CONSERVATION PLAN FOR GOLDEN EAGLES IN EASTERN NORTH AMERICA

A product of the
Eastern Golden Eagle Working Gro
Photo courtesy of Randy Flament

Todd E. Katzner[a], Tricia Miller[b], Andrew J. Dennhardt[c], Maxwell Field[d], Thomas Wittig[e], Elizabeth Mojica[f], Michael Lanzone[g], Mark Martell[h], Richard Bailey[i], Andrew Berry[j], Renee Dillard[d], David Brandes[k], David F. Brinker[l], Bracken Brown[m], Erynn Call[n], Jeffrey L. Cooper[o], Adam E. Duerr[b], Christopher J. Farmer[p], Shilo K. Felton[q], Julie Garvin[r], Rolf Gubler[s], Sergio Harding[o], Michael Jones[t], Christine Kelly[u], Hardy Kern[v], Netawn Kiogima[d], Craig Koppie[w], Jérôme Lemaître[x], Mercedes Maddox[y], Scott Mehus[z], Joel Merriman[aa], Amy Mitchell[bb], Bill Parsons[d], Evan Patrick[j], Nora Pennarola[cc], Margaret Rheude[cc], Casey Rucker[i], Scott Rush[dd], Ryan Schmitz[ee], Hank Seltzer[ff], Vincent A. Slabe[b], Eric Soehren[y], Johnny Wills[gg]

[a] U.S. Geological Survey, Boise, ID, U.S.A.
[b] Conservation Science Global, Cape May, NJ, U.S.A.
[c] U.S. Fish and Wildlife Service, Ventura, CA, U.S.A.
[d] Little Traverse Bay Bands of Odawa Indians, Harbor Springs, MI, U.S.A.
[e] U.S. Fish and Wildlife Service, Falls Church, VA, U.S.A.
[f] EDM International, Ft. Collins, CO, U.S.A.
[g] Cellular Tracking Technologies, Cape May, NJ, U.S.A.
[h] TetraTech Inc., Minneapolis, MN, U.S.A.
[i] West Virginia Division of Natural Resources, Elkins, WV, U.S.A.
[j] Bernheim Arboretum and Research Forest, Clermont, KY, U.S.A.
[k] Lafayette College, Easton, PA, U.S.A.
[l] Maryland Department of Natural Resources, Annapolis, MD, U.S.A.
[m] Hawk Mountain Sanctuary Association, Orwigsburg, PA, U.S.A.
[n] Maine Department of Inland Fisheries and Wildlife, ME, U.S.A.
[o] Virginia Department of Wildlife Resources, VA, U.S.A.
[p] Orsted Americas, Newark, NJ, U.S.A
[q] Renewable Energy Wildlife Institute, Washington, D.C., U.S.A.
[r] NextEra Energy Resources, OR, U.S.A.
[s] Shenandoah National Park, Luray, VA, U.S.A.
[t] American Eagle Foundation, Kodak, TN, U.S.A.
[u] North Carolina Wildlife Resources Commission, Asheville, NC, U.S.A.
[v] American Bird Conservancy, Columbus, OH, U.S.A.
[w] U.S. Fish and Wildlife Service, Annapolis, MD, U.S.A.
[x] Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, Québec City, Québec, Canada
[y] Alabama Department of Conservation and Natural Resources, Montgomery, AL, U.S.A.
[z] National Eagle Center, Wabasha, MN, U.S.A.
[aa] Avian Consulting Services, Washington, DC, U.S.A.
[bb] Birmingham Zoo, Birmingham, AL, U.S.A.
[cc] U.S. Fish and Wildlife Service, Bloomington, MN, U.S.A.
[dd] Mississippi State University, Mississippi State, MS, U.S.A.
[ee] Eagle Valley Nature Preserve, Glen Haven, WI, U.S.A.
[ff] Apex Clean Energy, Charlottesville, VA, U.S.A.
[gg] U.S. Forest Service, Nantahala National Forest, NC, U.S.A.

Suggested citation:

Katzner, T.E., T. Miller, A.J. Dennhardt, M. Field, T. Wittig, E. Mojica, M. Lanzone, M. Martell, R. Bailey, A. Berry, R. Dillard, D. Brandes, D.F. Brinker, B. Brown, E. Call, J.L. Cooper, A.E. Duerr, C.J. Farmer, S.K. Felton, J. Garvin, R. Gubler, S. Harding, M. Jones, C. Kelly, H. Kern, N. Kiogima, C. Koppie, J. Lemaître, M. Maddox, S. Mehus, J. Merriman, A. Mitchell, B. Parsons, N. Pennarola, M. Rheude, C. Rucker, S. Rush, R. Schmitz, H. Seltzer, V.A. Slabe, E. Soehren, J. Wills. 2023. Conservation plan for golden eagles in eastern North America. Eastern Golden Eagle Working Group. 81pp. https://egewg.org/conservation-plan

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Golden Eagles are one of eastern North America's apex predators and are of conservation concern range-wide. Nevertheless, the eastern population of this species has only recently been given recognition and study typical of such ecologically important taxa. Because of recent work, there now is a sufficient body of knowledge for the conservation planning outlined here. This document is a product of the Eastern Golden Eagle Working Group, an international collaborative effort among scientists and managers from across eastern North America and beyond who strive to ensure the long-term sustainability of the Eastern Golden Eagle population. Beyond providing background, this plan's purpose is to identify research and management needs and provide a foundation for future conservation planning and action to benefit the Eastern Golden Eagle population.

In eastern North America, Golden Eagles breed across every Canadian province except the island of Newfoundland; it is thought that the species no longer nests in the eastern U.S.A. Migration of these eagles follows leading lines (the Appalachian Mountains, shorelines of the Great Lakes, river systems, and the Atlantic coastline). Eastern Golden Eagles overwinter in nearly every eastern state, although numbers are thought to be greatest in the central Appalachian Mountains from North Carolina to Pennsylvania. During summer, these birds feed on a wide variety of prey; during winter their diet is tied to locally abundant species — carrion from deer, Wild Turkeys, and opportunistically other vertebrates.

Eastern Golden Eagles, although once overlooked in regional management plans, now have special conservation status in most states and provinces where they are found. Best estimates suggest that there are > 5,000 birds in this apparently stable population. That said, population size has only been robustly estimated for breeders in Québec and migratory birds in Pennsylvania; numbers of birds that migrate through the Great Lakes are not well estimated.

There is substantial cultural significance assigned to Golden Eagles, both globally and in eastern North America. For example, the Anishinabek, Native Americans of the Great Lakes region, have Golden Eagle ("Ginew Dodem") clan members. From the perspective of these groups, conserving eagles is important to honor their place in Native American culture.

In eastern North America, Golden Eagles are managed under laws and regulations promulgated by the U.S. Government, by individual U.S. states, and by Canadian provinces. Despite these protections, Eastern Golden Eagles face a number of anthropogenic threats including illegal shooting, collision with vehicles and infrastructure, poisoning, inadvertent trapping, effects from energy development, electrocution, disturbance, habitat alteration, and climate change. They also encounter natural threats tied to prey abundance, carrying capacity, weather, and disease. Finally, there are knowledge gaps concerning these threats and their impacts to Eastern Golden Eagles; this plan identifies research priorities to close those gaps.

This conservation plan identifies four key conservation objectives:

(1) maintain or increase breeding population size;
(2) protect habitat in breeding, migration, and wintering areas;
(3) maintain or develop long-term monitoring programs for the population; and
(4) reduce threats and anthropogenic causes of mortality.

The Eastern Golden Eagle Working Group seeks to work with other stakeholders to implement the actions outlined here to promote the conservation of this iconic species.

INTRODUCTION & BACKGROUND

Golden Eagles are of conservation concern in North America (USFWS 2016a). The species is enigmatic and emblematic of broad conservation value (Sergio et al. 2005). However, individual eagles face a large number of threats and there is compelling evidence that Golden Eagle populations in North America are at best stable, may be declining, and are being held beneath carrying capacity (USFWS 2016a; Millsap et al. 2022). That said, the Golden Eagle population across North America is composed of several distinct subgroups (Doyle et al. 2016), each of which exhibits different behaviors and faces different constraints and threats.

Golden Eagles in the heavily forested Allegheny Mountains of north central Pennsylvania at a site being monitored by trail cameras to document wintering populations. Randy Flament

Given the conservation concerns about Golden Eagles in North America, there is interest in developing management proposals for the species. These are often achieved via species-specific conservation plans. However, because of the distinct structure of Golden Eagle populations, there is value in developing specific conservation plans for each subgroup, rather than for the continental population as a whole. Accordingly, we have developed a conservation plan specific to Golden Eagles in eastern North America.

The target audience for this plan is conservation professionals, including management or research biologists, whether state, federal, provincial, tribal, NGO, or academic. Although specific cost projections for some of the proposed actions eventually will be necessary, they are not included here; this document is not a conservation business plan and its intent is not to specifically target fundraising professionals or budget managers. Likewise, although some conservation plans include a communications strategy for production of educational materials and outreach to the general public, such a strategy is not a part of this plan..

Our purpose in developing this conservation plan is twofold. First, we aim for this document to become an authoritative source for information specific to Golden Eagles in eastern North America. Second, we aim for this plan to identify research and management needs and provide a foundation for future conservation action to benefit Golden Eagle populations in eastern North America.

We have divided this plan into sections whose goals are to:

a. Identify and define what is an “Eastern Golden Eagle.”
b. Review the conservation status of the Eastern Golden Eagle population.
c. Highlight the cultural significance of Eastern Golden Eagles.
d. Describe management and legal responsibilities for the Eastern Golden Eagle.
e. Identify current threats to this population.
f. Characterize gaps in knowledge about Eastern Golden Eagles.
g. Propose conservation objectives and management actions to benefit Eastern Golden Eagles.

This conservation plan is a collaborative effort of the Eastern Golden Eagle Working Group (EGEWG) The group's objectives include collaboratively: (1) identifying gaps in knowledge and management about Eastern Golden Eagles; (2) prioritizing species-specific research needs for this geographic region; (3) promoting science-based conservation and management actions; (4) increasing public and governmental awareness about Eastern Golden Eagles, their biology and conservation status, and the need for their protection across their range; and (5) coordinating the activities of managers and biologists working with Eastern Golden Eagles.

Eastern Golden Eagle Working Group meeting in Maine, 2015. Unknown photographer

GENERAL SPECIES OVERVIEW

Species And Population Description

The Golden Eagle (*Aquila chrysaetos*) is a large, dark eagle with distinct juvenile and adult plumages (Bloom and Clark 2001; Liguori et al. 2020). Young birds are chocolate brown with golden heads and variably sized white patches on the underwings and tails. Adults also have golden heads but, because they have multiple ages of feathers, they have a more mottled appearance with varying shades of brown across the body, wings, and tail. Adults usually lack white on the underwings and tails. Sub-adult plumage is an intergrade between juvenile and adult plumage; individuals gradually develop adult-like plumage as they get older. In general, white in the wing and tail decreases over time as juvenile and sub-adult feathers are replaced by adult feathers, but some older birds have white and some younger birds have no white. Adult plumage is reached at about 5-6 years of age. Juvenile Bald Eagles (*Haliaeetus leucocephalus*), because of their brown plumage, are often mistaken for Golden Eagles. However, Bald Eagles have much larger bills than Golden Eagles and lack feathers on their legs, or tarsi. Feathered tarsi are a diagnostic feature of *Aquila* eagles.

Golden Eagle plumage transitions from the time they leave the nest until they reach maturity after 5 – 6 years, making it possible to age individual birds. Michael Lanzone

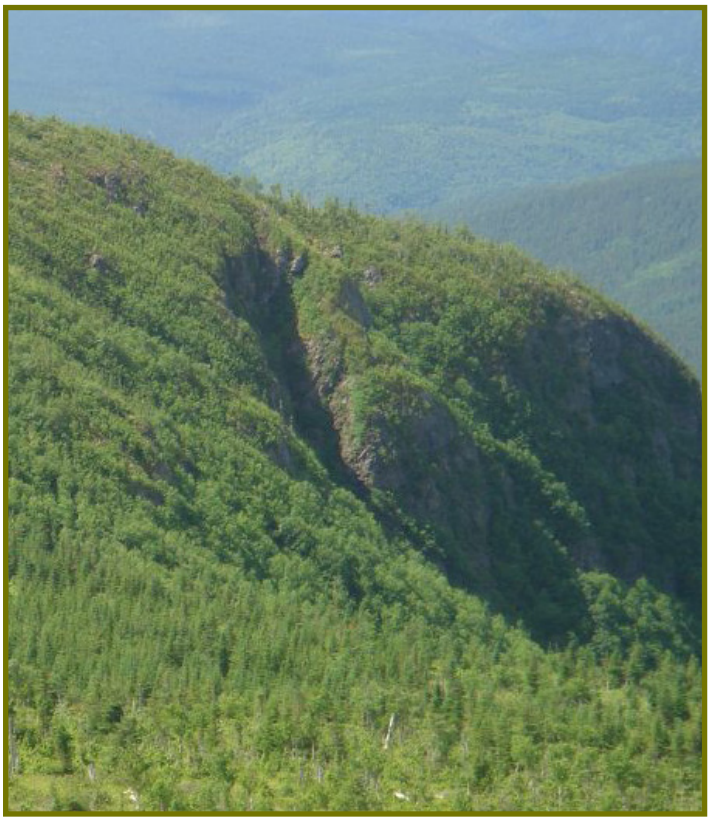
The Golden Eagle has a Holarctic distribution and six described subspecies, one of which occurs in North America (*A. c. candensis*; Orta 1992; Snow et al. 1998; Watson 2010). Within North America, the species is partially migratory; a generally sedentary population occupies the western US, Mexico, and southern Canada, but birds that summer north of approximately 55–60°N latitude tend to be migratory. Most of the western migratory population (i.e., birds that breed west of Manitoba) spend the winter from the Great Plains westward (approximately the 100th Meridian). The eastern population of Golden Eagles spends the summer in Canada from Manitoba east to Labrador and winters east of the Great Plains, in southern Canada and throughout the eastern U.S.A., from Minnesota and Maine to Louisiana and Florida (Katzner et al. 2012a; Miller et al. 2017). The eastern population is genetically distinct from western populations (Doyle et al. 2016). For the purposes of this report and for conservation management, we define an "Eastern Golden Eagle" as a member of the species that breeds or is hatched in a region that extends from Manitoba eastward to Labrador and spends the winter east of the Great Plains and the 100th Meridian.

Taxonomy

Taxonomy of Golden Eagles is reviewed in detail elsewhere (Katzner et al. 2020). Briefly, most recent genetic analyses suggest that there are 5 clades and 11 species within the genus *Aquila*. Of these, approximately 8 species in two clades are fairly closely related to Golden Eagles. Within its eastern North American range, there are no close relatives within the genus.

Distribution and Habitat

Breeding: Summer ranges of Eastern Golden Eagles are typically located in tundra north of 60°N, forested areas south of 55°N, and shrublands or grasslands at intermediate latitudes (Figure 1; Miller et al. 2017). Eastern Golden Eagles are found in the Atlantic and Mississippi Flyways (USFWS 2016a); some of the birds that winter in the Mississippi Flyway subsequently summer in the Central Flyway. Golden Eagles in Labrador, Ontario, and Québec select tundra, wet meadows, and forests for breeding territories (Katzner et al. 2012a; Morneau et al. 2015). From June to September Golden Eagles are observed in the eastern U.S.A. only rarely, typically in historical nesting sites in the northeast.



Nesting and foraging habitat for Eastern Golden Eagles in Québec. Andrew Dennhardt

Migration: Migration is strongly associated with landscapes that provide thermals or updrafts generated by topography (Figure 1; Katzner et al. 2020). This is especially true in the Appalachian Ridge and Valley, the Allegheny Plateau, and the Adirondack region (Katzner et al. 2012a). Migration in the Driftless Area (an unglaciated region of the upper Midwestern U.S.A.) also takes advantage of the valleys and bluffs that generate orographic updrafts (Wingfield 1991). Migration occurs throughout all states and provinces of the Atlantic and Mississippi Flyways, although migrating birds are more commonly observed farther north and infrequently in the extreme southeastern U.S. states (e.g., Florida, Louisiana).

Winter: During winter, Eastern Golden Eagles can be found in both the Atlantic and Mississippi Flyways, all eastern U.S. states, and most eastern Canadian provinces, with the possible exception of Nunavut and Newfoundland and Labrador (Figure 1; Figure 2). In Canada, the winter distribution of Eastern Golden Eagles is likely restricted largely to the southern third of Ontario and Québec, and there are many records of the species scavenging on baited camera sites in these regions (G. McMillan, unpublished data). In the U.S.A., Eastern Golden Eagles are more commonly seen in central Appalachian states (New York, Pennsylvania, Maryland, West Virginia, Virginia, and North Carolina) and less commonly seen in southern states (Alabama, Georgia, South Carolina, and Florida), especially in regions past the southern terminus of the

Appalachians. Numbers in states farther west are not well known, although recent camera trap data suggest that the Ozark Highlands Ecoregion may support more Golden Eagles than previously known (USFWS and T. Miller, unpublished data).

During winter, Eastern Golden Eagles use many different habitat components, but appear most abundant in large forested blocks with moderate to high topographic relief, as occurs in rugged areas of the Appalachian Mountains, including the Blue Ridge Mountains and the Great Smoky Mountains (Miller et al. 2017; McCabe et al. 2021). In the coastal plain of the eastern U.S.A., Eastern Golden Eagles are typically found in marshes (Millsap and Vana 1984), but also use large blocks of forest such as the Pine Barrens in New Jersey (T. A. Miller and M. J. Lanzone, unpublished data; Warner et al. 2022) and dense stands of loblolly pine in the Delmarva Peninsula (C. Koppie, unpublished data). Off-road trails and utility corridors within forest blocks are utilized by Eastern Golden Eagles. In the Midwest, these eagles are often associated with wildlife refuges or water bodies that concentrate wintering waterfowl. In addition, the bluff prairies and open valleys of the Driftless Region provide winter foraging opportunities for the species.

While the Golden Eagle has a global reputation for frequenting open lands, tracking data are consistent with abundance trends noted above, and tracked Eastern Golden Eagles frequently utilize large forest tracts (Miller et al. 2017; Duerr et al. 2019a). Preliminary analysis of tracking data held by the EGEWG shows that tracked birds in West Virginia and Kentucky highlands used forest 74% of the time. In Kentucky, 84% of GPS locations for 20 Golden Eagles were within large forest blocks, with 59% of those points in forest tracts greater than 4,047 ha (10,000 ac; forest tracts as defined in Evans and Abernathy 2009).

Use of Protected Lands

Some of the large forest tracts used by Eastern Golden Eagles are protected by state, provincial, or federal U.S. or Canadian governments, or by private landowners. Tracking data held by the EGEWG suggest that Golden Eagles used protected areas during winter and migration, with 29.3% of GPS locations from tracked eagles occurring within the protected areas as defined by the Protected Areas Database of the United States (PAD-US; Prior-Magee et al. 2020). Similar analyses have not been conducted for use of protected areas during summer.

Nesting

Eastern Golden Eagles currently nest only in Canada; historically used breeding territories in the U.S.A. are not known to be occupied at present. Nests are made of sticks, vegetation, and even animal bones (Katzner et al. 2012a). Generally, a Golden Eagle breeding territory contains multiple nests and pairs may shift from one nest to another in subsequent breeding seasons. Nest site use varies between eastern and western Golden Eagle populations; Eastern Golden Eagles typically nest on cliff sites but occasionally on trees in Québec; western Golden Eagles nest on cliffs, in trees, on the ground, or

Once nesting throughout New England, Golden Eagles now breed only in Canada, although historic territories in northern New England are regularly visited by non-breeders. Mick Thompson

on anthropogenic structures (Menkens and Anderson 1987; Steenhof et al. 1993; Katzner et al. 2020). Historical nest sites in the eastern U.S.A. occurred throughout New England and New York, on cliff faces or trees. There is evidence that birds introduced to the southern Appalachians (Wheeler 2014) may have produced occasional young (T. Katzner unpublished data).

Diet

Golden Eagles are opportunistic predators and in eastern North America hunt or scavenge a wide variety of birds and mammals. Randy Flament

Golden Eagles are opportunistic predators capable of taking prey up to the size of a small deer (Watson 2010; Kerley and Slaght 2013; Katzner et al. 2020). They hunt from elevated perches or on the wing either low to the ground or high above while soaring, taking most prey on or near the ground. There is comparatively little known about the diet or abundance of prey for Eastern Golden Eagles in breeding and wintering areas. In the western U.S.A., Golden Eagles primarily consume mammals and birds, most commonly rabbits and hares (*F. Leporidae*), ground squirrels (*F. Sciuridae*), and medium-sized birds (Bedrosian et al. 2017). In the eastern population, researchers have documented foraging on ungulates, Great Blue Heron (*Ardea herodias*), Canada Goose (*Branta canandensis*), Wild Turkey (*Meleagris gallopavo*), woodchuck (*Marmota monax*), snowshoe hare (*Lepus americanus*), red fox (*Vulpes vulpes*), and other similarly sized mammals (Todd 1989; Brodeur and Morneau 1999; Miller et al. 2017; Anctil et al. 2019). In eastern North America, Wild Turkey and white-tailed deer (*Odocoileus virginianus*) have increased in number in the past 50–100 years (Rooney 2001, Londe et al. 2023). It is notable that these increases have correlated with increasing numbers of Eastern Golden Eagles counted at migration hawk watch sites in the region. In addition to hunting live prey, Golden Eagles also scavenge at all times of the year.

