buehler et al. 1991, Grubb and King 1991, Montopoli and Anderson 1991, Grubb et al. 1992) and winter (Stalmaster and Newman 1978, Brown and Stevens 1997, McGarigol et al. 1991). CPW and the U.S. Fish and Wildlife Service have recommended disturbance buffer distance and timing restrictions for bald eagle nests and roost sites (U.S. Fish and Wildlife Service 2007, Colorado Parks and Wildlife 2020). However, bald eagles exhibit a wide range of tolerance and response to various human activities and their proximity (Buehler 2020), making it challenging to develop disturbance mitigation recommendations that are both defensible and consistent. We predict that along the northern Front Range, nesting bald eagles that are regularly exposed to human activity are more tolerant of human activities and at closer distances than eagles using nest sites where human activities are more limited. We further predict that eagles exposed to relatively high levels of anthropogenic structures and human activity during breeding are more likely to use areas with relatively high human activity and infrastructure during the nonbreeding period.

The goal of this study is to better understand current demographics and space use of bald eagles breeding along the northern Front Range, and the impact of human disturbance and changing land use on these measures. We will conduct this project during 2020 – 2024. Specific objectives include:

1) Quantify changes in land use around bald eagle nests along the northern Front Range over the past decade.
2) Quantify and compare demography (breeding effort, breeding success, survival) and space use (home range, daily movements) of breeding bald eagles nesting at sites along a gradient from

sites with little historical and no new disturbance activity to sites with relatively high historical disturbance levels and significant new disturbance activity during the study.
3) Quantify nonbreeding survival, and nonbreeding movements and space use of bald eagles breeding along the northern Front Range, in relation to anthropogenic features.

STUDY AREA

We are conducting this study along the Front Range corridor of northcentral Colorado, in Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld counties. This is an area of rapid human population growth (18% growth from 2000 to 2020), high anthropogenic development, and a relatively high concentration of use by bald eagles throughout the year. As such, nests are routinely exposed to varying levels of disturbance. Numerous bald eagle nests in this area have been closely monitored for multiple years to determine annual activity and success.

METHODS

Land Use Around Eagle Nests

CPW obtained a statewide land-use and land-cover dataset which quantified oil and gas development, wind and solar energy development, and residential development between 1970 and 2020 (Sushinsky 2020). To begin exploring the use of these spatial datasets for characterizing land use around bald eagle nests, we examined residential development data. Residential development was mapped using the Spatially Explicit Regional Growth Model (SERGoM) dataset (Bierwagen et al. 2010), a nationwide dataset that models housing density by decade between 1970 and 2100 at a spatial resolution of 100 m. The SERGoM model calculates the number of residential units needed for the growing human population based on U.S. Census data, land ownership, transportation, groundwater well density, and land cover.

The SERGoM data was clipped to the Colorado state boundary in ArcGIS 10.7 and fields for residential density class and housing density (units/ha) were added to the attribute table and updated as seen below. There are eleven housing density categories which are categorized into four residential density classes:

Residential density class	Housing density (units/ha)
Rural low	< 0.015
Rural high	0.015 - 0.03
Exurban lowest	0.04 - 0.06
Exurban low	0.07 - 0.12
Exurban high	0.13 - 0.24
Exurban highest	0.25 - 0.49
Suburban low	0.50 - 1.49
Suburban high	1.50 - 4.94
Urban low	4.95 - 12.34
Urban medium	12.35 - 24.70
Urban high	> 24.70

We calculated the percentage of the area in these classes, along with the coverage of commercial/industrial development, within 20 km^2 of known bald eagle nests in the study area during 1980, 1990, 2000, 2010, and 2020. We used the sum of coverage of exurban, suburban,

and urban residential development and commercial/industrial development, as an "urban index" around each nest site. We included alternate nest sites (Buehler 2000) in the sample of nest sites.

Nest Monitoring

In 2020, Bird Conservancy of the Rockies (BCR), a partner organization in this study, continued its Bald Eagle Watch program, where volunteers monitor known bald eagle nests in the study area. CPW also monitored nests. BCR and CPW have standardized monitoring protocols that provide detailed information to determine nest activity and fate, as well as habitat features and potential disturbance sources. For all nests, observers determined if the nest was occupied, and whether the nest was destroyed (e.g., by a weather event or a nest tree falling down), was abandoned or failed, hatching success (i.e., at least one egg hatched), and whenever possible, fledging success (i.e., at least 1 young fledged). Occupied nests were observed multiple times to determine the nest fate.

Capture and Marking Eagles With Transmitters

In 2020 CPW purchased three transmitters using Lois Webster Fund grant funds. The solar-powered transmitters use a GSM (Global System for Mobile Communication) platform, in which the transmitter's location is determined and recorded based on its proximity to cell phone towers. These transmitters are smaller and less expensive than transmitters that transmit signals to satellites (i.e., we purchased three GSM transmitters with data plans for the cost of one satellite transmitter and data plan), and because there are many cell phone towers throughout the study area, we expected GSM transmitters to be very effective for tracking space use by bald eagles. Transmitter data service provides up to one location every 2 hours during the night, every 15 minutes during the day when the eagle is not moving, and every 7 seconds when the eagle is flying.

We partnered with a consultant with extensive experience to lead our efforts to trap and mark eagles. Capture and marking methods were reviewed and approved by the CPW Institutional Animal Care and Use Committee. We attempted to capture one member of a pair of eagles at active nest sites, using baited, padded leg-hold traps adjusted for safe eagle capture (Bloom et al. 2007); trap sets were under constant observation and field personnel immediately retrieved captured eagles. Each captured bald eagle was weighed and carefully inspected to assess its overall health, and only eagles in good physical condition (i.e., no injuries, good feather condition, non-protruding keel, weight >3.75 kg) were marked. We marked each captured eagle with a standard U.S. Geological Survey rivet leg band and a GSM transmitter using a break-away backpack style X-harness constructed of Teflon ribbon straps (total weight of the transmitter and harness approximately 70 g: < 2% body mass of an adult male). The harness we used typically breaks down and the transmitter drops off within several years after marking.

RESULTS

Land Use Around Eagle Nests

Only one bald eagle nest site record was available in the study area for 1980, with an urban index of 0% within 20 km^2 of the nest. During 1990 (4 nest sites), 2000 (32 nest sites), 2010 (113 nest sites), and 2020 (197 nest sites), an increasing number of nests had a higher proportion of residential and commercial/industrial development (urban index) within 20 km^2 (Fig. 1). In 2020, the urban index ranged from 0 – 1.0, with an average of 0.4, suggesting that bald eagle

nests in the northern Front Range study area were subject to a broad range of anthropogenic impacts.

Nest Monitoring

We note that the following results are preliminary and final data checks are still being conducted. In 2020, 138 known bald eagle nests were checked and monitored in the study area counties. Of these, 27 nests (19.6%) were determined to have been destroyed prior to the 2020 nesting season, and an additional 16 nests (11.6%) were unoccupied during 2020. Of the 95 nests that were occupied in 2020, 20 nesting efforts failed to hatch any nestlings (21%), including four nests that were destroyed during the nesting season. A total of 75 nests produced 150 nestlings, and 72 nests produced 138 fledged young.

Capture and Marking Eagles With Transmitters

We ordered the transmitters in March and they were originally targeted for delivery by late May, because we wanted to capture adult eagles in nesting pairs that were still feeding young in the nest. However, due to supply chain problems and a slow-down in work schedules due primarily to coronavirus restrictions, the vendor was not able to ship the transmitters until the end of June 2020. After testing the transmitters and preparing harnesses used to attach them to eagles, we were prepared to attempt to capture eagles on July 10. Because of the delays in getting the transmitters, there were only a few remaining active nests with young that had not fledged.

We successfully captured and marked an adult female from a successful nest with two nearly-fledged young in Larimer County on July 13 (Fig. 2). We have been tracking her movements since then, and have visually observed the marked eagle, as well as her mate and (now fledged) young several times, and have confirmed that the eagle appears to be doing well and the transmitter is working properly. Over the approximately three months since marking, the eagle has used a core area of about 393.4 km^2, which includes several water bodies and a mix of rural, exurban, suburban, and urban development (Fig. 3). The eagle left this core area on September 14 and traveled 447.6 km to southeastern Wyoming, then returned to the core area three days later (Fig 3). Within the core area, the eagle has moved an average of 105 km per day (24-hr period); the shortest daily movement was 1.8 km (August 18), and the longest daily movement was 344.8 km (September 12).

We made several additional attempts to capture eagles from pairs using other nests through the end of August, but we were not successful. Following the nesting season, we successfully trapped a female eagle near at a nest in Weld County on 18 October. This eagle left the study area and moved to southern Colorado several days after marking; we will continue to monitor her to determine if she returns to the study area for the 2021 nesting season.