Breeding: There is limited information on breeding season prey resources for Eastern Golden Eagles. It is thought that breeding Eastern Golden Eagles feed on a variety of prey, including corvids, lagomorphs, ptarmigans, and waterfowl (Watson 2010; Katzner et al. 2020). Historical information suggests that birds, especially waterfowl and wading birds, may be taken by Eastern Golden Eagles with greater frequency than is observed by Golden Eagles in western North America (Todd 2000; Katzner et al. 2012a). Remains of corvids and caribou have been found in nests in Québec (J. Lemaître and C. Maissoneuve, personal communication). Scavenging is thought to be less common during the breeding season than during other seasons.

Nonbreeding: In the non-breeding season, Eastern Golden Eagles take live prey and scavenge carcasses, especially those of white-tailed deer, but also of livestock and feral hogs. There are numerous reports of Eastern Golden Eagles hunting Wild Turkey. A pellet found beneath the roost of a telemetered bird in Alabama contained Wild Turkey toes (T. A. Miller and M. J. Lanzone, unpublished data); a young eagle in the coastal plain was observed killing a Wild Turkey (C. Koppie, unpublished data); and there are videos available online showing Eastern Golden Eagles attacking turkeys (e.g., https://www.youtube.com/watch?v=H6ElFmm8_h8). In coastal areas and marshes, Canada Geese and other waterfowl may be important prey resources in winter (C. Koppie, unpublished data).

Breeding Season Behavior

Breeders (typically adults, occasionally older subadults) arrive on the breeding grounds from March to April. Non-breeding sub-adults (birds > 1 to <5 years old) typically arrive at breeding latitudes in late April or May and juveniles (birds < 1 year old) typically arrive during May and June (Miller et al. 2017). The breeding season typically occurs from April to October. Eggs are laid in April or May, hatching occurs in June and fledging in July and August. The post-fledging dependence period extends from fledging likely almost until migration begins.

Adults maintain breeding territories and home ranges that vary in size depending on prey availability, topography, vegetation, and prior breeding success. Miller et al. (2017) reports home ranges varying from 37 to 14,625 km^2. Pre-adult Eastern Golden Eagles tend to roam widely during the breeding season, typically with larger home ranges than adults (range: 68 – 110,446 km^2).

Migration Behavior

Tracking of Golden Eagles with GPS telemetry has led to important insights about migratory behavior, including phenology, flight behavior, routes taken, speed of migration, and determinants of departure and distance traveled. Paul Fusco

The population of Eastern Golden Eagles is predominantly migratory. However, some individuals that occupy lower latitudes, especially south of the Gulf of St. Lawrence, may not migrate every year (as verified by GPS telemetry; J. Lemaître, unpublished data; Maynard et al. 2022). Migratory behavior is influenced by a suite of factors including age, time of year, and weather (Duerr et al. 2015; Miller et al. 2016; Rus et al. 2017). Adults tend to spend less time migrating, especially during spring when they appear time limited (i.e., apparently wishing to arrive on breeding grounds after food becomes available but before competitors who may usurp their territory). In contrast, juveniles and sub-adults are energy-limited during both spring and autumn and, as such, spend more time migrating by increasing the length of stopovers and by exploring en route.

Spring migration occurs from late February to June (Miller et al. 2016; 2017). Movements tend to be staggered by age class with adults initiating migration first, followed by sub-adults, and then juveniles (Miller et al. 2016). In spring, adults tend to migrate when thermal updrafts are weaker and, therefore, they rely more on orographic updrafts (Duerr et al. 2012; 2015; Pirotta et al. 2018). This behavior concentrates early spring migrants along ridges, especially in the Appalachian Mountains. Spring migration is also concentrated along southern shores of the Great Lakes and the Gulf of St. Lawrence (Kerlinger 1989). In regions without shorelines and with less topographic relief, migration is not as concentrated spatially. In these regions, Eastern Golden Eagles appear to follow forested corridors, especially in the Midwest, and river corridors in Canada. Younger birds (pre-adults) migrate later in the season when thermals are more abundant and they use orographic updraft comparatively less (Miller et al. 2016; Rus et al. 2017).

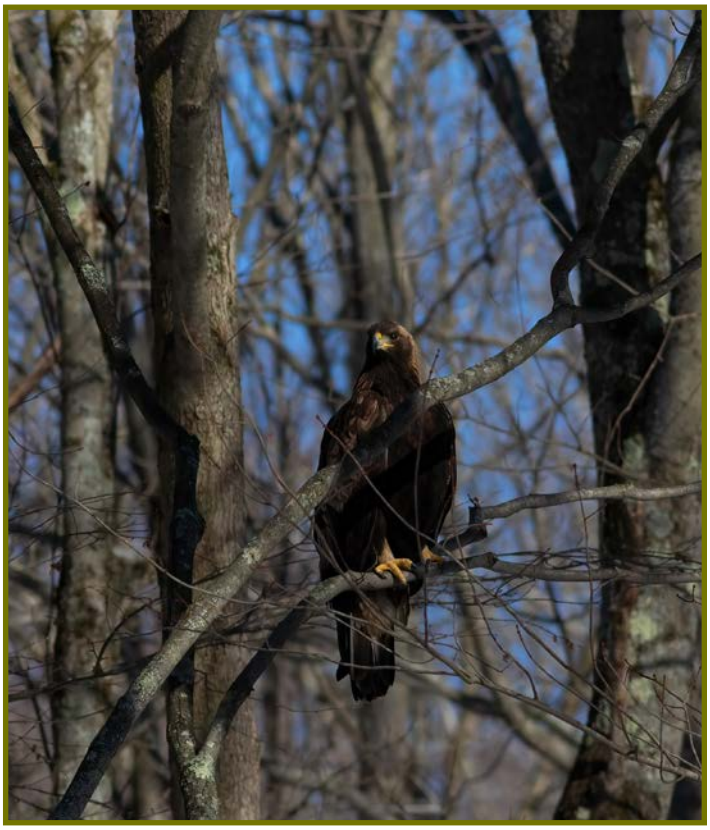
Fall migration occurs from September to January, with the highest numbers observed at hawk watches from late October to late November (Miller et al. 2016; 2017). Fall migrants are heavily concentrated along ridgelines where the birds utilize orographic updrafts; thermal updrafts are

weaker and less available at this time of year (Pirotta et al. 2018). Migration is also concentrated along northern shorelines of the Great Lakes and the Gulf of St. Lawrence as well as along the western shore of Lake Superior.

In one study, the total distance flown during migration by tracked Eastern Golden Eagles of all age classes ranged from 960 to 4,910 km and the straight-line distance between breeding and wintering areas ranged from 861 to 2,680 km (Miller et al. 2016). While actively migrating, Eastern Golden Eagles traveled at an average rate of 95 ± 15 km per day during fall and 132 ± 24 km per day during spring. Throughout the entire migratory period, including stopover days, eagles traveled at an average of 60 ± 18 km per day throughout fall migration and 103 ± 30 km per day throughout spring migration. The maximum distance traveled in one day was 528 km (Rus et al. 2017).

Winter Behavior

Eastern Golden Eagles arrive on their wintering grounds from October to January, with most birds arriving in November and December (Miller et al. 2017). In contrast to pre-breeding season migration, there is no age-related correlation in arrival date. During winter, birds are typically found in heavily forested areas, but sometimes also they occupy both coastal and interior marshes, presumably where waterfowl are concentrated. Winter home ranges of tracked birds range from 44 to 27,970 km^2 and tend to be mostly forested with small amounts of open areas. Older sub-adults (~3-4 years old) and adults (>4 years old) tend to have high winter site fidelity whereas young birds may shift their wintering areas northward. When individuals find carrion, they may roost near the carrion for several days (T. A. Miller and T. E. Katzner, unpublished data).



Golden Eagle perched in leafless deciduous forest habitat. Although typically thought of as a bird of open habitats, Eastern Golden Eagles prefer heavy forest cover in winter. January, Pennsylvania. © David Brandes

Interspecific Interactions

Bald Eagles are kleptoparasites who often steal prey from other species, including Golden Eagles. For example, a Golden Eagle was observed killing a Canada Goose in Maryland; a pair of adult Bald Eagles pursued the Golden Eagle and stole its prey (K. Smith and K. Smith, unpublished data). Bald Eagles are fierce defenders of their territories and will attack intruding raptors, including Golden Eagles. In one case, a Bald Eagle was observed driving a juvenile Golden Eagle into the water as it was migrating over Braddock Bay, New York (NYDEC, personal communication).

Bald and Golden Eagles have been recorded together at camera traps in the eastern U.S.A. It is unclear whether one species always is dominant over the other or whether dominance patterns are specific to individuals. However, when large numbers of Bald Eagles find a carcass, Eastern Golden Eagles tend not to be documented, suggesting that they may avoid large groups of Bald Eagles (T. A. Miller, T. E. Katzner, and M. J. Lanzone, unpublished data). Nevertheless, Eastern Golden Eagles

have been observed at communal roosts with Bald Eagles in the western U.S.A. and Maryland (Edwards 1969; L. Mojica, personal communication) and may roost communally in other eastern states as well.

Because Golden Eagles are predators of corvids (in the eastern U.S.A., mostly Common Ravens, *Corvus corax*, and American Crows, *Corvus brachyrhynchos*), corvids will harass them by chasing flying eagles or diving on perched eagles. At deer carcasses in the eastern U.S.A., both Common Ravens and American Crows react to the presence of Golden Eagles with specific calls (M. J. Lanzone and T. A. Miller, unpublished data). Anecdotal observations suggest that Common Ravens appear less likely to land on the ground when a Golden Eagle is perched in a nearby tree (M.J. Lanzone, T.A. Miller personal observations).

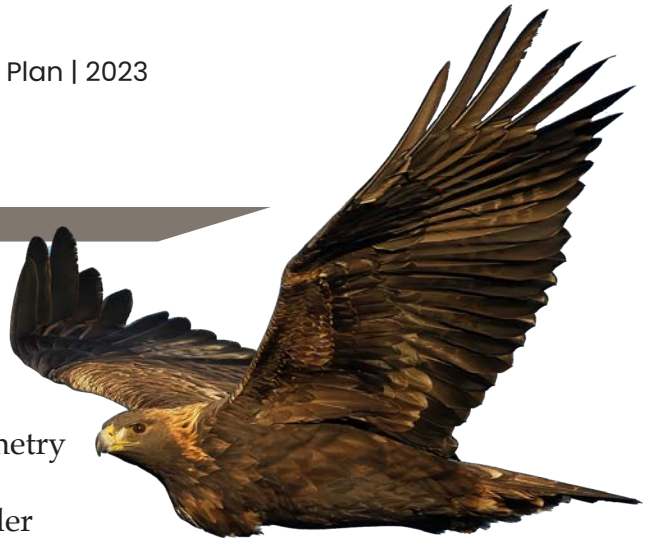
Summary Of Past Research Activities

Golden Eagle being fitted with cellular transmitter by Mike Lanzone from Cellular Tracking Technologies and Dr. Trish Miller from Conservation Science Global. Randy Flament

Prior to the creation of the EGEWG, there was only sparse research on Eastern Golden Eagles. A comprehensive, chronological bibliography with papers from the 1800s through today is provided in the Appendix. Maurice Broun, the original curator at Hawk Mountain Sanctuary in Kempton, Pennsylvania, reported notable migration of Golden Eagles in the 1930s (Broun 1935) and since then Golden Eagles have been regularly reported as migrants at eastern hawk watches (for details see www.hawkcount.org). Golden Eagle nests in New York and Maine were monitored by state biologists until the 1990s when they were no longer occupied. In one satellite telemetry study conducted in eastern North America (Brodeur et al. 1996), Golden Eagles were captured along the eastern shore of Hudson Bay, Québec. Those birds migrated to the central and southern Appalachian Mountains and the upper Midwestern U.S.A. Likewise, a migration model documented potential drivers of migratory behavior of Eastern Golden Eagles in Pennsylvania (Brandes and Ombalski 2004). The animal movement theory developed in that paper has been widely applied to eagles and other species across the globe.

The formation of the EGEWG in 2010, coincided with, and to some degree spurred, initiation of many studies of Eastern Golden Eagles. The bulk of recent work is based on GPS-tagged individuals, captured both on wintering grounds and in Québec during the breeding season. This work identified predominant migration pathways of Eastern Golden Eagles, distributions across the year, home range sizes and habitat associations for both summer and winter, environmental and individual-based drivers and correlates of migration behavior, roosting and perching behavior, and movement in general. There are also several papers based on camera trapping conducted over bait piles during winter. These studies have led to insight into age structure on wintering grounds, distributional response to climate change, and insight into a host of scavengers beyond eagles. Finally, there are several papers exploring trends in migratory count data and lead exposure of Eastern Golden Eagles. Future work is planned to expand on many of these themes; some of this is covered in subsequent sections of this Conservation Plan.

POPULATION STATUS



Randy Flament

Historical Population Size and Distribution

Historically, little has been known regarding the size and distribution of the Golden Eagle population in eastern North America (Katzner et al. 2012a). Recent evidence based on telemetry data has revealed broad distributions during annual breeding, nonbreeding, and migratory periods (Morneau et al. 2015; Miller et al. 2017;, McCabe et al. 2021). Katzner et al. (2012a) suggested that Eastern Golden Eagles spend summers in Newfoundland and Labrador, Québec, and Ontario, but indicated gaps in our understanding of how eagles are distributed within these areas. More recent research has revealed that birds wintering east of the Mississippi River also may summer in northern areas of New Brunswick, Manitoba, Saskatchewan, Nunavut, and the Northwest Territories (Figure 1; Mehus and Martell 2010; Nelson et al. 2015; Miller et al. 2017; McCabe et al. 2021). Additionally, Eastern Golden Eagles once nested in areas of the northern Appalachian Mountains in the U.S.A., with anecdotal data suggesting a sharp decline in numbers occupying that area over the past century. Known breeding locations in the northeastern U.S.A. have not been occupied since the mid-to-late 1990s (Maine and New York), 1970s (Vermont), 1960s (New Hampshire), or 1880s (Massachusetts; Forbush 1929; Spofford 1971a; b; Todd 2000). More recently, trends in migration counts from 1974 to 2004 suggest an increase in the migratory population based on positive long-term (e.g., 10- and 30-year) trends at two Great Lakes sites (Holiday Beach, Ontario and Hawk Ridge, Minnesota) and two Pennsylvania sites (Hawk Mountain and Waggoner's Gap; Farmer et al. 2008).

Current Population Size and Distribution

There are three classes of indices commonly used to understand the population size and distribution of Eastern Golden Eagles: migration count indices, camera trap (presence-only) indices, and other count or presence-only indices. The latter include Christmas Bird Count and Breeding Bird Survey [counts], eBird [presence], bird banding resights [presence], and aerial nest surveys [counts/ presence] (Sullivan et al. 2009; Smith 2013; Morneau et al. 2015). Some of these data are incorporated into estimates of population size.

> ***Migration count indices***: Migration counts are useful tools in assessing trends in migratory raptor populations (Bednarz et al. 1990; Farmer et al. 2007; Hussell and Ruelas Inzunza 2008), particularly for a species like the Golden Eagle that is sparsely distributed and difficult to survey on breeding territories and during winter. Nevertheless, because of varying observer effort, detectability, and the effects of weather on visible migration, migration counts must be used with caution (Dunn et al. 2008). Counts are typically considered reliable indicators when aggregated over extended periods (≥ 10 years) with relatively constant observer effort and a standardized count methodology. However, recent work suggests that trends in migration counts may also reflect shifting of migratory behavior and patterns in response to climate change or other factors (Viverette et al. 1996; Rosenfield et al. 2011; Van Buskirk 2012; Bolgiano 2013; Paprocki et al. 2014; 2017; Therrien et al. 2017). Such considerations are particularly important for Eastern Golden Eagles, whose migratory behavior is flexible.

Migration count data spanning 16 years (2004–2019), all collected after the period covered by Farmer et al. (2008), are presented here to summarize trends in counts in the northeastern U.S.A. Data considered are from ten sites in eastern North America with consistent count protocols and seasonal Golden Eagle totals averaging at least 50 individuals (Table 1, Figure 3). Most sites only have sufficient data from fall but very few have sufficient data from both fall and spring. Rather than raw counts, we used count indices developed for the Raptor Population Index project that account for annual variation in days and hours of site coverage. Annual indices were downloaded from the Birds Canada NatureCounts website (Birds Canada 2018; see Crewe et al. 2016 for additional details on analyses). The indices were evaluated for a monotonic trend using a nonparametric Mann-Kendall test (Mann 1945; Kendall 1948). Of the ten sites, eight showed no trend in annual count indices. One (Allegheny Front, Pennsylvania) had a statistically significant increasing trend in both spring and fall, while another (Holiday Beach, Ontario) had a statistically significant decreasing trend. Although migration count data do not always reflect population trends, these data suggest that the Eastern Golden Eagle population may have been stable during the period 2004–2019.

Camera trap indices: Camera traps are often used to monitor wildlife, especially those that are difficult to observe directly. The Appalachian Eagle Monitoring Program (Jachowski et al. 2015) established a protocol to standardize collection of data from camera-trap sites, with the goal of better understanding the distribution of Eastern Golden Eagles throughout the Appalachian Mountain region. We used data collected at camera-trap sites that operated at least once during January and February from 2008 to 2013 to describe the relative densities of wintering Golden Eagles in the eastern U.S.A. (Jachowski et al. 2015). Jachowski et al. (2015) summarized data from photographs to show the maximum number of eagles (one to four) that occurred in a single photograph by day, thus giving a minimum number of Eastern Golden Eagles that were known to use the site by day. We averaged these minimum counts to obtain an index of Eastern Golden Eagle use at camera traps.

A Golden Eagle in West Virginia at a site being monitored by trail cameras to document wintering populations. Chuck Waggy, Eastern Golden Eagle Working Group

There were 172 camera-trap sites operated between 2 and 59 days per year during January and February from 2008 to 2013. Eastern Golden Eagles were recorded at 105 of these sites, with an average minimum count of 0.65 Golden Eagles per day (range 0.03 to 2.0). Wintering Golden Eagles were recorded from Maine to Arkansas, with the highest indices occurring along the Appalachian Mountains in West Virginia and Virginia (Figure 4). They also were recorded at camera traps located in southeastern Minnesota and southwestern Wisconsin (Mehus and Martell 2010), along the Appalachian Mountains of western North Carolina (Kelly and Tomcho 2017), and at the U.S. Department of Energy Savannah River Site within the coastal plain of South Carolina (Vukovich et al. 2015). Independent predictions of resource selection by Eastern Golden Eagles that was based on animal tracking data correspond well to the spatiotemporal distribution with which they were detected at camera-trap sites (Figure 5; McCabe et al. 2021).

Other count and presence-only indices: Other indices of population status include count or presence-only indices collected during the breeding or non-breeding season for Eastern Golden Eagles. For example, trained citizen scientists and sometimes state and federal contractors encounter Golden Eagles during systematic monitoring programs held annually across North America in winter (Christmas Bird Count; NAS 2020) and summer (Breeding Bird Survey; Pardieck et al. 2020). However, these monitoring programs rarely record Eastern Golden Eagles. This result likely is due to known spatial biases in sampling (e.g., Breeding Bird Survey observations occur at roadside locations often far from areas inhabited by secretive species). Similarly, bird banding resights and aerial nest surveys rarely record Eastern Golden Eagles, except during targeted nest surveys on a portion of their summer breeding grounds (Morneau et al. 2015). eBird is a database of bird observations to which birdwatchers and others contribute. The quality of eBird records is variable, however, since user checklists are often recorded opportunistically in space and time, and untrained users may record numerous false-positive and false-negative detections during surveys (Sullivan et al. 2009; Horns et al. 2018). This drawback is especially true for eagles, as immature Bald Eagles are sometimes misidentified as Golden Eagles (i.e., a false positive), and Golden Eagles can be misidentified as immature Bald Eagles (i.e., a false negative). As a consequence, such citizen science programs may not be appropriate for monitoring Golden Eagles, especially in the forests of eastern North America. For this reason, we do not report population indices from these types of presence-only sources to describe the distribution and abundance of Eastern Golden Eagles.