DISCUSSION

Despite some challenges, the first field season of the study was fairly successful. This fall we will further analyze GIS layers to quantify historical and current land use around each of the known bald eagle nests in the study area. We will continue to annually monitor nesting activity and land use patterns at all known nests through the 2024 nesting season. We will continue to monitor the two eagles we have successfully captured and marked. In addition, we will attempt to capture and mark additional eagles throughout the fall. However, we will primarily target

future nesting seasons to capture and mark eagles. CPW is purchasing 20 more transmitters this fall, and we will attempt to use them to mark eagles during the 2021 and 2022 nesting seasons. Data on marked eagles will be collected at least through 2024. We will analyze data and prepare reports and manuscripts for publication in 2025.

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Figure 1. Distribution of the mean urban index (the sum of the proportional area of exurban, suburban, and urban residential development, and commercial/industrial development) within 20 km^2 around bald eagle nests each decade, 1990-2020, in northcentral Colorado.

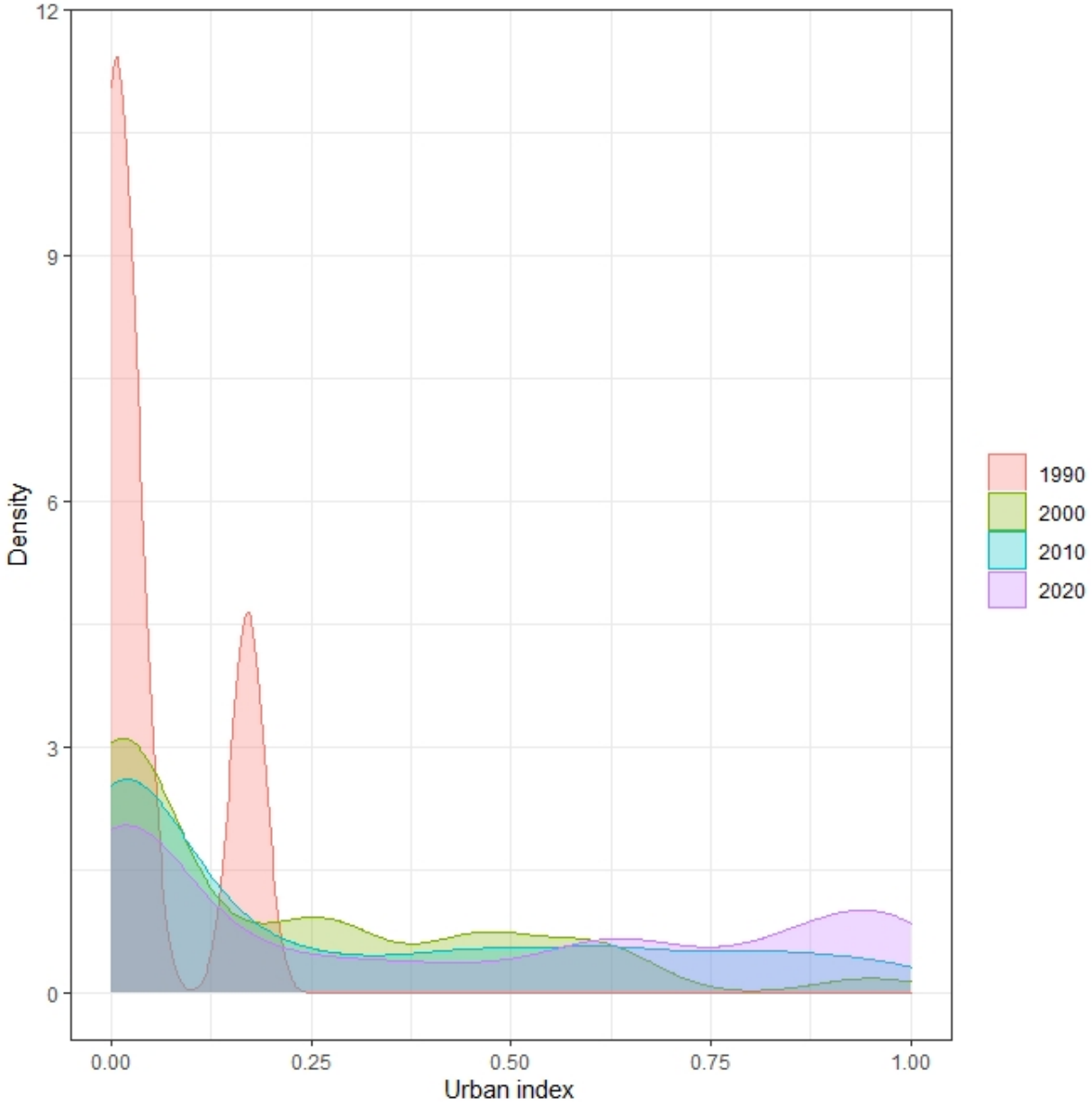
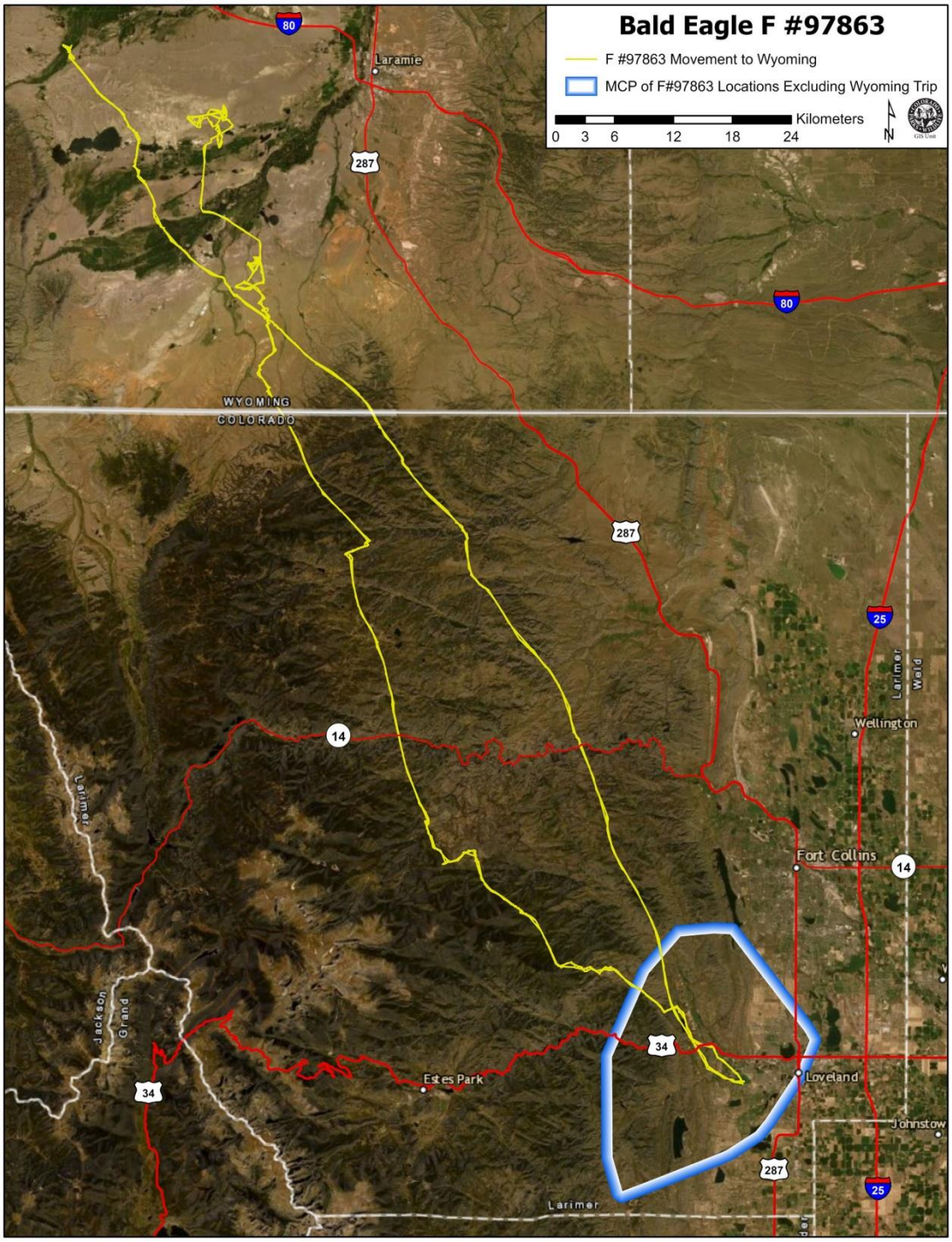


Figure 2. Bald eagle captured and marked with a leg band (above) and backpack transmitter (below) during the 2020 nesting season in Larimer County, Colorado. Photo credits: Miranda Middleton.

Figure 3. Minimum convex polygon (MCP) area used during July 10 to October 20, 2020, by an adult female bald eagle captured and marked with a transmitter in Larimer County. A brief trip to Wyoming is marked in yellow, but was not included in the MCP area.



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