Abundance estimates: Recent population estimates suggest that the Eastern Golden Eagle population is much smaller than the Golden Eagle population of western North America. The western population in the contiguous U.S.A. was estimated to be 18,000–32,000 individuals during 2006–2012 (Good et al. 2007; Millsap et al. 2013; Nielson et al. 2014), 31,254 individuals in 2014 (USFWS 2016a), and 31,229–32,257 during a study period from approximately 1997–2016 (Millsap et al. 2022). The Golden Eagle population in Alaska was first estimated to number 4,091 individuals in 2014 and 2015 (Nielson and McManus 2014; Nielson et al. 2014; 2015) and later estimated to number 12,717 individuals during 2016–2018 (Booms et al. 2021). In contrast, the Eastern Golden Eagle population is estimated to number at or above 5,000 individuals (Dennhardt et al. 2015a; Morneau et al. 2015).

The flight behavior of migrating Eastern Golden Eagles provides an opportunity to estimate the size of this population. Much of the eastern population migrates through the Appalachian Mountains of Pennsylvania, U.S.A. twice a year, with major flight paths along the Allegheny Front and the westernmost ridges of the Ridge and Valley physiographic province of Pennsylvania, West Virginia, Maryland, and Virginia (Figure 1; Brandes and Ombalski 2004; Miller et al. 2014; Dennhardt et al. 2015a; b; 2017). Approximately 1,300 individuals are estimated to migrate along Kittatinny Ridge, a prominent ridgeline that is used during fall migration (Dennhardt et al. 2015b; 2017). Little is known about the numbers of Eastern Golden Eagles migrating through other areas (Katzner et al. 2012a) and there are few credible estimates of the numbers of Eastern Golden Eagles that migrate through the area of the Great Lakes. Furthermore, there are few estimates of the numbers of Golden Eagles that breed or winter in any of the states or provinces within the range of Eastern Golden Eagles (but see Morneau et al. 2015). However, regional and localized population estimates will likely improve as the number of monitoring sites increases, and tracking and analytical technologies continue to advance.

Province and State-specific Conservation Status

Eastern Golden Eagles are given special conservation status in most states and provinces in which they are found. NatureServe (2021) lists the Canadian national status as 4 or 5 ("Apparently Secure" or "Secure", respectively). However, this appears to be based largely on the western component of the population, as eastern provinces have breeding season statuses of either 1 ("Critically Imperiled": Manitoba and Ontario), 2 ("Imperiled": Newfoundland and Labrador) or 3 ("Vulnerable": Nunavut, Saskatchewan, Québec; Table 2). NatureServe statuses for non-breeding Golden Eagles in the eastern U.S.A. run the gamut from "Critically Imperiled" (Georgia, Indiana, Louisiana, Maine, Maryland, Massachusetts, Mississippi, New York, South Carolina, Tennessee, Virginia) to "Secure" (Pennsylvania; Table 3). Only a few states provide a status for both the breeding and non-breeding seasons (Kentucky, Maine, New York, Virginia) and two provide a separate status for migratory and non-breeding seasons (Minnesota, Pennsylvania). Recognition of the at-risk status of the Eastern Golden Eagle population likely is due, at least in part, to the efforts of the EGEWG to publicize knowledge and conservation status of this population.

A Golden Eagle comes in for a landing in north central Pennsylvania. Randy Flament

CULTURAL SIGNIFICANCE

"High in the sky, swooping and wheeling in the wind is the Eagle. The Eagle sits on a high place between this world and the next. The Eagle tells the Creator of the Anishinabek who have finished their earthly time."

Benton-Banai 1979

The Golden Eagle has been revered and respected by humans since the beginning of recorded history. Many cultures believe that eagles are the link between humankind and the divine. Ancient Greeks believed that the Golden Eagle was the signature bird of Zeus, king of the gods (Theoi Project 2017). Norse mythology says that Yggdrasil, the World Tree, had a Golden Eagle perched on top of it (Doty 2002). The Golden Eagle was the model for the Aquila, which was the most prominent symbol of the legions of Ancient Rome. Golden Eagles have been trained historically as falconry birds in both Europe and Asia (McGough 2019).

At least five countries (Albania, Austria, Germany, Kazakhstan, and Mexico) have the Golden Eagle as their national animal, making this bird the most common official national animal in the world (CLO 2019). It may be that the popularity of the Golden Eagle in Europe led to the Bald Eagle being used as the national symbol of the U.S.A. Early Europeans were eager to name places after this worldly bird. Along the Franconia Notch State Parkway in New Hampshire is Eagle Cliff, rising 1,036 m (3,400 ft) along the western flank of Mount Lafayette. This prominent rock outcropping was named in honor of the Golden Eagles that nested here until the 1890s (Gertner 2017). Modern-day bird watchers flock to places like Hawk Ridge Bird Observatory in Minnesota, Mackinac Straits Raptor Watch in Michigan, or Hawk Mountain Sanctuary in Pennsylvania (e.g., www.hmana.org) to catch a glimpse of and marvel at these amazing raptors as they migrate by.

Man and boy in traditional regalia, with a dance bustle made of Golden Eagle feathers. These feathers are so sacred that if they fall to the ground, they must be cleansed in a spiritual ceremony. Through its Eagle Indian religious permits, the U.S. Government provides Golden Eagle feathers and parts to qualifying members of Federally recognized tribes for religious and cultural uses. Mary Anne Enriquez

Native American tribes and First Nations hold eagles in the highest respect, as they are often a clan animal and extremely culturally significant. Within the U.S.A., members of federally recognized Native American tribes (as established under the Federally Recognized Tribal List Act 1994) can possess eagle feathers for religious purposes per the Bald and Golden Eagle Protection Act (16 U.S.C. §§668–668d) and Eagle Indian Religious Permits (50 C.F.R. §§22 et seq.). Tribal members often use feathers as part of regalia outfits for dancing events at Pow Wows and in other traditional ceremonies. Wildlife rehabilitation and educational facilities that care for permanently injured eagles that are non-releasable to the wild are required to collect all of the eagles' molted feathers. These feathers, and carcasses of eagles, are required to be shipped to the United States Fish and Wildlife Service (USFWS) National Eagle Repository in Commerce City, Colorado. From there the feathers are distributed to Native Americans who have obtained a federal permit for tribal religious purposes.

The Native American tribes of the Great Lakes region, known collectively as the Anishinabek, have both Bald Eagle (Migizi Dodem) and Golden Eagle (Ginew Dodem) clan members. The clan system is used to define family and function, with each clan fulfilling different roles within the community. Teachings may vary according to different families, but these clan systems and spiritual practices are still practiced today. The Ginew Dodem clan is characterized as more aggressive and independent, while the Migizi Dodem clan is believed to fly highest and provide a more direct link to the Creator (N. Kiogima and R. Dillard, personal communications).

Tribal members are invested in eagle conservation. For example, within the range of the Eastern Golden Eagle, preserving the Bald Eagle for the next seven generations is a high priority for the Little Traverse Bay Bands (LTBB) of Odawa Indians Natural Resources Department. In italics on these pages, LTBB members articulate the significance of eagles to the Tribal citizens.

These shared stories of important connections to both the Bald and the Golden Eagle are just a small sample of the myriad number of culturally significant links between eagles and both Native Americans and First Nations People. From the perspective of these groups, conserving eagles is important to honor their place in Native American culture.

"The Anishinabek look to the Eagle as the messenger to the Creator. The eagle carries our prayers to the Creator. The Eagle lets the Creator know that some of us are trying to live and walk in a Good Way. The Anishinabek believe that when we see an Eagle that we need to respectfully put some tobacco down on mother earth to show the Creator that we're still living in a Good Way and also to thank the Eagle for doing his responsibility and showing us that we need to remember our own responsibilities here. The Eagle can see far. Some say that the Eagle Clan people have the ability to see far also, even to the point of seeing people or things as they really are."

J. Mitchell, Little Traverse Bay Bands of Odawa Indians Tribal Elder and Pipe Carrier, personal communication

MANAGEMENT RESPONSIBILITIES UNDER STATE, PROVINCIAL, & FEDERAL LAWS

In Eastern North America, Golden Eagles are managed under a variety of laws and regulations promulgated by the U.S. Government as well as by individual U.S. states and Canadian provinces. Within the U.S.A., the USFWS manages Golden Eagles and other migratory birds in partnership with state wildlife agencies. Federal laws establish minimum protections for Golden Eagles, while state governments can establish more restrictive standards. In Canada, Golden Eagles are not recognized either as migratory under the Migratory Birds Convention Act nor as at risk under the Species at Risk Act, and are therefore solely managed under provincial laws.

The USGS Bird Banding Laboratory regulates trapping and marking of all birds in the U.S., including this banded Golden Eagle. Billy Pope

U.S. Laws and Regulations

Three U.S. Federal laws protect Golden Eagles: the Lacey Act of 1900 (16 U.S.C. §3371), the Migratory Bird Treaty Act (MBTA) of 1918 (16 U.S.C. §§703–711; 40 Stat. 755), and the Bald and Golden Eagle Protection Act (Eagle Act) of 1940 (16 U.S.C. §§668–668d; 54 Stat. 250). The Lacey Act regulates the trade of wildlife, or their parts or products, that have been taken or possessed illegally, across boundaries of states, countries, or Indian reservations.

The MBTA prohibits the possession, taking, selling, transporting, and importing of migratory birds, including Golden Eagles, their nests, eggs, parts, or products, when such items are included in terms of conventions between the U.S.A., Canada, Mexico, Japan, and Russia. "Take" under this statute includes actions to pursue, hunt, take, capture, kill, possess, sell, barter, purchase, ship, export, or import protected species. U.S. regulations allow for permitting of banding and marking, rehabilitation, and falconry of Golden Eagles (50 C.F.R. §§21.70, 21.76, 21.82).

The Eagle Act serves as the primary federal law for protection of Eastern Golden Eagles. In 1962, the U.S. Congress amended the Eagle Act, originally passed as the Bald Eagle Protection Act, to add protection for Golden Eagles. The rationale for the amendment was to address anthropogenic pressures threatening the species' conservation within the U.S.A. The amendment also bolstered enforcement for protection of Bald Eagles; the similar appearance of Golden Eagles and juvenile and subadult Bald Eagles had produced claims of mistaken identity between the species and unlawful killing of Bald Eagles.

The Eagle Act prohibits individuals and organizations from taking, possessing, selling, purchasing, bartering, offering for sale, transporting, exporting, or importing either eagle species, whether alive or

dead. These protections extend to eagle parts, eggs, and nests. The law defines "taking" as actions to "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb Bald or Golden Eagles." The Act's implementing regulations in turn define "disturb" as "to agitate or bother a Bald or Golden Eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (50 C.F.R §22.6). The definitions of these terms provide the foundation for enforcement and permitting actions related to these laws.

There are several regulations under the Eagle Act (1940) covering possession of Golden Eagles, their feathers, and parts; the taking of Golden Eagle nests; and the intentional and incidental taking of live Golden Eagles. Through qualifying application, individuals may possess Golden Eagles for science and exhibition (50 C.F.R §22.50), Indian religious use (50 C.F.R §22.60), and falconry (50 C.F.R §21.82). Where Golden Eagles depredate domesticated flocks and herds, state governors may request, and the USFWS Director may approve, a depredation control order for Golden Eagles in the requesting state (50 C.F.R §§ 22.120 and 22.122). The USFWS may also issue permits to approved individual applicants for take of Golden Eagles that are depredating or that pose a human safety risk (50 C.F.R §22.100).

Further, the USFWS may authorize the removal of Golden Eagle nests if they impair resource development and recovery or the function of a human-engineered structure, threaten public health and safety, harm an interest in a particular locality, or are the subject of a safety emergency (50 C.F.R. §§22.75 and 22.85). These authorizations are limited to alternate (i.e., unused) nests except in the case of functional hazards where eggs and nestlings are not yet present or when there is an eagle or human safety emergency. Removal of nests to protect an interest in a particular locality must provide a net benefit to eagles either directly through the action of removal or indirectly through compensatory mitigation.

Precipitated in part by the U.S. federal delisting of the Bald Eagle under the Endangered Species Act, in 2009 the USFWS created regulations for permitting the incidental take of Bald and Golden Eagles (74 F.R. §46877; 50 C.F.R. §22.80)[1]. However, until the 2016 amendment of these regulations (81 F.R. 91551ff), the USFWS did not authorize incidental take of Golden Eagles east of the 100th meridian (i.e., within the eastern U.S.A.). Under current implementation, USFWS regulates authorization of incidental take within Eagle Management Units (EMU), geographic regions that have been delineated according to population and migration patterns. Within this framework, USFWS manages Eastern Golden Eagles within an EMU composed of the Atlantic and Mississippi Flyways (USFWS 2016a).

According to the Eagle Act, the USFWS may only permit take or possession of Golden Eagles if the actions are consistent with the preservation of the species. As part of the agency's 2016 regulatory revisions, USFWS defined this preservation standard to mean "consistent with the goals of maintaining stable or increasing breeding populations in all eagle management units and the persistence of local populations throughout the geographic range of each species" (50 C.F.R. § 22.6). For Golden Eagles, the local area population is the estimated number of Golden Eagles within 109 miles of the human activity or project of interest. In this case, 109 miles was chosen because it is the typical natal dispersal distance for the species (USFWS 2016b). USFWS determined that with few exceptions, the authorized incidental taking of Golden Eagles and removal of Golden Eagle nests is unsustainable due to the general status of the population of this species (USFWS 2016a; USFWS 2016c), and therefore determined that incidental take must be offset with compensatory mitigation (50 C.F.R. § 22.80(c)(1)(i-ii); 50 C.F.R. § 22.85(b)(8)).

[1]On September 30, 2022, USFWS proposed revisions to its eagle incidental take permit regulations with the stated purpose "to increase the efficiency and effectiveness of permitting, facilitate and improve compliance, and increase the conservation benefit for eagles" (87 F.R. 59598).

State Laws

Golden Eagles and their feathers are protected not only at the federal level within the U.S. and Canada but also under state and provincial laws. Peter Kaminski, Creative Commons

In addition to federal laws, most U.S. states within the range of Eastern Golden Eagles also provide some level of protection for this species (Table 4) and many states list Golden Eagles in their State Wildlife Action Plans (SWAPs). Of the 31 states where Eastern Golden Eagles can occur (Figure 2), four list the species as either "Endangered" or "Threatened;" three of these are states in which the species historically nested. At least 21 states provide some level of legal protection for eagles, although in some cases these laws are not specific to eagles but are instead tied to general protection for birds or wildlife. Two states have no protections for Golden Eagles, and we were unable to determine levels of protection for the remaining 8 states. Finally, as of summer 2023, 12 states include Golden Eagles in their SWAPs and the remaining 19 do not.

Canadian Laws and Regulations

Canadian Federal Laws

Canada's Migratory Bird Convention Act (MBCA) of 1994 does not include protection for Golden Eagles. Likewise, Accipitrid species are not listed under Article I of the MBCA. Additionally, the Committee on the Status of Endangered Wildlife of Canada assessed in 1996 that the Golden Eagle was nationally 'Not at Risk' (Government of Canada 2015, 2017). Consequently, the species is not protected by the Species at Risk Act at the federal level.

Provincial Laws

The following sections summarize provincial protections of Eastern Golden Eagles (Table 5). Our information is gathered from the expertise of EGEWG members and publicly available sources. Further protections may exist of which we are unaware. Likewise, although not mentioned here, Golden Eagles are also protected in western provinces.

Manitoba. While the Golden Eagle is not listed under Manitoba's Endangered Species and Ecosystem Act, it is protected alongside "all vultures, eagles, hawks, osprey, and falcons" under Division 6 of the province's Wildlife Act (C.C.S.M. c. W130). This law prohibits the hunting, trapping, taking, killing, and capturing of these species, as well as the possession of their parts.

New Brunswick. The Golden Eagle is not assigned a protected status under New Brunswick's Species At Risk Act (SNB2012 Chapter 6). However, the province does consider the Golden Eagle a protected form of wildlife under its Fish and Wildlife Act (SNB1980 Chapter F-14.1), which regulates take, possession, and other treatment of wildlife.

Newfoundland and Labrador. Golden Eagles are not listed under the province's Endangered Species Act (SNL2001 Chapter E-10.1). All raptors, including eagles, are included under Part V.81 of the Wildlife Act of Newfoundland and Labrador (O.C. 96-809). The act stipulates that:

1. A person shall not hunt, take, kill or have in his or her possession an eagle, falcon, hawk, osprey, or owl of any species.
2. A person shall not sell or purchase or offer to sell or purchase or expose for sale any eagle, falcon, hawk, osprey, or owl of any species.
3. Notwithstanding subsections (1) and (2), the minister or his or her agent may issue a permit to authorize the possession of raptors.

Nunavut. Under the Consolidation of Wildlife Act (S.Nu. 2003, c.26), Golden Eagle nests are protected from injury, molestation, or destruction, regardless of occupancy status due to the species' classification as a bird of prey. Along with all other wild animals, Golden Eagles are protected from harassment, pursuit, and molestation. The act provides certain exceptions to these protections for lawful harvesting activities.

Ontario. Ontario identifies the Golden Eagle as endangered on its Species at Risk in Ontario List (MNRF 2016). This designation entitles the species to protection from harm and harassment and its habitats from damage and destruction under the provincial Endangered Species Act of 2007. The Act mandates the creation of a Recovery Strategy for the species. Ontario's Golden Eagle Recovery Strategy (Wyshynski and Pulfer 2015) enumerates the following objectives:

1. identify, reduce, and mitigate threats to the Golden Eagle and its breeding and non-breeding habitat in Ontario;
2. identify and protect currently occupied and newly identified habitat of the Golden Eagle in Ontario;
3. increase knowledge of Golden Eagle biology in Ontario including distribution, abundance, life history, habitat needs, and impact of threats to this population; and
4. increase public awareness and understanding of the Golden Eagle and its habitat in Ontario.

The Recovery Strategy also advises on habitat to be included in species-specific regulations that implement the Act's prohibition against habitat damage and destruction. The strategy's stated recovery goal is "to maintain existing individuals and populations, allow for the natural increase of successfully breeding Golden Eagles in Ontario and minimize threats."

Québec. Québec protects Golden Eagles under multiple laws and agreements (EROP 2020). In 2005, the province designated the Golden Eagle as vulnerable under Article 10 of the Act Respecting Threatened and Vulnerable Species (RSQ Chapter E-12.01). The Act also enables official designation and protection of threatened or vulnerable habitat for a species, although this process has not yet been applied to the Golden Eagle. Additionally, the Golden Eagle receives consideration and protection through the Environmental Quality Act (RSQ Chapter Q-2), which requires project developers to conduct environmental impact studies that include a focus on threatened and vulnerable species. For example, land-based wind energy projects planned within 20 km of Golden Eagle nests are required to perform two years of telemetry studies (MRNF 2008).

Québec's Act Respecting the Conservation and Development of Wildlife (CQLR Chapter C-61.1) further enables preservation of the species by prohibiting hunting or trapping of wildlife and disturbance, destruction, or damaging of eggs or nests. Under this law, individuals must report Golden Eagles injured or killed and transfer them to wildlife law enforcement (MELCCFP 2023).

The province implements two notable agreements between its ministries for the benefit of Golden Eagles. The 1996 agreement between the Ministry of Natural Resources and the Ministry of the Environment and Wildlife (Gouvernement du Québec 2017) creates a collaborative process for incorporating the protection of threatened and vulnerable species into provincial forest planning and management. This agreement establishes 300 m buffers around Golden Eagle nests in which all forestry activities are prohibited, and a timing restriction on forestry activities between 300 m and 700 m of occupied nests during the breeding season (MRNF 2016). A more recent agreement between the Ministry of National Defense and the Institute for Environmental Surveillance and Research (Beaupré et al. 2014) includes the requirement of an airspace buffer of 4.63 km around occupied Golden Eagle nests during the breeding season within a defined zone of the province's North Shore region.

Most states and provinces require a buffer around Golden Eagle nests to minimize disturbance. MELCCFP

CURRENT THREATS

Anthropogenic Threats

Shooting: Despite receiving federal protection under MBTA, shooting continues to be a primary cause of eagle deaths across the species' ranges. After necropsying 1,427 Golden Eagle carcasses, the National Wildlife Health Center determined that 15% of the fatalities were due to shooting (Russell and Franson 2014). This study noted that shooting accounted for 24% (95% CI 12–39%) of the Golden Eagles submitted from the Atlantic Flyway (part of the range of the Eastern Golden Eagle). At a wildlife rehabilitation center in Québec, 2 out of 24 Golden Eagles evaluated between 1986 and 2007 had been shot (Desmarchelier et al. 2010). The USFWS estimated that approximately 69 first-year and 601 after-first-year Golden Eagles (95% credible intervals: 20–174 and 354–926) are shot annually in the western U.S.A., and that shooting is the leading anthropogenic cause of death for these western eagle populations (Millsap et al. 2022). It is also likely that rates and demographic effects of shooting remain underrepresented, as evidence may be hidden and deaths difficult to attribute to a particular cause (APLIC 2006, Katzner et al 2012a).

Collisions with vehicles and power lines. Collisions with vehicles and electric infrastructure can result in trauma or death. The USFWS estimates 51 first-year and 560 after-first-year Golden Eagles die annually from collision-related injuries in the western U.S.A. (95% CI: 11–143 and 322–877; Millsap et al. 2022). Within the eastern population, 23% of carcasses submitted to the National Wildlife Health Center from 1975 to 2013 died from trauma, similar to the national rate for trauma injuries (Russell and Franson 2014). Trauma injuries from collisions may be treatable but blunt force trauma can ultimately be lethal.

Collisions with vehicles are a source of mortality for Golden Eagles, one that may be mitigated by relocation of roadkill. HawkWatch International

Collisions with distribution and transmission lines occur in western populations, where carcasses are found mid-span and may or may not show physical signs of electrocution (Olendorff and Lehman 1986; Harness et al. 2003). Carcasses in these settings are typically collected incidentally so the true number of power line collisions is unknown. There is evidence that in migration, Eastern Golden Eagles can avoid transmission lines by adjusting their flight altitude (Luzenski et al. 2016). The level of collision risk for eagles within a breeding or wintering territory is not known, but frequent line crossings between hunting, nesting, and roosting areas could increase risk (Harness et al. 2003).

Vehicle collisions are a widespread problem for Golden Eagles scavenging on roadkill. Golden Eagles are more likely to scavenge in winter months (Bedrosian et al. 2017), and a majority of their carcasses are found on roads in the fall and winter months (Hunt 2002; Lonsdorf et al. 2018). The frequency of raptor deaths due to vehicle collision, and specifically those of Golden Eagles,

appears to be increasing in recent decades (Lutmerding et al. 2012; Russell and Franson 2014). While most reports are from western North American populations, collisions with automobiles and trains are documented in the eastern population. The Québec Ministry of Transportation collected 5 Golden Eagles from roadsides from 1987 to 2018 (EROP 2020). Certain state and provincial transportation departments have increased their efforts to remove ungulate carcasses in areas with many eagle collisions as a tactic to reduce the availability of carcasses to eagles and thus reduce frequency of those collisions (Riginos et al. 2017; EROP 2020).

Poisoning. Poisoning is a leading cause of death of Golden Eagles in the western U.S.A., with approximately 32 first-year and 395 after-first-year eagles dying from this cause each year (95% CI 4–109 and 201–675; Millsap et al. 2022). Of the different types of poisoning reported, lead is the most common toxicant found to be causing fatalities in North American Golden Eagle populations. Lead poisoning occurs as a result of the ingestion of carcasses or offal from hunted or dispatched animals containing residues in the form of fragments, shot, or intact bullets from lead-based ammunition (Hunt et al. 2006; Kramer and Redig 1997). While there are no specific mortality estimates for lead poisoning of Golden Eagles in eastern North America, estimates of the proportion of Golden Eagle fatalities resulting from lead poisoning vary from 2.1% to 4.8%, and Golden Eagles had higher rates of lead poisoning in the Atlantic Flyway than in other Flyways (Russell and Franson 2014; USFWS 2016a; Slabe 2019). A recent study suggested that 30% of Golden Eagles captured during the wintering period in states ranging from New York south to Alabama had blood lead concentrations consistent with sublethal lead poisoning (Slabe et al. 2020). This lead exposure appears to suppress population growth by an estimated 0.8% (Slabe et al. 2022), and 47% of eagles in the study showed chronic levels of lead poisoning. Feeding ecology is an important determinant of lead in Golden Eagles. In general, birds show higher rates of acute lead poisoning during the winter period when scavenging is more common (Bedrosian 2012; Slabe et al. 2020).

Carrion is an important component of the Golden Eagle diet in winter, which makes them vulnerable to lead poisoning from ingested bullet fragments. © David Brandes.

Eagles are exposed to other compounds that can have lethal and sublethal effects, though toxicity levels are not well understood for free-ranging Golden Eagles (Herring et al. 2017; Niedringhaus et al. 2021). Anticoagulant rodenticides were found in 77% of Golden Eagles tested (n=17) including 3 individuals sampled in Georgia and Pennsylvania (Niedringhaus et al. 2021). Although both first- and second-generation rodenticides were detected in this study, the second-generation compound bromadiolone was the most commonly detected. The effects of mercury exposure are not well understood for Golden Eagles but several studies in Canada and the western U.S.A. suggest exposure levels are generally low and that mercury is not impacting populations of this species (Noble et al. 1993; Craig and Craig 1998; Langner et al. 2015; Herring et al. 2017). Likewise, populations continue to be affected from DDT poisoning both chronically and from historical collapses or regional extinctions from the chemical despite the ban on its use

in the U.S.A. 50 years ago (Watson and Davies 2015). Finally, baits poisoned for carnivores (e.g., M44s) can also present a threat to other scavengers, including eagles (Russell and Franson 2014).

By-catch from trapping. Incidental by-catch from furbearer trapping has been documented for Golden Eagles throughout their eastern range (Bortolotti 1984; Katzner et al. 2012a; Fitzgérald et al. 2014). This threat is most prominent during fall and winter months, but some by-catch also occurs at other times of year (Bortolotti 1984; Fitzgérald et al. 2014). By-catch has been documented on Québec breeding grounds, with 34 Golden Eagles reported trapped from 1986 to 2012, accounting for 62% of all recoveries of live and dead individuals in that period (Fitzgérald et al. 2014). Fitzgérald et al. (2014) noted that trapping by-catch is underreported, with perhaps only ~33.5% of known eagle captures reported by trappers. This is despite a large-scale program initiated in 2008 to facilitate reporting in Québec (EROP 2022). The USFWS estimated that in the western U.S.A., trapping by-catch causes fatalities of 88 first-year and 191 after-first-year Golden Eagles per year (95% CI: 30–203 and 67–409; Millsap et al. 2022).

Wind energy. Collision with wind turbines is perhaps the best-documented threat associated with energy development, due to well-developed standards for monitoring and reporting (e.g., USFWS 2012; 2013; PGC 2013; USFWS 2016b). High risk is associated with low altitude flight, and research indicates that eagles typically fly at significantly lower altitudes when using updrafts along terrain features than when using convective thermals (Katzner et al. 2012b). Whereas collision mortality related to wind turbines consistently has been recognized as a threat in the western U.S.A. (Pagel et al. 2013), few collisions of Golden Eagles with turbines have been reported in eastern states. In fact, as of late 2022, there are only 3 reported incidents, one each in Michigan, Indiana, and Iowa (M. Rheude, USFWS, personal communication). Golden Eagle fatalities have not been documented in the initial years of operation at wind facilities in the Atlantic Flyway, despite rigorous short-term monitoring requirements called for at some projects in some states (e.g., Taucher et al. 2012).

Wind turbines pose a threat to Golden Eagles from direct injury and mortality, and from habitat loss and modification during and following construction. Taylor Berge

In addition to the potential for fatalities, wind energy facilities can cause indirect impacts on the population because turbines are often placed on the windy ridgetops preferred by eagles (Miller et al. 2014). Eagles that alter their movement patterns could also change their energy budgets and possibly avoid areas or habitats important to their survival or reproduction. Research in western Canada documented avoidance of a wind facility placed along a migratory leading line (Johnston et al. 2014), suggesting that wind turbines may displace migrating Golden Eagles from preferred habitats. Although published evidence is lacking, anecdotal reports from telemetry data indicate that such avoidance also occurs in the eastern U.S.A. (T. Miller, personal communication.)

Mountaintop removal mining. Throughout the Appalachian Mountains, ridges used by wintering Golden Eagles are sometimes affected by surface mining, primarily for coal to supply coal-fired power plants (Wickham et al. 2013). The primary driver of habitat impacts in upland areas in the region is the mining technique known as mountaintop removal. There is some taxon-specific information regarding the effects on wildlife of this practice in uplands, and a

substantial amount of research has focused on the negative impacts of the practice on water bodies and water quality. Historical mountaintop removal and valley filling in Kentucky, Tennessee, Virginia, and West Virginia destroyed 387,000 acres of mature deciduous forest, primarily in ridgetop settings (Winegrad 2004) such as those frequented by wintering Golden Eagles. This habitat alteration has continued recently and from 1986 – 2011, the footprint of all mining activities expanded by 233% in West Virginia alone (Bailey and Rucker 2021). Due to their remoteness from road networks and other sources of development, clearing of ridgetop forests during mining operations can cause loss of interior forests at rates 1.8–5.0 times greater than the rate of overall forest loss (Wickham et al. 2007). This likely affects Golden Eagles because interior forests provide a buffer from human disturbance in winter.

There are substantial ecological impacts of mountaintop removal, many of which could be relevant to Golden Eagles (Wickham et al. 2013). For example, loss of topographic complexity could be an issue due to the species' use of slopes and ridgetops for movement and roosting (Katzner et al. 2012a; Duerr et al. 2019a). Although it is not known if forest fragmentation is harmful to Golden Eagles, outright forest loss does mean loss of habitat for the species (Katzner et al. 2012a). Soil loss can alter prey distribution (Wickham et al. 2013), and changes to biological diversity may be relevant because a less diverse ecosystem may be less capable of supporting apex predators. Finally, conversion of a carbon sink into a carbon source increases atmospheric carbon, a driver of climate change, which could negatively affect Golden Eagles (see Climate Change section below). An estimated 5.2 avian fatalities occur per gigawatt-hour of electricity produced by fossil fuels, inclusive of coal (which is primarily obtained in the eastern U.S.A. via mountaintop removal; Sovacool 2013). Although work to date has not evaluated such impacts to Golden Eagles, it is likely that similar consequences extend to this species.

Oil and gas extraction via hydraulic fracturing. Like mountaintop removal, oil and gas extraction, particularly via hydraulic fracturing, or fracking, in the eastern U.S.A. has inspired research on the effects of land clearing and impacts to aquatic resources (Latta et al. 2015). However, a few publications have examined terrestrial impacts likely relevant to Golden Eagles. Such impacts include forest loss and fragmentation, human activity and disturbance, noise pollution, and changes in water quality (Brittingham et al. 2014). Species most at risk from fracking appear to be those with extensive range overlap with oil shale regions, while also having intrinsic characteristics such as limited range, small population size, specialized habitat requirements, and high sensitivity to disturbance (Brittingham et al. 2014). All of these risk characteristics apply to Eastern Golden Eagles, suggesting that fracking should be carefully studied to best determine actual impacts to the species.

In areas where shale-drilling/hydraulic fracturing is heavy, a dense web of roads, pipelines and well pads can fragment contiguous forests and grasslands. Bruce Gordon at EcoFlight

Oil and gas extraction can involve a number of activities with the potential to disturb or harm Golden Eagles. These include construction and use of access roads, installation of above-ground equipment and power lines, exposure to waste and contaminants, noise pollution, and general drilling activities. There is mixed evidence as to whether these stressors are relevant to birds. For example, increased traffic and dust

due to fracking activity in rural areas within the Bakken region of North Dakota did not reduce avian abundance or change behavior, although dust penetrated 180 m into adjacent fields (Spiess et al. 2019). Despite that finding, the study suggested that wildlife in areas of historically intense human use may be more resilient than those in previously undisturbed habitats, such as interior forests.

Effects of fracking on Louisiana Waterthrush (*Parkesia motacilla*) have been well studied in the central Appalachian Mountains region. This species accumulated barium and strontium at significantly higher levels near sites of fracking activity than in those without fracking (Latta et al. 2015); both metals are associated with fracking fluids that enter the food chain via water contamination. This effect was observed in the Marcellus shale region and the Fayetteville shale region in the eastern and southeastern U.S.A., both areas frequented by Golden Eagles. Likewise, while ground-feeding birds and water-associated birds are the most susceptible to mortality at oil waste pits, waste pits have also been documented to cause the mortality of Golden and Bald Eagles (Trail 2006). Finally, construction, road travel, and human presence associated with fracking, whether on wintering or breeding grounds, may also be detrimental to Golden Eagles, as they are in other settings (Kaisanlahti-Jokimaki et al. 2008, Steenhof et al. 2014).

Electrocution. Electrocution is a leading anthropogenic cause of death of Golden Eagles in the western U.S.A. An estimated 69 first-year and 437 adult Golden Eagle individuals are electrocuted annually in the western U.S.A. (95% CI: 20–174 and 231–731; Millsap et al. 2022). While a majority of electrocution incidents occur in the Central and Pacific Flyway populations, electrocuted Golden Eagles are documented in low numbers in the Mississippi Flyway and Atlantic Flyways (Russell and Franson 2014). Incidentally collected electrocution data involving Eastern Golden Eagles includes one incident in the Virginia mountains (J. Cooper, VDWR, personal communication) and one in Québec (EROP 2020).

Power lines cause electrocution and collision deaths of Golden Eagles, both of which have been documented most extensively in western populations. J. Maughn, Creative Commons

Disturbance. Anthropogenic disturbance can originate from many sources including, but not limited to, recreational activities (e.g., rock climbing, snowmobiling, hiking, photography) and industrial activities (e.g., mining, gas extraction, logging, airport traffic, and road construction). Disturbances limited in length or occurring during the non-breeding season likely have minimal effects on eagles. However, disturbance at a nest site during the breeding season can have a significant impact on nest success by decreasing the probability of initiating the nesting cycle, decreasing the number of young produced, or by causing nest failure (Steenhof et al. 2014, Katzner et al. 2020).

Human activities near current or historic nesting sites could dissuade Golden Eagles from breeding at these locations. Although there is no longer an extant breeding population in the eastern U.S.A., the New York State Department of Environmental Conservation identified recreational rock climbing as a challenge for attracting new breeding pairs to historic eyrie sites

(NYSDEC 2014). As described above, resource extraction through surface mining or fracking can be a source of long-term disturbance to Golden Eagles through noise, road building, and habitat loss (Steenhof et al. 2014; Katzner et al. 2020; EROP 2020).

Habitat fragmentation, alteration, and loss. There have not been explicit studies to test the effects of habitat fragmentation, alteration, and loss on Eastern Golden Eagles. However, the species utilizes a variety of habitats in eastern North America and is highly likely to be vulnerable to these changes in land use. Habitat utilization by Eastern Golden Eagles, and thus susceptibility to impacts, is affected by age, breeding activity, habitat quality, space use, and resource selection (Miller et al. 2017). The amount of space used both during the breeding and the wintering seasons appears to decrease with age (Miller et al. 2017). Thus, impacts of habitat alteration may be more relevant to older, territorial eagles than to younger non-territorial birds.

Alteration of habitat in eastern North America is occurring for a variety of reasons. First, afforestation has been occurring for centuries as a result of farm abandonment, reduced logging, changes in forest management activities, and increased fire suppression (Drummond and Loveland 2010). Second, some areas are experiencing increased development for energy extraction and residential structures, resulting in forest fragmentation. A decrease in habitat is likely a factor in the displacement of eagles. It has been speculated that the extirpation of breeding Golden Eagles from the eastern U.S.A. was connected in part to the overall decrease of open areas due to fire suppression and direct persecution of eagles (Morneau et al. 2012).

As discussed above, current threats to breeding habitat in Québec and Newfoundland and Labrador include habitat loss and overall increased human presence in remote areas (EROP 2020). Habitat loss in particular is associated with renewable energy facilities, generally by processes such as road building and clearing of turbine pads and laydown yards.

Threats to migratory and winter habitat of Eastern Golden Eagles are similar to those associated with breeding habitat. During the winter, Eastern Golden Eagles are known to utilize ridgelines with consistent wind currents for foraging and flight subsidy (Miller et al. 2017). As discussed above, these areas are affected by many threats. Together these can fragment and alter landscapes, not only in the ways noted above, but also by disrupting migratory pathways.

Climate Change. Climate change due to anthropogenic warming of the atmosphere is a widely acknowledged threat to biodiversity (IPCC 2007; Settele et al. 2014) and human society (IWGSCC 2010). In the context of biodiversity, discussion of climate change often centers on extinction risk, highlighting the seriousness of this threat to many species. Eastern Golden Eagles migrate and winter in the eastern U.S.A.; however, they breed in northern Canada where the potential disruption and weather fluctuations caused by climate change are expected to be more pronounced. The increased rate of change in these regions, known as arctic amplification, is expected to produce rapid, unpredictable changes in plant and animal communities (Callaghan et al. 2005; MacDonald 2010), which are likely to produce direct impacts

Recent research has shown that climate change can lead to changes in precipitation patterns, which can cause increased rainfall and increased mortality of nestling Golden Eagles. Alexandre Anctil

for breeding Golden Eagles (Davidson et al. 2020). Recent research has shown that changes in precipitation regime leading to increased rainfall (which is likely in a warming arctic) increased nestling mortality (Anctil et al. 2014), and reduced prey delivery rates, resulting in reduced nestling weights (Robinson et al. 2017) for arctic nesting Peregrine Falcons (*Falco peregrinus*). Additionally, climatic conditions have been linked to adult survival during the outbound migration of Peregrine Falcons from the Arctic (Franke et al. 2011). These direct impacts of climatic change may also be relevant to Golden Eagle populations of the region. Golden Eagles in Alaska are vulnerable to extreme fluctuations in weather conditions during incubation and early nestling stages of breeding (McIntyre and Schmidt 2012). Declines in the breeding success of this population were hypothesized, in part, to be a result of a reduction in adult fitness due to stresses during the migration and wintering periods while using non-breeding habitat in lower latitudes. For example, loss of non-breeding habitat from wildfires can impact eagle breeding fitness by displacing individuals and changing prey availability (Kochert and Steenhof 2002). The threat is a growing concern for Golden Eagles as the number of wildfire incidents and their intensity continues to increase. Although these issues have not been extensively studied in eastern North America, it seems reasonable to expect that processes affecting other arctic raptors, and especially eagles, are highly relevant to Eastern Golden Eagles.

Another likely effect of climate change on Golden Eagles is encroachment of forest and shrub cover types on open foraging areas in the species' arctic and subarctic breeding range (MacDonald 2010). Additionally, Golden Eagle movements are strongly influenced by the availability of atmospheric updrafts sufficient to support soaring flight (e.g., Bohrer et al. 2012;, Duerr et al. 2019b), and therefore the species is likely to be impacted by changes in the distribution of updrafts as prevailing wind patterns shift with climate. Because the availability of updrafts strongly influences migration speed (Duerr et al. 2012; 2015), Golden Eagles migrating through eastern North America may experience significant climate-driven changes in timing of migration. Finally, although the extent of winter range for the species in eastern North America is only now being documented (Miller et al. 2023), it seems likely that changes in forest distribution and in mammalian and avian prey resulting from climate change may also impact Eastern Golden Eagles (Marneweck et al. 2021).

Perhaps the greatest climate change related threat to Eastern Golden Eagles may be a lack of recognition among conservationists and managers that the species occurs in the region. As an example,the National Audubon Society's climate change assessment for the Atlantic Flyway does not list the Golden Eagle among the high vulnerability, moderate vulnerability, low vulnerability, or stable species known to winter in the Flyway, and the climate change assessment for the species omits its eastern range from the analysis (NAS 2019a; b). Past experience suggests that because they no longer breed in the eastern U.S.A., Eastern Golden Eagles are often ignored in assessments focused on nesting populations.

Golden Eagles face dozens of threats throughout their range and life cycle, making conservation efforts relevant for population persistence. Caroline Legg, Creative Commons

Natural Threats and Limiting Factors

Biologists studying golden eagles take a variety of morphometric measurements, including of the exposed culmen as in this picture, to document variation in size. Billy Pope

Prey abundance. Golden Eagle nesting density, reproductive success, and home range size are influenced by prey abundance and habitat quality (Collopy and Edwards 1989, McIntyre and Adams 1999, Miller et al. 2017). Eastern North America is thought to be low quality habitat for Golden Eagles (Morneau et al. 2012), resulting in large home ranges (Miller et al. 2017). This could be a response by birds to low-quality habitat that requires increased ranging to access sufficient prey to successfully rear nestlings. Along these same lines, if these eagles require open habitat for foraging, the availability of that habitat may limit the number of nesting territories, as forest cover has increased due to afforestation and fire suppression (Morneau et al. 2012).

Carrying capacity. The carrying capacity of the eastern region for Golden Eagles is unknown but data suggest the population may be limited by the quality of breeding territories. Specifically, the spacing between breeding territories is farther apart in the eastern population (13–20 km Gaspé Peninsula; Katzner et al. 2012a) compared to western North American (5–15 km; Beecham and Kochert 1975; Ritchie and Curatolo 1982) and European populations (4.2–10.8 km Scotland; Watson et al. 1992; Watson 2010). Likewise, home ranges are larger in the eastern population than in those other populations (Morneau et al. 1994, Miller et al. 2017).

The Eastern Golden Eagle population does not appear to be limited by nest site availability. This is suggested by the fact that many cliff-nesting sites in northern Québec are unoccupied by breeding eagles (Morneau et al. 2015, Anctil et al. 2019; EROP 2020).

Meteorological conditions. Weather conditions during the breeding season can affect nest success and productivity levels in Golden Eagles. Golden Eagle territories in Idaho had higher nest failure rates and later hatching dates when winter weather extended into the beginning of the breeding season (Steenhof et al. 1997). A late spring and heavy snowpack may have delayed egg laying by pairs observed in 2018 in Québec (Anctil et al. 2019). In contrast, in Alaska, severe spring weather was not shown to affect productivity; instead, nest success was dependent on prey availability (McIntyre and Schmidt 2012). Climate change may alter the severity and timing of weather fronts during the breeding season.

Parasitic and Protozoal Diseases. Endoparasites are commonly reported in free-ranging raptors, including Golden Eagles. Parasitic organisms include nematodes, cestodes, flukes, protozoal organisms, hemoparasites, and others. Most parasitic infections are asymptomatic, although heavy infestations or comorbidities that suppress the host's immune response may result in clinical signs ranging from lethargy and diarrhea to anorexia and emaciation and may lead to death (Jones 2006). Nematodes, also called roundworms, are the most common and potentially pathogenic parasites reported among raptors presented to veterinary or rehabilitation centers. Avian trichomoniasis is an infectious disease caused by the flagellated protozoan parasite *Trichomonas gallinae*. The parasite is found worldwide and typically affects the upper digestive system and respiratory tract resulting in formation of caseous plaques within the oropharynx as well as the nasal passages, infraorbital sinuses, and syrinx (Samour and Naldo 2003). Severe

infections may result in starvation or suffocation (Amin et al. 2014). *T. gallinae* is commonly harbored by species within the Columbidae family, and raptors become infected following consumption of Rock Pigeons (*Columba livia*), Mourning Doves (*Zenaida macroura*), and other Columbiformes. Several studies suggest that increased rates of trichomoniasis in raptors may be associated with anthropogenic loss of native habitat, decline in preferred prey populations, and a dietary shift towards increased consumption of Rock Pigeons (Palma et al. 2006; Real et al. 2006). Dudek et al. (2018) found *T. gallinae* infection in 13% (12/96) of nestling Golden Eagles in 10 western states and 41% (13/32) of nestlings in southwestern Idaho. The same study also noted that Rock Pigeons had, over time, become more common in eagle diets and that the probability of *T. gallinae* infection of nestlings was positively correlated to the proportion of Rock Pigeons in their diet.

Sarcocystis falcatula is a protozoal organism with a two-host life cycle. The Virginia opossum (*Didelphis virginiana*) serves as the definitive host in North America (Dubey et al. 1991; Greiner 2008). Birds of prey may serve as intermediate hosts and become infected by consuming sporulated oocysts that are present in the feces of the definitive host or by ingesting tissue of opossums that carry *S. falcatula* sporocysts (Dubey et al. 1991; Greiner 2008). An unidentified *Sarcocystis sp*. (presumably *S. falcatula*) was reported as a cause of encephalitis in a Golden Eagle from southwestern Virginia (Dubey et al. 1991). Clinical signs prior to death included a slight head tilt, depression, and apparently affected vision, yet the eagle was described to be in good physical condition. Likewise, an adult female Golden Eagle from southern Indiana was admitted to a rehabilitation center with emaciation, lethargy, neurologic deficits, and an inability to fly due to infection by *S. falcatula* (Wünschmann et al. 2010).

Viral Diseases. Viral diseases can have devastating consequences for free-ranging avian species. Pox virus was the second most-common infectious disease reported for Bald and Golden Eagles presented to the National Wildlife Health Center (Russell and Franson 2014). Cutaneous pox virus infections result in proliferation of epithelial cells in non-feathered areas of the skin of the face and legs. As lesions progress in size, individuals are subject to trauma, hemorrhage, necrosis, and secondary bacterial infections; lesions may also obstruct vision or the ability to eat (van Riper and Forrester 2007).

Rehabilitated eagles, like this one, can live many years in the wild after being treated for disease or injury. Keith Hoden

Other viral diseases that may be of concern for Eastern Golden Eagles include Newcastle disease virus (NDV), West Nile virus (WNV), and avian influenza virus. NDV, also called paramyxovirus serotype 1 (PMV-1), has a broad host range with worldwide distribution (Leighton and Heckert 2007). It is a highly contagious viral pathogen, and all avian species are considered susceptible. Low virulence NDV strains are present in poultry and free-ranging birds, especially waterfowl. Virulent Newcastle disease, formerly known as exotic Newcastle disease, causes significant mortality, approaching 100%, in poultry. Clinical signs that raptors display are dependent on the overall health of the raptor and the virulence of the viral strain but may include anorexia, vomiting, diarrhea, and neurologic signs. Some raptors may remain asymptomatic despite infection.

Diagnostic analysis can provide insight into blood-borne diseases carried by Eastern Golden Eagles. Billy Pope

WNV infection is caused by a flavivirus (Family *Flaviviridae,* genus *Flavivirus*) that was initially isolated from a woman in the West Nile region of Uganda in 1937 (McLean and Ubico 2007). WNV gained a foothold in North America in 1999 in New York, NY. Raptors are frequently infected and exhibit varying degrees of morbidity and mortality. Transmission of WNV occurs primarily via the mosquito *Culex pipiens* in Europe and North America. However, ingestion of infected prey species (e.g., Rock Pigeons and, for other predators, House Sparrows (*Passer domesticus*) may also serve as a means of acquiring WNV. Clinical signs vary and include lethargy and depression, anorexia, weight loss, neurologic signs, impaired vision or blindness, pinching-off blood feathers, and often death. Data regarding the incidence and prevalence of WNV infections in Golden Eagles are limited. One study reported on gross and histologic lesions on 15 Bald Eagles and 3 Golden Eagles resulting from WNV (Wünschmann et al. 2014).

Avian influenza A is a member of the virus family Orthomyxoviridae and has a worldwide distribution as a result of broad dissemination by migratory avian species (Gerlach 1994; Ritchie 1995; Stallknecht et al. 2007). Avian influenza A virus has been recovered from numerous avian species including birds of prey, although waterfowl, shorebirds, and passerine species typically serve as primary reservoirs (Ritchie 1995; Stallknecht et al. 2007). Raptors that prey on waterfowl and shorebirds may accordingly become infected. Consequently, influenza A virus may occur in raptors along the major flyways used by migratory avian prey during the fall and spring. There are only a few specific reports of recent strains of avian influenza affecting Golden Eagles (Caliendo et al. 2022; USDA 2023). However, Goyal et al. (2010) report on the isolation and characterization of two subtypes of avian influenza from a Bald Eagle; many Bald Eagles died during the 2022-2023 outbreak of highly pathogenic avian influenza (USDA 2023).

Fungal Diseases. Aspergillosis, most often caused by *Aspergillus fumigatus*, is an infectious but non-contagious fungal disease commonly reported in raptors, especially Gyrfalcons (*Falco rusticolus*), Red-tailed Hawks (*Buteo jamaicensis*), Northern Goshawks (*Accipiter gentilis*), and Golden Eagles (Jones and Orosz 2000; Redig 2000). *Aspergillus spp*. are ubiquitous in the environment, with infections commonly resulting from inhalation of fungal spores or secondary to an event such as trauma that compromises a host raptor's immune system (Jones and Orosz 2000; Redig 2000; Tell 2005; Arné et al. 2021). Clinical signs may be nonspecific, such as depression, lethargy, anorexia, and weight loss, or more directly associated with the respiratory system including dyspnea and change or loss of voice (Joseph 2000; Redig 2000; Jones 2006). Of 1,477 Golden Eagles presented to the National Wildlife Health Center, aspergillosis was the most common infectious disease, reported in 15 Golden Eagles, or 1% of the total birds evaluated (Russell and Franson 2014).

CURRENT KNOWLEDGE GAPS & RESEARCH TO ADDRESS GAPS

Despite the recent growth in research on Eastern Golden Eagles, there remain a number of gaps in our knowledge of this population. Addressing these knowledge gaps would aid in the conservation of this population, improve management, and facilitate permitting when required. Below is a breakdown of these knowledge gaps by topic.

Distribution and Habitat Associations

Historic Golden Eagle nest cliff in western Maine. ©David Brandes.

Until recently, our understanding of Golden Eagle distribution in the eastern U.S.A. was based primarily on incidental detections during midwinter eagle surveys (Millsap and Vana 1984). Although densities were not quantified, it was believed that Golden Eagles wintered in the eastern U.S.A. in low numbers. Since 2005, much has been learned about habitat use and distribution of Eastern Golden Eagles, especially in the Appalachian Mountains, Cumberland Plateau, and Driftless regions (Mehus and Martell 2010; Katzner et al. 2012a; Duerr et al. 2019a; Miller et al. 2017; Katzner et al. 2020; McCabe et al. 2021). A knowledge gap recognized by Millsap and Vana (1984) includes the limited understanding of the species' winter distribution and habitat use in the Midwest, interior Southeast (Mississippi, Louisiana, Arkansas, Missouri, Iowa), and far Northeast (Maine, Vermont, New Hampshire, northern New York) regions. Additional focus in areas of the Midwest and southern states like Missouri, Arkansas, and Louisiana may also be important to understand the dividing line between eastern and western wintering populations of Golden Eagles.

Information on the distribution of Eastern Golden Eagles during the breeding season can be inferred from limited telemetry data and a number of surveys conducted for environmental impact assessments. Approximately 50 Golden Eagle breeding sites were discovered during surveys in Newfoundland and Labrador during the 1980s and 1990s (Morneau et al. 2015). Likewise, aerial surveys in Québec during the 1990s revealed 123 territories and 260 nests (Morneau et al. 2012). Other survey work, including breeding bird atlases and dedicated Golden Eagle surveys, has added information about breeding season distribution. In Ontario, surveys in 2001–2003 revealed 14 occupied territories near Hudson Bay. In eastern Manitoba, Breeding Bird Atlas surveys in Wapusk National Park documented seven pairs and three nests in 2011 and 2012 (Asselin et al. 2013). A knowledge gap that emerges from this work highlights the potential value of a habitat-suitability study to explore nesting site preferences in eastern Canada (Morneau et al. 2015). Most prior surveys have focused on cliffs. However, it is important that new search areas include conifer forests in areas with gentle topography where cliffs are absent. This study is particularly important since Golden Eagles are known to nest in trees and detecting tree nests can be difficult.

Although nest surveys can provide information about breeding sites, rarely are non-breeding birds documented during the nesting season. Telemetry studies by members of the EGEWG have revealed additional breeding sites in Labrador, Manitoba, Ontario, and Québec, as well as areas used by non-breeding birds (Katzner et al. 2012a; Miller et al. 2017, EGEWG unpublished data). As nests are comparatively easy to identify, habitat use and suitability are relatively easier to understand for nesting birds, but harder to identify and less well known for non-breeding birds. Because of the demographic relevance of non-breeding subadult Golden Eagles, there is substantial importance to research focusing on their habitat, dietary, and ecological associations.

Another gap in knowledge is the lack of habitat models to predict occurrence of the Eastern Golden Eagle. Over the past decade, research by the EGEWG has resulted in 114 individuals being outfitted with high-resolution telemetry units, generating approximately 4.6 million GPS locations throughout the eastern U.S.A. and Canada. This research has greatly increased our understanding of Golden Eagle spatial ecology in the eastern U.S.A. Further, this effort suggests that the Appalachian Mountains support a large number of wintering Golden Eagles (October through May) and may represent the core of the wintering range for the northeastern Canada breeding population (Katzner et al. 2012a; Miller 2012; Miller et al. 2017). However, much of these data have not been analyzed to understand how Golden Eagles use the landscape and airspace across the many physiographic provinces of the eastern U.S.A. An analysis at that level would help inform understanding of, and ability to predict, habitat use, including the geographic airspaces and altitudes used by wintering Eastern Golden Eagles that potentially put them at risk of interacting with wind turbines.

Roosting habitat is also a critical component of wintering habitat and has not been widely evaluated across the Eastern Golden Eagle's range. A macro-scale analysis of roost site selection was completed by the EGEWG (Duerr et al. 2019a). Building on this work to delineate known roosts and identification of micro-site habitat characteristics of roosts would allow targeted management and protection of this important component of wintering habitat.

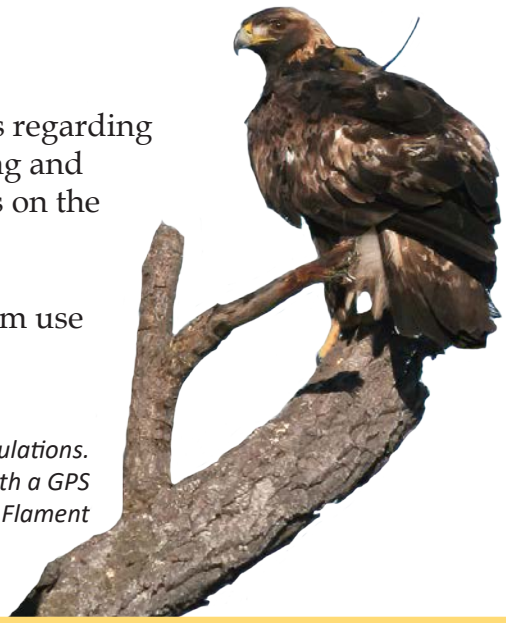
Density

There is generally poor knowledge of the relative densities of Golden Eagles, both in summer in eastern Canada and in winter in the eastern U.S.A. More extensive analysis of existing camera trap and telemetry data could help inform density estimates as well as inform questions on productivity, winter distribution, and long-term change. Importantly, telemetry data and camera trap data could be combined with eBird data or other surveys to better understand the probability with which Golden Eagles are detected in eastern landscapes. Integrated models to perform such analyses recently have been proposed by the USFWS (2022).

Wildlife Health

Currently, there are limitations in our understanding of health concerns regarding Eastern Golden Eagles. Knowledge gaps include the influence of existing and emerging diseases, contaminants, and the co-evolution of comorbidities on the health of individuals and populations.

Perhaps one of the greatest knowledge gaps relate to how the threat from use of lead ammunition can be most effectively mitigated. Lead toxicity is a nationwide problem that affects both North American eagle species.



Telemetry studies provide critical information on distribution and density of Golden Eagle populations. This image was captured after the release of the second Eastern Golden Eagle affixed with a GPS transmitter at the Allegheny Front Hawk Watch in the late fall of 2006. Randy Flament

Lead bullets fragment on impact. Exposure to lead when scavenging has resulted in the suppression of the growth of the nationwide Golden Eagle population. The Peregrine Fund

Models suggest that individual mortality and morbidity due to lead toxicity have resulted in the suppression of the growth of the nationwide Golden Eagle population (Slabe et al. 2022). Other recent studies have revealed similar results at the state level for Bald Eagles (e.g., Hanley et al. 2022). Legal bans on lead ammunition are one alternative to address this threat, but there are few prospects for bans as of the date of this plan. Non-lead ammunition distribution programs can be effective at reducing lead toxicity in eagles (Bedrosian et al. 2012), and a pilot distribution program has been initiated in New York. There is limited knowledge as to the best ways to inform eastern U.S. and Canadian hunters of the negative effect of lead on eagles. Although studies have been conducted regarding public persuasion in other regions (e.g., Schulz et al. 2019), the extent to which they are relevant to eastern settings is unclear. This knowledge gap is important because additional information could increase the effectiveness of education. Finally, the extent of poisoning from other heavy metals (e.g., mercury), anticoagulant rodenticides, and other toxicants has not been thoroughly investigated in Golden Eagles in eastern North America.

Climate Change

A major gap in our knowledge is how climate change is affecting, and will continue to affect, Eastern Golden Eagles. Climate change has the potential to create new challenges for Golden Eagles related to changes in food availability, habitat, and other conditions throughout the annual cycle. We know little about how interactions between vegetation and prey affect breeding success in eastern Canada or winter survival. Studies in Alaska and Idaho imply strong links between eagle demography and climate (e.g., Steenhof et al. 1997; McIntyre and Schmidt 2012), suggesting that a warmer climate could have substantial effects on eagles. As an example, if otherwise open areas become increasingly more vegetated, the number or accessibility of prey could be reduced. Likewise, it seems possible that climate may affect migration behavior and timing, as well as winter food availability and survival.

Climate change may have consequences for eagles beyond the nesting season. Winter habitat may be altered by climate change, and it is unclear how that could affect Eastern Golden Eagles. Similarly, Davidson et al. (2020) examined the influence of climate change on several aspects of migration behavior of the Alaskan population of Golden Eagles. Applying that approach to the eastern population could help inform researchers regarding the influence of climate change on many different aspects of eagle migration behavior, including timing, phenology, flight altitudes, and short-stopping. Likewise, climate change can affect the density and distribution of vectors of avian disease, potentially impacting eagles. There are several examples of this in the literature. Changes in the timing and intensity of black flies (*Diptera: Simuliidae*) have contributed to increased nestling mortality of Peregrine Falcons in Greenland (Lamarre et al. 2018). Also, the range of Mexican chicken bugs (*Haematosiphon inodorus*) has expanded in the western U.S.A., apparently affecting the physiology and health of Golden Eagle nestlings in Idaho (Dudek et al. 2021). Climate change and fire also have affected the diet of Golden Eagles in Idaho, apparently affecting the frequency of infection by a protozoan *T. gallinae*. Together these data suggest potential indirect effects of climate change that are poorly understood but potentially serious for this species.

Demography and Causes of Death

Perhaps one of the most important and consequential knowledge gaps for the Eastern Golden Eagle population is the lack of understanding of their demography. Although breeding ecology is well known for many other populations of Golden Eagles (e.g., Katzner et al. 2020), only nests of the Gaspé section of the Eastern Golden Eagle population have been consistently monitored (EROP 2020). Likewise, a recent study evaluated age-specific survival and causes of death of Golden Eagles in the western U.S.A. (Millsap et al. 2022), but no similar study has been conducted for eastern birds. Understanding these details is important because preliminary evidence suggests that some causes of death, especially by-catch in leg-hold traps and snares set for mammalian predators, may be more demographically important for eastern birds than for their western counterparts. Furthermore, given the substantial change in habitat components, especially forest cover, over the past century in the eastern U.S.A., it is likely important to link winter behavior and habitat to survival of these eagles. Demography can also be linked to other topics that may be high priorities for research. For example, Bald Eagle populations are growing exponentially in the range of Eastern Golden Eagles, and, as discussed above, there is great potential for competitive interactions between the two species. Natural history knowledge of these two species suggests that it is reasonable to expect that increasing numbers of Bald Eagles will impact Golden Eagle density, distribution, abundance, and even breeding and survival. Finally, although we have reasonable estimates for the numbers of eagles that migrate through Pennsylvania (e.g., Dennhardt et al. 2015a), limited data are available for birds that use other migration routes and estimates for the western population are likely more robust (Millsap et al. 2013).

Conservation Management

From a management perspective, several themes emerge as important knowledge gaps that may directly affect conservation of this species. First, the state-specific conservation status of the species is inconsistent in that many State Wildlife Action Plans only consider breeding birds and ignore birds such as Golden Eagles that are present only in winter. Upcoming revision to State Wildlife Action Plans presents an opportunity to address this inconsistency. Second, there are few established mitigation options for take of Eastern Golden Eagles. This issue is important because mitigation in the western U.S.A. is focused on power pole retrofits, as eagles in treeless regions use power poles routinely for perching. Retrofits do not appear to be relevant in the heavily forested eastern U.S.A. and there are presently few other authorized mitigation options available in the East.

Conservation efforts should include migratory habitat as well as wintering and breeding habitats. Randy Flament

PROPOSED CONSERVATION OBJECTIVES & MANAGEMENT ACTIONS

Conservation Objectives

Based on the evaluation of the current status, threats, and knowledge gaps for Eastern Golden Eagles, the EGEWG developed a set of proposed conservation objectives for this population. These objectives are targeted at the key threats and issues that this small population appears to face. Although these objectives do not focus on the important cultural role of this eagle population, cultural significance is an important rationale for conserving this population.

The key conservation objectives we have identified for Eastern Golden Eagles are:

1. Maintain or increase breeding population size
2. Protect habitat in breeding, migration, and wintering areas
3. Maintain or develop long-term monitoring programs
4. Reduce threats and anthropogenic causes of mortality

We have identified a series of proposed management actions that we feel will promote progress toward each of these the conservation objectives. All of these actions will rely on effective international partnerships. These management actions are discussed below.

1. Objectives & Actions To Maintain Or Increase Breeding Population Size

Golden Eagle nestlings. Mick Thompson

Protecting Eastern Golden Eagles on their breeding grounds is an important component of maintaining a stable or growing population. The Province of Québec has a well developed plan for recovery of the Eastern Golden Eagle population (EROP 2020). This plan identifies a series of actions that can be taken, and metrics to evaluate their success, to maintain or increase the size of the breeding population of Eastern Golden Eagles. The Québec plan is also a good model for other provinces or U.S. states that may wish to develop their own strategy to promote the conservation of breeding, or potentially breeding, Golden Eagles.

The Québec plan seeks to reduce threats to habitats and individuals, and improve population monitoring efforts to obtain a more precise profile of the population and its productivity (EROP 2020). The plan identifies five objectives, and a series of associated actions, to be completed in 10 years (2020–2030). These are:

i. ***Maintain and improve population monitoring efforts through structured surveys.*** This monitoring scheme uses productivity, rather than population counts, as an indicator and proposes implementation of monitoring in both northern and southern Québec. Likewise, migration counts are used as an index of long-term population trends.

ii. ***Ensure long-term protection of nesting sites.*** This objective involves maintaining and increasing protection of known nesting sites and surveying for new sites. Two steps are envisioned: (a) analyzing the viability of territories, the threats associated with each of them, and protection measures currently in place and (b) prioritizing actions to optimize the protection of nesting sites.

iii. ***Increase monitoring of threats.*** Of particular interest are threats from accidental trapping, or by-catch, toxicant poisoning (e.g., lead, anticoagulant pesticides, flame retardants), electrocutions, and collisions. Steps envisioned for this objective are (a) engagement in data collection initiatives with organizations involved in furbearer trapping to better understand the conditions surrounding incidental eagle trapping, (b) collection and analysis of samples to monitor the impact of lead contamination in the Golden Eagle population, (c) creation of a Québec bank of biological tissues from birds of prey, and (d) gathering additional documentation of cases of injured or dead eagles resulting from electrocution or collisions with vehicles, power lines, and wind turbines.

iv. ***Implement measures to counter threats to survival of individual Golden Eagles.*** Measures will focus on the sharing of best management practices to avoid lead exposure and by-catch via accidental trapping. These will be implemented by working with states and provinces to conduct outreach via their websites, social media profiles, etc.

v. ***Disseminate knowledge and pursue the awareness efforts necessary for the recovery of the Golden Eagle.*** This objective focuses on development of a communication strategy to target stakeholders, including First Nations, trappers, hunters, and the general public, all of whom may have an interest in Golden Eagles and all of whom can take actions to support conservation of this species.

Beyond Québec, another important set of actions to increase the size of the breeding population is to identify and implement mechanisms to encourage passive spread of breeding birds back into the historic breeding range of the species. Actions along these lines could involve protection of historic breeding sites and, potentially, implementation of actions to make those sites more attractive. Maine, New Hampshire, and New York may be particularly well suited to these activities, as these were the states where nesting was most recently documented (in some cases in the 1990s).

2. Objectives & Actions To Protect Habitat In Breeding, Migration, & Wintering Areas

Breeding territory in the Gaspé Peninsula of Canada. Andrew Dennhardt

While the Eastern Golden Eagle population may benefit from efforts focused on breeding birds and their resources, there also is conservation value to supporting the species during migration and wintering. Non-breeding population conservation actions will be most effective if they are focused on increasing the number and condition of Golden Eagles returning to the breeding grounds.

Based on evaluation of the biology of the species as documented above, the following actions would be well suited to promoting conservation of Eastern Golden Eagles throughout the annual cycle.

i. ***Review and potentially upgrade the conservation status of the species*** at the level of individual states and provinces to ensure that the species occurs in State Wildlife Action Plans for every state within the species' eastern distribution.

ii. ***Map critical migration, stopover, and wintering habitats*** to enable prioritization of conservation for these areas.

iii. ***Establish strategies to work with landowners***, both public and private, whose lands overlap those critical areas, to protect habitat.

iv. ***Predict potential changes in wintering areas resulting from climate change*** to enable prioritization of protection and restoration efforts.

v. ***Increase engagement about and awareness of the species in eastern North America:***

a. Keep the EGEWG web page up-to-date

b. Develop lesson plans for teachers; highlight existing lesson plans.

c. Encourage development of citizen science counts for Golden Eagles. Encourage participation in those counts and ensure that counts are designed to contribute to conservation efforts.

d. Develop and implement targeted public outreach efforts and materials regarding Golden Eagle identification, sources of mortality, and how individuals can mitigate

them, including poisoning caused by lead ammunition and rodenticides, vehicular collisions, shooting, and trapping by-catch.

e. Coordinate with raptor rehabilitators to collect data to enable precise identification of sources of injury and mortality, as well as geographic locations of bird recovery, and outcomes of rehabilitation.

3. Objectives & Actions To Maintain Or Develop Long-term Monitoring Programs

Genetic sample from an Eastern Golden Eagle. Billy Pope

Current Eastern Golden Eagle population monitoring efforts include migration counts from specific sites, camera trapping, animal biotelemetry, and systematic winter surveys (e.g., National Eagle Center's one-day driving routes). Each of these methods yields valuable information but may not be representative for Golden Eagles in the entirety of their eastern range. We propose the following framework for monitoring Eastern Golden Eagles during migration and at wintering grounds (monitoring on breeding grounds is incorporated into conservation objective #1, above):

i. Identify monitoring goals. We propose the following two monitoring goals for this population:

a. Estimate population size and trajectory; these are key data required to evaluate recovery, stability, or decline of the Eastern Golden Eagle population.
b. Monitor use of migration routes and wintering areas; these are key data to target protection efforts, inform habitat conservation and enhancement, and reduce threats by informing siting of infrastructure.

ii. Identify and integrate existing monitoring. Existing monitoring is being conducted by state and provincial agencies, non-profits, educational institutions, federal agencies, and others. Raptor rehabilitators and mortality databases also provide "passive monitoring" that can be useful for eagle conservation, when these data meet appropriate quality standards. Integrating these data into a common, shared, database is important to long-term effectiveness of monitoring plans for this species.

There are likely ongoing monitoring efforts of which the EGEWG is not aware. We propose that requests for information be sent to biologists in each state, asking if Eastern Golden Eagle

winter surveys are being conducted or if Golden Eagles have been noted in general winter bird surveys, with a request to connect with the surveyors. Doing so would allow the integration of these data into larger-scale monitoring efforts. Identifying and integrating existing monitoring can be broken into two steps:

a. Compile a database of existing monitoring efforts and data: Once existing data are identified, a key next step is to determine how to compile and compare data. Once the format of these data have been identified, a database can be built to house them, database managers can be identified, and protocols can be established for adding new data. These actions may require creation of data-sharing agreements and terms and conditions for collection, integration, and use of new data.

b. Identify and address geographic gaps in monitoring for Eastern Golden Eagles: After existing data are characterized, identified, and integrated, a next step is to characterize the geographic coverage of existing monitoring to identify gaps in coverage. Identifying gaps is a straightforward mapping exercise. Subsequent steps are to work strategically to implement monitoring in those areas. This can be done by identifying partners in gap areas, identifying the most appropriate type of monitoring for those sites, and identifying and procuring funding to support monitoring.

4. Objectives & Actions To Reduce Threats & Anthropogenic Causes of Mortality

Power lines are a well documented threat to Golden Eagles. Kevin McGowen

General knowledge is lacking on the relative significance of different causes of death of Eastern Golden Eagles. Therefore, a key step in understanding this issue is improved outreach and communication with a wide variety of stakeholders who can provide data on why eagles die. Possible groups for improved outreach and communication include:

i. ***Wildlife Rehabilitators:*** To date, data on causes of death of eagles have not been collected and aggregated from wildlife rehabilitators. Within the U.S.A., federal agencies are unable to specifically require reporting of these data and the National Eagle Repository does not collect information on causes of death. Private groups (e.g., EGEWG) or permitting entities could develop relationships with rehabilitators in the U.S.A. and Canada and begin to aggregate these data for eagles and other raptors.

ii. ***Law Enforcement Professionals:*** Wildlife law enforcement officers typically only report data on eagle fatalities that may have been a result of criminal activity. Establishing procedures and protocols to encourage reporting of all eagle fatalities would improve understanding of causes of death.

iii. ***Energy Industry:*** Although industry typically reports on fatalities of eagles, development of a simplified way to document information on eagle fatalities could improve monitoring to understand cause of death of eagles.

iv. ***Transportation Managers:*** Eagles commonly are killed by collision with automobiles and trains, yet these fatalities are not regularly or consistently reported. Developing broad frameworks for highway, transportation, and railway departments and police to report eagle fatalities would be an important contribution to tracking this source of mortality.

v. ***Trappers, hunters, and animal control professionals:*** By-catch is an important threat to Eastern Golden Eagles. Providing information to mitigate this threat would benefit eagles and also provide opportunities for additional data collection on this cause of death. Relevant themes could include what actions to take if an eagle is trapped incidentally, how to differentiate Bald Eagles and Golden Eagles, how to minimize the chance of by-catch, and how to report by-catch to state agencies.

vi. ***General public:*** Members of the general public (including the groups above) occasionally encounter dead eagles. Within parts of the state of Washington, there are drop-off locations for dead eagles (https://www.fws.gov/program/migratory-bird-permit/living-around-birds#Dropoff); this approach may be a good model for the eastern region as well.

In addition to these steps, there are a number of actions that can be taken to address threats eagles face. Here, we provide management actions that could mitigate those sources of mortality. The following anthropogenic threats are identified and described in Section 7, "Current Threats."

i. ***Shooting.*** Shooting appears to be one of the more prevalent causes of mortality for Eastern Golden Eagles. Addressing this illegal activity can be enhanced through collaboration between law enforcement agencies and conservation groups, scientists, and managers. Such collaborations have proven effective in other settings (e.g., KTVB 2022) and would likely be effective for Eastern Golden Eagles.

A Golden Eagle shot neat a power line; inset shows a radiograph of the bird with bullet fragments. Illegal shooting is an important source of mortality for Golden Eagles across North America. Eve Thomason

ii. ***Poisoning.*** Poisoning relevant to eagles is from lead, rodenticides, and, in the U.S.A., poisoned bait for carnivores (M44s). A variety of voluntary and regulatory programs have been implemented to phase out use of lead ammunition; implementation of such programs in the range of Eastern Golden Eagles would benefit the species. Examples of these programs include the North American Non-lead Partnership (https://nonleadpartnership.org/) and Hunters for Eagle Conservation (https://huntersforeagleconservation.org/).

Use of rodenticides is heavily regulated but there are still opportunities for management action that could benefit Eastern Golden Eagles. For example, use of lower concentrations of anticoagulants has been implemented effectively in the European Union (Frankova et al. 2019). Likewise, use of M44s has been phased out in some states and public lands, likely to the benefit of eagles. In both cases, outreach especially may broaden awareness of this issue.

iii. ***Trapping by-catch.*** Several states and provinces have developed protocols to reduce by-catch of eagles. For example, both Virginia (Virginia Administrative Code. § 4VAC15-40-221) and Québec (EROP 2020) have well-developed plans in this regard. Key steps in both of these plans are asking trappers to bury bait or place bait at a distance from traps, educating trappers, improving systems for follow-up with trappers and rehabilitators, and developing guidance on when trapped birds can and cannot be released without medical care. Québec also calls for long-term follow-up and models to understand population-level consequences of fatalities from by-catch. These protocols are useful models that can be implemented by other states and provinces within the range of Eastern Golden Eagles.

The leg of the Eastern Golden Eagle in the prior photo after the bird was caught in a leg hold trap in West Virginia. This eagle endured a bone infection and about 4 months of rehabilitation, including daily capture and dosing with antibiotics, before recovery and being released back to the wild. Todd Katzner and National Aviary in Pittsburgh

iv. ***Energy development and extraction.*** Energy development, whether via wind, solar, mountaintop removal, or oil and gas extraction are important threats to eagles. There are several possible means of addressing these activities' impacts on the Eastern Golden Eagle population.

When energy facilities are being developed, site locations can be checked against telemetry data and predictive maps of relative use by Golden Eagles. Use data can then be accounted for in design of pre- and post-construction monitoring plans (Québec has rigorous recommendations in this regard: https://mffp.gouv.qc.ca/nos-publications/protocole-inventaires-oiseaux-proie-implantation-eoliennes/). Use data and biological information also can be incorporated into guidelines and recommendations to minimize impacts to eagles from facility construction and operation. A good example of this is targeted wind turbine curtailment. Within the U.S.A., there is federal and state guidance specific to eagles for land-based wind facilities, but guidelines are generally lacking for other types of energy production that affect Eastern Golden Eagles.

With regard to mountaintop removal, understanding threats can include research to better understand how loss of topographic complexity, forest loss and fragmentation, and soil loss affect Golden Eagles and their prey. Similarly, effects to eagles from oil and gas extraction can be predicted, at least in part, by overlaying maps of existing and historic gas wells, of potential

areas for fracking, and of known eagle use (especially on summering and wintering grounds). Identification of tools to encourage adherence to state, provincial, and federal laws governing incidental take of eagles by energy facilities is another action to help mitigate this threat.

v. ***Electrocution and collisions.*** Protocols to address electrocution and collisions of eagles are especially well-developed in the western U.S.A. Encouraging use of the Avian Power Line Interaction Committee's (APLIC) protocols for powerlines (APLIC 2006; 2012; 2018) would be helpful for mitigating this threat. Programs promoting "in-lieu fee" (e.g., https://info.burnsmcd.com/mitigationbankingusa/projects/eagle-protection-and-offset-program and https://www.eaglemitigation.com/) are useful in the western U.S.A., where perching opportunities are limited. However, these may be less helpful in the range of Eastern Golden Eagles, where arboreal perching opportunities are plentiful and few electrocutions have been recorded.

vi. ***Human disturbance to birds.*** Québec's Golden Eagle recovery plan (EROP 2020) spends much time discussing causes of nest disturbance and the need to minimize it. The plan suggests: (a) research on the effect of disturbance from rock climbing, photography, snowmobiling, hiking, drone use, etc., (b) analysis of the viability of eagle territories and their associated threats and protections, (c) development of a strategy to prioritize actions to maximize protection of nesting sites, and (d) implementation of surveys to discover and document previously unknown eagle nests and territories.

vii. ***Habitat fragmentation, alteration, and loss; climate change.*** Habitat fragmentation, alteration, loss, and climate change may be major threats to Eastern Golden Eagles. In particular, as is documented above in the "General Species Overview," this population is strongly associated with certain habitat components throughout its range and weather has a strong influence on migratory movements and likely on distribution and abundance of prey. As noted above, conservation action to mitigate habitat alteration includes slowing habitat loss and degradation, and working with partners to identify, protect, and restore habitat. Similarly, steps to reduce climate change and mitigate its impacts are well understood (e.g., from the Intergovernmental Panel on Climate Change; www.ipcc.ch), and may also benefit Eastern Golden Eagles.

Industrial and residential development infringes on Easter Golden Eagle habitat near Bernheim Forest in Kentucky. ©Bernheim

Additional Measures

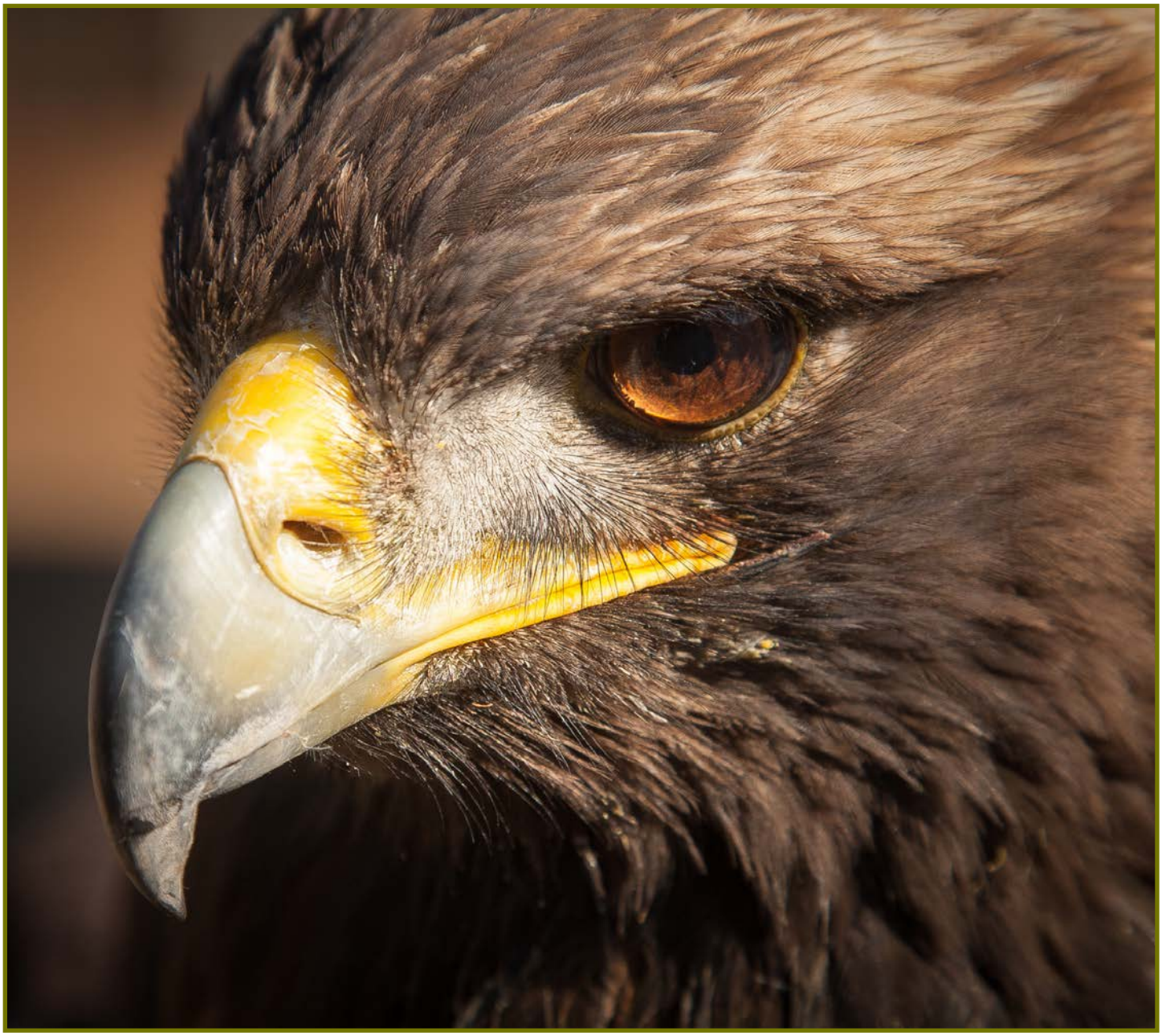
Measurements taken on a Golden Eagle. Billy Pope

Beyond these steps to address general threats, there are two additional steps the EGEWG identified that can be useful in promoting conservation of Golden Eagles in eastern North America. These are:

1. ***Development and implementation of compensatory mitigation programs for Eastern Golden Eagles.*** As is noted above, in-lieu fee programs for power pole retrofits are unlikely to be useful in eastern North America. Alternative options for compensatory mitigation may include mitigation for lead poisoning of eagles or for vehicle collision fatality by relocating ungulate roadkill. Some of these are currently being developed.
2. ***Increased engagement and awareness of the species in eastern North America.*** Potential actions in this regard might be (a) development of simple and effective information to guide correct identification of the two eagle species, (b) development of lesson plans for teachers or links to existing ones (e.g., those of the National Eagle Center are a good example; www.nationaleaglecenter.org), (3) updating of the information and content of the EGEWG web page (www.egewg.org), and (4) encouraging citizen science participation in scientifically useful counts of Golden Eagles.

CONCLUSIONS

Eastern Golden Eagles are iconic, not well known outside scientific communities, and of high conservation concern. The actions of the EGEWG have resulted in substantial contributions to science, conservation, and awareness of this population. The knowledge, objectives, and actions identified in this plan can continue to grow the impact of this productive international collaboration. Our team looks forward to working with other stakeholders to implement the actions outlined here.



Eastern Golden Eagle. Billy Pope

ACKNOWLEDGMENTS

The authors of this conservation plan would like to thank the many organizations, people, and stakeholders who have contributed to our efforts in creating this work. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service. This is Hawk Mountain Sanctuary's Conservation Science publication number 393.

Each section of this document was written by one or more authors. The lead authors of each section were:

1. **Executive summary –** Todd Katzner
2. **Introduction –** Todd Katzner
3. **General species overview** - Tricia Miller, Andrew Berry, Craig Koppie, Amy Mitchell, Rolf Gubler, Ryan Schmitz
4. **Population status** - Andrew Dennhardt, David Brandes, Adam Duerr, Mercedes Maddox
5. **Cultural significance** - Maxwell Field, Bill Parsons, Netawn Kiogima, Renee Dillard, Scott Mehus, Caleb Hickman
6. **Management responsibilities under state, provincial, and federal laws** - David F. Brinker, Jeffrey L. Cooper, Jérôme Lemaître, Thomas W. Wittig
7. **Current threats** - Libby Mojica, Chris Farmer, Michael Jones, Bracken Brown, Vince Slabe
8. **Knowledge gaps and research to address gaps** - Mike Lanzone, Jeff Cooper, Scott Rush, Evan Patrick
9. **Proposed conservation objectives and management actions** - Nora Pennarola, Margaret Rheude, Joel Merriman, Mark Martell, Jérôme Lemaître, Hardy Kern, Christine Kelly
10. **Conclusions –** Todd Katzner
11. **Acknowledgments –** all authors
12. **Literature cited –** all authors

Once all the sections were complete, the full document was then compiled edited by Todd Katzner and sent to a small group of co-editors. These co-editors provided suggestions and Katzner provided a final review. The co-editors for this document were: Rich Bailey, Erynn Call, Shilo Felton, Julie Garvin, Sergio Harding, Todd Katzner, Trish Miller, Casey Rucker, Hank Seltzer, Vince Slabe, Eric Soehren, and Johnny Wills. Finally, several colleagues provided extremely helpful peer reviews of this document. Reviewers included: Rebecca Peak, Tom Hudson, Ulgonda Kirkpatrick and Vassilios Hartofilax. Design by Debra Reynolds.

LITERATURE CITED

Amin, A., I. Bilic, D. Liebhart, and M. Hess. 2014. Trichomonads in birds: a review. Parasitology 141:733–747.

Anctil, A., A. Franke, and J. Bêty. 2014. Heavy rainfall increases nestling mortality of an Arctic top predator: experimental evidence and long-term trend in peregrine falcons. Oecologia 174:1033–1043.

Anctil, A., D. Potvin-Leduc, and J. Lemaître. 2019. Suivi de l'aigle royal dans le Nord-du-Québec: connaître la population pour mieux la protéger 2018. Ministère des Forêts, de la Faune et des Parcs, Gouvernement du Québec, Canada. [In French.]

Arné, P., V. Risco-Castillo, G. Jouvion, C. Le Barzic, C. and J. Guillot. 2021. Aspergillosis in wild birds. Journal of Fungi 7:241.

Asselin, N. C., M. S. Scott, J. Larkin, and C. Artuso. 2013. Golden Eagles (*Aquila chrysaetos*) breeding in Wapusk National Park, Manitoba. Canadian Field-Naturalist 127:180-184.

APLIC (Avian Power Line Interaction Committee). 2006. Suggested practices for avian protection on power lines: the state of the art in 2006. Avian Power Line Interaction Committee, Washington, DC.

APLIC (Avian Power Line Interaction Committee). 2012. Reducing avian collisions with power lines: the state of the art in 2012. Edison Electric Institute and Avian Power Line Interaction Committee, Washington, DC.

APLIC (Avian Power Line Interaction Committee). 2018. Eagle risk framework: A practical approach for power lines. Edison Electric Institute and Avian Power Line Interaction Committee, Washington, DC.

Bailey, R.S. and C.B. Rucker, Eds. 2021. The Second Atlas of Breeding Birds in West Virginia. The Pennsylvania State University Press, University Park, PA.

Beaupré, P., J. Lemaître, and A. Sebbane. 2014. Inventaire de l'aigle royal et du pygargue à tête blanche dans l'aire d'entraînement militaire CYA-733, Côte-Nord, Ministère des Forêts, de la Faune et des Parcs, Gouvernement de Québec, Canada. [In French.]

Bednarz, J. C., D. Klem Jr, L. J. Goodrich, and S. E. Senner. 1990. Migration counts of raptors at Hawk Mountain, Pennsylvania, as indicators of population trends, 1934–1986. Auk: Ornithological Advances 107:96–109.

Bedrosian, B., D. Craighead, and R. Crandall. 2012. Lead exposure in Bald Eagles from big game hunting, the continental implications and successful mitigation efforts. PLoS ONE 7:e51978.

Bedrosian, G., J. W. Watson, K. Steenhof, M. N. Kochert, C. R. Preston, B. Woodbridge, G. E. Williams, K. R. Keller, and R. H. Crandall. 2017. Spatial and temporal patterns in Golden Eagle diets in the western United States, with implications for conservation planning. Journal of Raptor Research 51:347–367.

Beecham, J. J., and M. N. Kochert. 1975. Breeding biology of the Golden Eagle in southwestern Idaho. Wilson Bulletin 87:506–513.

Benton-Banai, E. 1979. The Mishomis book: The voice of the Ojibway. Indian Country Press, St. Paul, MN.

Birds Canada. 2018. Raptor population index. Data accessed from NaturCounts, a node of the Avian Knowledge Network, Birds Canada. https://www.naturecounts.ca. Accessed 01 August 2020.

Bloom, P. H., and W. S. Clark. 2001. Molt and sequence of plumages of Golden Eagles and a technique for in-hand ageing. North American Bird Bander 26:97–116.

Bohrer, G., D. Brandes, J. T. Mandel, K. L. Bildstein, T. A. Miller, M. Lanzone, T. Katzner, C. Maisonneuve, and J. A. Tremblay. 2012. Estimating updraft velocity components over large spatial scales: contrasting migration strategies of golden eagles and turkey vultures. Ecology Letters 15:96–103.

Bolgiano, N. 2013. Evidence for changed migration of Red-tailed Hawks in eastern North America. Hawk Migration Studies 38:16–24.

Booms, T. L., N. A. Paprocki, J. M. Eisaguirre, C. P. Barger, S. B. Lewis, and G. A. Breed. 2021. Golden Eagle abundance in Alaska: migration counts and movement data generate a conservative population estimate. Journal of Raptor Research 55:496–509.

Bortolotti, G. R. 1984. Trap and poison mortality of Golden and Bald Eagles. Journal of Wildlife Management 48:1173–1179.

Brandes, D., and D. W. Ombalski. 2004. Modeling raptor migration pathways using a fluid-flow analogy. Journal of Raptor Research 38:195–207.

Brittingham, M. C., K. O. Maloney, A. M. Farag, D. D. Harper, and Z. H. Bowen. 2014. Ecological risks of shale oil and gas development to wildlife, aquatic resources and their habitats. Environmental Science and Toxicology 48:11034–11047.

Brodeur, S., R. Decarie, D. M. Bird, and M. Fuller. 1996. Complete migration cycle of Golden Eagles breeding in northern Québec. Condor 98:293–299.

Brodeur, S., and F. Morneau. 1999. Rapport sur la situation de l'aigle royal (*Aquila chrysaetos*) au Québec. Société de la faune et des parcs du Québec, Direction de la faune et des habitats, Québec, Canada. [In French.]

Broun, M. 1935. The hawk migration during the fall of 1934, along the Kittatinny Ridge in Pennsylvania. Auk 52:233–248.

Caliendo, V., L. Leijten, M. van de Bildt, E. Germeraad, R. A. Fouchier, N. Beerens, and T. Kuiken. 2022. Tropism of highly pathogenic avian influenza H5 viruses from the 2020/2021 epizootic in wild ducks and geese. Viruses 14:280.

Callaghan, T. V., L. O. Björn, F. S. Chapin III, Y. I. Chernov, T. R. Christensen, B. Huntley, R. Ims, M. Johansson, D. Jolly, S. Jonasson, N. V. Matveyeva, W. Oechel, N. Panikov, and G. Shaver. 2005. Arctic tundra and polar desert ecosystems. Pages 243–351 *in* Arctic Climate Impact Assessment (C. Symon, L. Arris, and B. Heal, Eds.). Cambridge University Press, Cambridge, UK and New York, NY.

Collopy, M. W., and T. C. Edwards Jr. 1989. Territory size, activity budget, and role of undulating flight in nesting Golden Eagles. Journal of Field Ornithology 60:43–51.

CLO (Cornell Lab of Ornithology). 2019. All about birds. Cornell Lab of Ornithology, Ithaca, New York. https://www.allaboutbirds.org. Accessed on 21 February 2023.

Craig, E. H., and T. H. Craig. 1998. Lead and mercury levels in golden and bald eagles and annual movements of golden eagles wintering in east central Idaho, 1990–1997. Technical Bulletin No. 98-12. Idaho Bureau of Land Management, Boise, ID.

Crewe, T. L., P. D. Taylor, D. Lepage, A. C. Smith, and C. M. Francis. 2016. Quantifying regional variation in population trends using migrating counts. Journal of Wildlife Management 80:245–255.

Davidson, S. C., G. Bohrer, E. Gurarie, S. LaPoint, P. J. Mahoney, N. T. Boelman, J. U. H. Eitel, L. R. Prugh, L. A. Vierling, J. Jennewein, E. Grier, O. Couriot, A. P. Kelly, A. J. H. Meddens, R. Y. Oliver, R. Kays, M. Wikelski, T. Aarvak, J. T. Ackerman, J. A. Alves, E. Bayne, B. Bedrosian, J. L. Belant, A. M. Berdahl, A. M. Berlin, D. Berteaux, J. Bêty, D. Boiko, T. L. Booms, B. L. Borg, S. Boutin, W. S. Boyd, K. Brides, S. Brown, V. N. Bulyuk, K. K. Burnham, D. Cabot, M. Casazza, K. Christie, E. H. Craig, S. E. Davis, T. Davison, D. Demma, C. R. DeSorbo, A. Dixon, R. Domenech, G. Eichhorn, K. Elliott, J. R. Evenson, K.-M. Exo, S. H. Ferguson, W. Fiedler, A. Fisk, J. Fort, A. Franke, M. R. Fuller, S. Garthe, G. Gauthier, G. Gilchrist, P. Glazov, C. E. Gray, D. Grémillet, L. Griffin, M. T. Hallworth, A.-L. Harrison, H. L. Hennin, J. M. Hipfner, J. Hodson, J. A. Johnson, K. Joly, K. Jones, T. E. Katzner, J. W. Kidd, E. C. Knight, M. N. Kochert, A. Kölzsch, H. Kruckenberg, B. J. Lagassé, S. Lai, J.-F. Lamarre, R. B. Lanctot, N. C. Larter, A. D. M. Latham, C. J. Latty, J. P. Lawler, D.-J. Léandri-Breton, H. Lee, S. B. Lewis, O. P. Love, J. Madsen, M. Maftei, M. L. Mallory, B. Mangipane, M. Y. Markovets, P. P. Marra, R. McGuire, C. L. McIntyre, E. A. McKinnon, T. A. Miller, S. Moonen, T. Mu, G. J. D. M. Müskens, J. Ng, K. L. Nicholson, I. J. Øien, C. Overton, P. A. Owen, A. Patterson, A. Petersen, I. Pokrovsky, L. L. Powell, R. Prieto, P. Quillfeldt, J. Rausch, K. Russell, S. T. Saalfeld, H. Schekkerman, J. A. Schmutz, P. Schwemmer, D. R. Seip, A. Shreading, M. A. Silva, B. W. Smith, F. Smith, J. P. Smith, K. R. S. Snell, A. Sokolov, V. Sokolov, D. V. Solovyeva, M. S. Sorum, G. Tertitski, J. F. Therrien, K. Thorup, T. L. Tibbitts, I. Tulp, B. D. Uher-Koch, R. S. A. van Bemmelen, S. V. Wilgenburg, A. L. V. Duyke, J. L. Watson, B. D. Watts, J. A. Williams, M. T. Wilson, J. R. Wright, M. A. Yates, D. J. Yurkowski, R. Žydelis, and M. Hebblewhite. 2020. Ecological insights from three decades of animal movement tracking across a changing Arctic. Science 370:712–715.

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2015a. Integrating citizen-science data with movement models to estimate the size of a migratory Golden Eagle population. Biological Conservation 184:68–78.

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2015b. Modeling autumn migration of a rare soaring raptor identifies new movement corridors in central Appalachia. Ecological Modelling 303:19–29.

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2017. Applying citizen-science data and mark-recapture models to estimate numbers of migrant Golden Eagles in an Important Bird Area in eastern North America. Condor: Ornithological Applications 119:817–831.

Desmarcelier, M., A. Santamaria-Bouvier, G. Fitzgérald, and S. Lair. 2010. Mortality and morbidity associated with gunshot in raptorial birds from the province of Quebec: 1986 to 2007. Canadian Veterinary Journal 51:70-74.

Doty, W.G., Ed. 2002. The times world mythology. Times Books, London, UK.

Doyle, J. M., T. E. Katzner, G. W. Roemer, J. W. Cain, B. A. Millsap, C. L. McIntyre, S. A. Sonsthagen, N. B. Fernandez, M. Wheeler, Z. Bulut, P. H. Bloom, and J. Andrew DeWoody. 2016. Genetic structure and viability selection in the Golden Eagle (*Aquila chrysaetos*), a vagile raptor with a Holarctic distribution. Conservation Genetics 17:1307–1322.

Drummond, M. A., and T. R. Loveland. 2010. Land-use pressure and a transition to forest-cover loss in the eastern United States. BioScience 60:286–298.

Dubey, J. P., S. L. Porter, A. L. Hattel, D. C. Kradel, M. J. Topper, and L. Johnson. 1991. Sarcocystosis-associated clinical encephalitis in a Golden Eagle (*Aquila chrysaetos*). Journal of Zoo and Wildlife Medicine 22:233–236.

Dudek, B. M., M. T. Henderson, S. F. Hudon, E. J. Hayden, and J. A. Heath. 2021. Haematophagous ectoparasites lower survival of and have detrimental physiological effects on golden eagle nestlings. Conservation Physiology 9:coab060.

Dudek B. M., M. N. Kochert, J. G. Barnes, P. H. Bloom, J. M. Papp, R. W. Gerhold, K. E. Purple, K. V. Jacobson, C. R. Preston, C. R. Vennum, J. W. Watson, and J. A. Heath. 2018. Prevalence and risk factors of Trichomonas gallinae and Trichomonosis in Golden Eagles (*Aquila chrysaetos*) nestlings in western North America. Journal of Wildlife Diseases 54:755–764.

Duerr, A. E., M. E. Braham, T. A. Miller, J. L. Cooper, J. T. Anderson, and T. E. Katzner. 2019a. Roost- and perch-site selection by Golden Eagles (*Aquila chrysaetos*) in eastern North America. Wilson Journal of Ornithology 131:310–328.

Duerr, A. E., T. A. Miller, L. Dunn, D. A. Bell, P. H. Bloom, R. N. Fisher, J. A. Tracey, and T. E. Katzner. 2019b. Topographic drivers of flight altitude over large spatial and temporal scales. Auk 136:ukz002.

Duerr, A. E., T. A. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. A. Tremblay, T. Katzner, and C. Franklin. 2015. Flight response of slope soaring birds to seasonal variation in thermal generation. Functional Ecology 29:779–790.

Duerr, A. E., T. A. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, and T. Katzner. 2012. Testing an emerging paradigm in migration ecology shows surprising differences in efficiency between flight modes. PLoS ONE 7:e35548.

Dunn, E. H., D. J. T. Hussell, and E. Ruelas Inzunza. 2008. Recommended methods for population monitoring at raptor-migration watch sites. Pages 447-459 in State of North America's Birds of Prey (K. L. Bildstein, J. P. Smith, and E. Ruelas I., and R. R. Veit, Eds.). Series in Ornithology, No. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

Eakle, W., P. Haggerty, M. R. Fuller, and S. Phillips. 2013. USGS Data Series 753: Golden Eagle records from the Midwinter Bald Eagle Survey—Information for wind energy management and planning. Available at https://pubs.usgs.gov/ds/753/figure1.html.

eBird. 2020. eBird Basic Dataset. Version EBD_relApr-2020. Cornell Lab of Ornithology, Ithaca, NY.

Edwards, C. C. 1969. Winter behavior and population dynamics of American eagles in western Utah. Dissertation, Brigham Young University, Provo, UT.

EROP (Équipe de Rétablissement des Oiseaux de Proie du Québec). 2020. Plan de rétablissement de l'aigle royal (*Aquila chrysaetos*) au Québec — 2020–2030. Produced for le Ministère des Forêts, de la Faune et des Parcs., Québec, Canada. https://mffp.gouv.qc.ca/documents/faune/especes/plan_retablissement_aigle_royal_2020-2030.pdf. Accessed 25 Feb 2021. [In French.]

EROP (Équipe de Rétablissement des Oiseaux de Proie du Québec). 2022. Accidental capture of eagles: what to do to avoid them and how to act when they occur. Gouvernement de Québec, Canada.

Evans, M. and G. Abernathy. 2009. Large forest tracts of Kentucky. Kentucky State Nature Preserves Commission, Frankfort, KY.

Farmer, C. J., D. J. T. Hussell, and D. Mizrahi. 2007. Detecting population trends in migratory birds of prey. Auk: Ornithological Advances 124:1047–1062.

Farmer, C. J., R. J. Bell, B. Drolet, L. J. Goodrich, E. Greenstone, D. Grove, D. J. T. Hussell, D. Mizrahi, F. J. Nicoletti, and J. Sodergren. 2008. Trends in autumn counts of migratory raptors in northeastern North America, 1974–2004. Pages 179–215 in State of North America's Birds of Prey (K. L. Bildstein, J. P. Smith, and E. Ruelas I., and R. R. Veit, Eds.). Series in Ornithology, No. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

Fitzgérald, G., J. A. Tremblay, J. Lemaître, and A. St-Louis. 2014. Captures accidentelles d'aigles royaux et de pygargues à tête blanche par les trappeurs d'animaux à fourrure au Québec. Le Naturaliste canadien 139:82–89. [In French.]

Forbush, E. H. 1929. Birds of Massachusetts and other New England states, part 2. Massachusetts Department of Agriculture, Norwood, MA.

Franke, A., J. F. Therrien, S. Descamps, and J. Bêty. 2011. Climatic conditions during outward migration affect apparent survival of an arctic top predator, the Peregrine Falcon *Falco peregrinus*. Journal of Avian Biology 42:544–551.

Frankova, M., V. Stejskal, and R. Aulicky. 2019. Efficacy of rodenticide baits with decreased concentrations of brodifacoum: validation of the impact of the new EU anticoagulant regulation. Scientific Reports 9:16779.

GBIF.org (Global Biodiversity Information Facility) (2021). Occurrence Download. Available at https://doi.org/10.15468/dl.ftgf62.

Gerlach H. 1994. Viruses. Pages 862–948 *in* Avian medicine: principles and applications (B. W. Ritchie, B. J. Harrison, and L. R. Harrison, Eds.). Wingers Publishing, Lake Worth, FL.

Gertner, L. 2017. Eagle Cliff. The historical marker database. <HMdb.org>. Accessed 21 February 2023.

Good, R. E., R. M. Nielson, H. Sawyer, and L. L. McDonald. 2007. A population estimate for Golden Eagles in the western United States. Journal of Wildlife Management 71:395–402.

Gouvernement du Québec. 2017. Mesure de protection de l'aigle royal à l'égard des activités d'aménagement forestier. Sous-comité faune de l'Entente administrative, Québec, Canada. [In French.]

Government of Canada. 2015. Golden Eagle (*Aquila chrysaetos*). https://wildlife-species.canada.ca/bird-status/oiseau-bird-eng.aspx?sY=2014&sL=e&sB=GOEA&sM=a. Accessed 1 November 2021.

Government of Canada. 2017. Birds protected under the Migratory Birds Convention Act. https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legal-protection/convention-act.html. Accessed 1 November 2021.

Goyal, S. M., N. Jindal, Y. Chander, M. A. Ramakrishnan, P. T. Redig, and A. Sreevatsan. 2010. Isolation of mixed subtypes of influenza A virus from a Bald Eagle (*Haliaeetus leucocephalus*). Virology Journal 7:174.

Greiner E.C. 2008. Isospora, atoxoplasma, and sarcocystis. Pages 108-119 *in* Parasitic diseases of wild birds (C. T. Atkinson, N. J. Thomas, and D. B. Hunter, Eds.). Wiley-Blackwell, Ames, IA.

Grove, G., and N. Bolgiano. 2012. Winter raptor survey in Pennsylvania-results from 2001-2011. Hawk Migration Studies 37:4–10.

Hanley, B. J., A. A. Dhondt, M. J. Forzán, E. M. Bunting, M. A. Pokras, K. P. Hynes, E. Dominguez-Villegas, and K. L. Schuler. 2022. Environmental lead reduces the resilience of bald eagle populations. Journal of Wildlife Management 86:e22177.

Harness, R. E., S. Milodragovich, and J. Schomburg. 2003. Raptors and power line collisions. Colorado Birds 37:118–122.

Herring, G., C. A. Eagles-Smith, and J. Buck. 2017. Characterizing Golden Eagle risk to lead and anticoagulant rodenticide exposure: a review. Journal of Raptor Research 51:273–292.

Horns, J. J., F. R. Adler, and Ç. H. Şekercioğlu. 2018. Using opportunistic citizen science data to estimate avian population trends. Biological Conservation 221:151–159.

Hunt, W. G. 2002. Golden Eagles in a perilous landscape: predicting the effects of mitigation for wind turbine blade-strike mortality. Report P500-02-043F. California Energy Commission, PIER – Environmental Area, Sacramento, CA.

Hunt, W. G., W. Burnham, C. N. Parish, K. Burnham, B. Mutch, and J. L. Oaks. 2006. Bullet fragments in deer remains: implications for lead exposure in scavengers. Wildlife Society Bulletin 34:167-170.

Hussell, D. J. T., and E. Ruelas Inzunza. 2008. Long-term monitoring: the Raptor Population Index in principle. Pages 151-164 in State of North America's Birds of Prey (K. L. Bildstein, J. P. Smith, and E. Ruelas I., and R. R. Veit, Eds.). Series in Ornithology, No. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

IWGSCC (Interagency Working Group on the Social Cost of Carbon). 2010. Technical support document: social cost of carbon for regulatory impact analysis under executive order 13990. Washington, DC.

IPCC (Intergovernmental Panel on Climate Change). 2007. Report of the Intergovernmental Panel on Climate Change (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, Eds.). Cambridge University Press, Cambridge, UK and New York, NY.

Jachowski, D. S., T. Katzner, J. L. Rodrigue, and W. M. Ford. 2015. Monitoring landscape-level distribution and migration phenology of raptors using a volunteer camera-trap network: raptor camera-trapping. Wildlife Society Bulletin 39:553–63.

Johnston, N. N., J. E. Bradley, and K. A. Otter. 2014. Increased flight altitudes among migrating Golden Eagles suggest turbine avoidance at a Rocky Mountain wind installation. PLoS ONE 9:e93030.

Jones, M.P., 2006. Selected infectious diseases of birds of prey. Journal of Exotic Pet Medicine 15:5-17.

Jones, M. P., and S. E. Orosz. 2000. The diagnosis of aspergillosis in birds. Seminars in Avian and Exotic Pet Medicine 9:52–58.

Joseph, V. 2000. Aspergillosis in Raptors. Seminars in Avian and Exotic Pet Medicine 9:66-74.

Kaisanlahti-Jokimaki, M.L., J. Jokimaki. E. Huhta, M. Ukkola, P. Helle, and T. Ollila. 2008. Territory occupancy and breeding success of the Golden Eagle (*Aquila chrysaetos*) around tourist destinations in northern Finland. Ornis Fennica 85:2–12.

Katzner, T. E., M. N. Kochert, K. Steenhof, C. L. McIntyre, E. H. Craig, and T. A. Miller. 2020. Golden Eagle (*Aquila chrysaetos*), version 2.0. Birds of the World (P. G. Rodewald and B. K. Keeney, Eds.). Cornell Lab of Ornithology, Ithaca, NY.

Katzner, T. E., D. Brandes, T. Miller, M. Lanzone, C. Maisonneuve, J. A. Tremblay, R. Mulvihill, and G. T. Merovich, Jr. 2012b. Topography drives migratory flight altitude of golden eagles: implications for on-shore wind energy development. Journal of Applied Ecology 49:1178–1186.

Katzner, T. E., B. W. Smith, T. A. Miller, D. Brandes, J. Cooper, M. J. Lanzone, D. W. Brauning, C. Farmer, S. Harding, D. E. Kramar, C. Koppie, C. Maisonneuve, M. Martell, E. K. Mojica, C. Todd, J. A. Tremblay, M. Wheeler, D. F. Brinker, T. E. Chubbs, R. Gubler, K. O'Malley, S. Mehus, B. Porter, R. P. Brooks, B. D. Watts, and K. L. Bildstein. 2012a. Status, biology, and conservation priorities for North America's eastern Golden Eagle (*Aquila chrysaetos*) population. Auk 129:168–176.

Kelly, C. A., and J. Tomcho Jr. 2017. A camera-trap survey documents widespread distribution of over-wintering Golden Eagles in western North Carolina. The Chat 81:60–79.

Kendall, M.G. 1948. Rank correlation methods. Griffin, London, UK.

Kerley, L. L., and J. C. Slaght. 2013. First documented predation of sika deer (*Cervus nippon*) by Golden Eagle (*Aquila chrysaetos*) in Russian Far East. Journal of Raptor Research 47:328–330.

Kerlinger, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, IL.

Kochert, M. N., and K. Steenhof. 2002. Golden Eagles in the U.S. and Canada: Status, trends, and conservation challenges. Journal of Raptor Research 36:32–40.

Kramer, J. L., and P. T. Redig. 1997. Sixteen years of lead poisoning in eagles, 1980-95: An epizootiologic view. Journal of Raptor Research 31:327-332.

KTVB. 2022. Two Treasure Valley men sentenced after shooting golden eagle. 16 June 2022. Available at https://www.ktvb.com/article/news/crime/treasure-valley-men-sentenced-after-shooting-golden-eagle/277-d8fe3015-e389-421d-b1f5-63a46f8a04a1.

Lamarre, V., P. Legagneux, A. Franke, N. Casajus, D. C. Currie, D. Berteaux, and J. Bêty. 2018. Precipitation and ectoparasitism reduce reproductive success in an arctic-nesting top-predator. Scientific Reports 8:8530.

Langner, H. W., R. Domenech, V. A. Slabe, and S. P. Sullivan. 2015. Lead and mercury in fall migrant Golden Eagles from western North America. Archives of Environmental Contamination and Toxicology 69:54–61.

Latta, S., L. C. Marshall, M. W. Frantz, and J. D. Toms. 2015. Evidence from two shale regions that a riparian songbird accumulates metals associated with hydraulic fracturing. Ecosphere 6:144.

Leighton F. A., and R. A. Heckert. 2007. Newcastle disease and related avian paramyxoviruses. Pages 3–16 *in* Infectious diseases of wild birds (N. J. Thomas, D. B. Hunter, and C. T. Atkinson, Eds.). Blackwell Publishing, Ames, IA.

Liguori, J., J. L. Watson, F. Nicoletti, and D. Oleyar. 2020. In-hand guide to diurnal North American raptors. HawkWatch International, Inc., Salt Lake City, UT.

Londe, D.W., Moeller, A.K., Lukacs, P.M., Fuhlendorf, S.D., Davis, C.A., Elmore, R.D. and Chitwood, M.C. 2023. Review of range-wide vital rates quantifies eastern wild turkey population trajectory. Ecology and Evolution 13:e9830.

Lonsdorf, E., C. A. Sanders-Reed, C. Boal, and T. D. Allison. 2018. Modeling Golden Eagle-vehicle collisions to design mitigation strategies. Journal of Wildlife Management 82:1633–1644.

Lutmerding, J. A., M. Rogosky, B. Peterjohn, J. McNicoll, and D. Bystrak. 2012. Summary of raptor encounter records at the Bird Banding Lab. Journal of Raptor Research 46:17–26.

Luzenski, J., C. E. Rocca, R. E. Harness, J. L. Cummings, D. D. Austin, M. A. Landon, and J. F. Dwyer. 2016. Collision avoidance by migrating raptors encountering a new electric power transmission line. Condor 118:402–410.

MacDonald, G. M. 2010. Global warming and the Arctic: a new world beyond the reach of the Grinnellian niche? Journal of Experimental Biology 213:855–861.

Mann, H. B. 1945. Nonparametric tests against trend. Econometrica 13:245–259.

Marneweck, C. J., T. E. Katzner, and D. S. Jachowski. 2021. Predicted climate-induced reductions in scavenging in eastern North America. Global Change Biology 27:3383–3394.

Maynard, L. D., J. F. Therrien, J. Lemaître, T. Booms, T. A. Miller, T. Katzner, S. Somershoe, J. Cooper, R. Sargent, and N. Lecomte. 2022. Interannual consistency of migration phenology is season-and breeding region-specific in North American Golden Eagles. Ornithology 139:ukac029.

McCabe, J. D., J. D. Clare, T. A. Miller, T. E. Katzner, J. Cooper, S. Somershoe, D. Hanni, C. A. Kelly, R. Sargent, E. C. Soehren, C. Threadgill, M. Maddox, J. Stober, M. Martell, T. Salo, A. Berry, M. J. Lanzone, M. A. Braham, and C. J. W. McClure. 2021. Resource selection functions based on hierarchical generalized additive models provide new insights into individual animal variation and species distributions. Ecography 44:1756–1768.

McGough, L. M. 2019. Partnerships and understanding between Kazakh pastoralists and Golden Eagles of the Altai Mountains: a multi-species ethnography. Dissertation, University of St. Andrews, Scotland, UK.

McIntyre, C. L., and L. G. Adams. 1999. Reproductive characteristics of migratory Golden Eagles in Denali National Park, Alaska. Condor 101:115–123.

McIntyre, C. L., and J. H. Schmidt. 2012. Ecological and environmental correlates of territory occupancy and breeding performance of migratory Golden Eagles *Aquila chrysaetos* in interior Alaska. Ibis 154:124–135.

McLean R. G., and S. R. Ubico. 2007. Arboviruses in birds. Pages 17-62 *in* Infectious diseases of wild birds (N. J. Thomas, D. B Hunter, and C. T. Atkinson, Eds.). Blackwell, Ames, IA.

Mehus, S., and M. Martell. 2010. A wintering population of Golden Eagles in southwestern Wisconsin and southeastern Minnesota. Passenger Pigeon 72:135–41.

Menkens, G. E., Jr., and S. H. Anderson. 1987. Nest site characteristics of a predominantly tree-nesting population of Golden Eagles. Journal Of Field Ornithology 58:22–25.

Miller, T. A. 2012. Movement ecology of Golden Eagles (*Aquila chrysaetos*) in eastern North America. Dissertation, Pennsylvania State University, State College, PA.

Miller, T. A., R. P. Brooks, M. Lanzone, D. Brandes, J. Cooper, C. Maisonneuve, J. Tremblay, J. Wilhelm, A. Duerr, and T. Katzner. 2016. Limitations and mechanisms influencing migratory performance of soaring birds. Ibis 158:116–134.

Miller, T. A., R. P. Brooks, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, A. Duerr, and T. Katzner. 2014. Assessing risk to birds from industrial wind energy development via paired resource selection models. Conservation Biology 28:745–755.

Miller, T. A., R. P. Brooks, M. J. Lanzone, J. Cooper, K. O'Malley, D. Brandes, A. Duerr, and T. E. Katzner. 2017. Summer and winter space use and home range characteristics of Golden Eagles (*Aquila chrysaetos*) in eastern North America. Condor: Ornithological Applications 119:697–719.

Miller, T.A., M.J. Lanzone, M.A. Braham, A.E. Duerr, J. Cooper, S. Somershoe, D. Hanni, E.C. Soehren, C. Threadgill, M. Maddox, J. Stober, C. Kelly, T. Salo, A. Berry, M. Martell, S. Mehus, B. Dirks, R. Sargent, and T.E. Katzner. 2023. Winter distribution of Golden Eagles (*Aquila chrysaetos*) in the eastern USA. Journal of Raptor Research. 57:522-532.

Millsap, B. A., and S. L. Vana. 1984. Distribution of wintering Golden Eagles in the eastern United States. Wilson Bulletin 96:692–701.

Millsap, B. A., G. S. Zimmerman, W. L. Kendall, J. G. Barnes, M. A. Braham, B. E. Bedrosian, D. A. Bell, P. H. Bloom, R. H. Crandall, R. Domenech, D. Driscoll, A. E. Duerr, R. Gerhardt, S. E. J. Gibbs, A. R. Harmata, K. Jacobson, T. E. Katzner, R. N. Knight, J. M. Lockhart, C. McIntyre, R. Murphy, S. J. Slater, B. W. Smith, J. P. Smith, D. W. Stahleker, and J. W. Watson. 2022. Age-specific survival rates, causes of death, and allowable take of Golden Eagles in the western United States. Ecological Applications 32:e2544.

Millsap, B. A., G. S. Zimmerman, J. R. Sauer, R. M. Nielson, M. Otto, E. Bjerre, and R. Murphy. 2013. Golden Eagle population trends in the western United States: 1968–2010. Journal of Wildlife Management 77:1436–1448.

MELCCFP (Ministère de l'Environnement, Ministère de la Lutte aux Changements Climatiques, and Ministère de la Faune et des Parcs). 2023. Sport hunting in Québec 2022–2024: animals that must be declared. Québec, Canada.

MRNF (Ministère des Ressources Naturelles et de la Faune). 2008. Protocole d'inventaires d'oiseaux de proie dans le cadre de projets d'implantation d'éoliennes au Québec –– 8 janvier 2008. Ministére des Ressources Naturelles et de la Faune, Secteur Faune Québec, Canada. [In French.]

MNRF (Ministère des Ressources Naturelles et de la Faune). 2016. Golden Eagle government response statement. https://www.ontario.ca/page/golden-eagle-government-response-statement. Accessed November 1, 2021.

Morneau, F., S. Brodeur, R. Décarie, S. Carrière, and D. M. Bird. 1994. Abundance and distribution of nesting Golden Eagles in Hudson Bay, Québec. Journal of Raptor Research 28:220–225.

Morneau, F., B. Gagnon, S. Poliquin, P. Lamothe, N. D'Astous, and J. A. Tremblay. 2012. Breeding status and population trends of Golden Eagles in northeastern Québec, Canada. Avian Conservation and Ecology 7:4.

Morneau, F., J. A. Tremblay, C. S. Todd, T. E. Chubbs, C. Maisonneuve, J. Lemaître, and T. E. Katzner. 2015. Known breeding distribution and abundance of Golden Eagle in eastern North America. Northeastern Naturalist 22:236–247.

NAS (National Audubon Society). 2019a. How climate change will reshape the range of the Golden Eagle. https://www.audubon.org/field-guide/bird/golden-eagle#bird-climate-vulnerability Accessed 27 Nov 2019.

NAS (National Audubon Society). 2019b. Survival by degrees: 389 bird species on the brink. Vulnerable Birds in Atlantic Flyway. https://www.audubon.org/climate/survivalbydegrees/flyway/atlantic. Accessed 27 Nov 2019.

NAS (National Audubon Society). 2020. The Christmas Bird Count historical results. http://www.christmasbirdcount.org. Accessed 01 August 2020.

NatureServe. 2021. NatureServe Explorer. https://explorer.natureserve.org. Accessed 01 March 2021.

Nelson, D. M., M. Braham, T. A. Miller, A. E. Duerr, J. Cooper, M. Lanzone, J. Lemaître, and T. Katzner. 2015. Stable hydrogen isotopes identify leapfrog migration, degree of connectivity, and summer distribution of Golden Eagles in eastern North America. Condor: Ornithological Applications 117:414–429.

Niedringhaus, K. D., N. M. Nemeth, S. Gibbs, J. Zimmerman, L. Shender, K. Slankard, H. Fenton, B. Charlie, M. F. Dalton, E. J. Elsmo, R. Poppenga, B. Millsap, and M. G. Ruder. 2021. Anticoagulant rodenticide exposure and toxicosis in Bald Eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) in the United States. PLoS ONE 16:e0246134.

Nielson, R. M., G. DiDonato, L. McManus, and L. L. McDonald. 2015. A survey of Golden Eagles (*Aquila chrysaetos*) in the western U.S.: mid-winter 2015. Western Ecosystems and Technology, Inc., Cheyenne, WY.

Nielson, R. M., and L. McManus. 2014. A survey of Golden Eagles (*Aquila chrysaetos*) in the western U.S.: mid-winter 2014. Western Ecosystems and Technology, Inc., Cheyenne, WY.

Nielson, R. M., L. McManus, T. Rintz, L. L. McDonald, R. K. Murphy, W. H. Howe, and R. E. Good. 2014. Monitoring abundance of Golden Eagles in the western United States. Journal of Wildlife Management 78:721–730.

Noble, D. G., J. E. Elliott, and J. L. Shutt. 1993. Environmental contaminants in Canadian raptors 1965–1989. Canadian Wildlife Service, National Wildlife Research Centre, Ottawa, ON, Canada.

NYSDEC (New York State Department of Environmental Conservation). 2014. Species assessment for Golden Eagle. Albany, New York, USA.

Olendorff, R. R., and R. N. Lehman. 1986. Raptor collisions with utility lines: an analysis using subjective field observations. Bureau of Land Management, Sacramento, CA. Report to Pacific Gas and Electric Company, San Ramon, California, USA. https://archive.org/details/raptorcollisions6801olen.

Orta, J. 1992. Golden Eagle *Aquila chrysaetos*. Pages 197–198 *in* Handbook of the birds of the world (J. del Hoyo, A. Elliott, J. Sargatal, and J. Cabot, Eds.). Lynx Edicions, Barcelona, Spain.

Pagel, J. E., K. J. Kritz, B. A. Millsap, R. K. Murphy, E. L. Kershner, and S. Covington. 2013. Bald and Golden Eagle mortalities at wind energy facilities in the contiguous United States. Journal of Raptor Research 47:311–315.

Palma, L., P. Beja, M. Pais, and L. C. da Fonseca. 2006. Why do raptors take domestic prey? the case of Bonelli's eagles and pigeons. Journal of Applied Ecology 43:1075–1086.

Paprocki, N., J. A. Heath, and S. J. Novak. 2014. Regional distribution shifts help explain local changes in wintering raptor abundance: implications for interpreting population trends. PLoS One 9:e86814.

Paprocki, N., D. Oleyar, D. Brandes, L. Goodrich, T. Crewe, and S. W. Hoffman. 2017. Combining migration and wintering counts to enhance understanding of population change in a generalist raptor species, the North American Red-tailed Hawk. Condor: Ornithological Applications 119:98–107.

Pardieck, K. L., D. J. Ziolkowski Jr., M. Lutmerding, V. I. Aponte, and M. A. R. Hudson. 2020. North American Breeding Bird Survey dataset 1966–2019: U.S. Geological Survey Data Release. U.S. Geological Survey, Washington, DC.

PGC (Pennsylvania Game Commission). 2013. Pennsylvania Game Commission wind energy voluntary cooperation agreement: Amendment 1. Pennsylvania Game Commission, Harrisburg, PA.

Pirotta, E., T. Katzner, T. A. Miller, A. E. Duerr, M. A. Braham, and L. New. 2018. State space modelling of the flight behaviour of a soaring bird provides new insights to migratory strategies. Functional Ecology 32:2205–2215.

Prior-Magee, J. S., L. J. Johnson, M. J. Croft, M. L. Case, C. M. Belyea, and M. L. Voge. 2020. Protected Areas Database of the United States (PAD-US) 2.1: provisional release. Available at https://www.sciencebase.gov/catalog/item/5f186a2082cef313ed843257.

Real, J., S. Mañosa, and E. Muñoz. 2006. Trichomoniasis in a Bonelli's Eagle population in Spain. Journal of Wildlife Diseases 36:64–70.

Redig, P. 2000. Aspergillosis. Pages 275–287 *in* Avian Medicine (Samour, J., Ed). Mosby, London, UK.

Riginos, C., B. Bedrosian, and H. Copeland. 2017. Priority areas for reducing Golden Eagle-vehicle mortalities in Wyoming. Final report to National Fish and Wildlife Foundation, Washington, DC.

Ritchie, R. J., and J. A. Curatolo. 1982. Notes on Golden Eagle productivity and nest site characteristics, Porcupine River, Alaska. Journal of Raptor Research 16:123–127.

Ritchie, B. W. (Ed.). 1995. Avian viruses: function and control. Wingers Publishing, Lake Worth, FL.

Robinson, B. G., A. Franke, and A. E. Derocher. 2017. Weather-mediated decline in prey delivery rates causes food-limitation in a top avian predator. Journal of Avian Biology 48:748–758.

Rooney, T.P. 2001. Deer impacts on forest ecosystems: a North American perspective. Forestry 74:201-208.

Rosenfield, R. N., D. Lamers, D. L. Evans, M. Evans, and J. A. Cava. 2011. Shift to later timing by autumnal migrating Sharp-shinned Hawks. Wilson Journal of Ornithology 123:154–158.

Rus, A. I., A. E. Duerr, T. A. Miller, J. R. Belthoff, and T. E. Katzner. 2017. Counterintuitive roles of experience and weather on migratory performance. Auk: Ornithological Advances 134:485–497.

Russell, R. E., and J. C. Franson. 2014. Causes of mortality in eagles submitted to the National Wildlife Health Center 1975–2013. Wildlife Society Bulletin 38:697–704.

Samour, J. H., and J. L. Naldo. 2003. Diagnosis and therapeutic management of trichomoniasis in falcons in Saudi Arabia. Journal of Avian Medicine and Surgery 17:136–143.

Schulz, J. H., S. A. Wilhelm Stanis, E. B. Webb, C. J. Li, and D. M. Hall. 2019. Communication strategies for reducing lead poisoning in wildlife and human health risks. Wildlife Society Bulletin 43:131–140.

Sergio, F., I. Newton, and L. Marchesi. 2005. Top predators and biodiversity. Nature 436:192.

Settele, J., R. Scholes, R. Betts, S. Bunn, P. Leadley, D. Nepstad, J. T. Overpeck, and M. A. Taboada. 2014. Terrestrial and inland water systems. Pages 271-359 *in* Climate change 2014: impacts, adaptation and vulnerability (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mas-trandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White Eds.). Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY.

Slabe, V. A. 2019. Lead exposure of North American raptors. Dissertation, West Virginia University, Morgantown, WV.

Slabe, V. A., J. T. Anderson, J. Cooper, T. A. Miller, B. Brown, A. Wrona, P. Ortiz, J. Buchweitz, D. McRuer, E. Dominguez Villegas, S. Behmke, and T. Katzner. 2020. Feeding ecology drives lead exposure of facultative and obligate avian scavengers in the eastern United States. Environmental Toxicology and Chemistry 39:882–892.

Slabe, V. A., J. T. Anderson, B. A. Millsap, J. L. Cooper, A. R. Harmata, M. Restani, R. H. Crandall, B. Bodenstein, P. H. Bloom, T. Booms, J. Buchweitz, R. Culver, K. Dickerson, R. Domenech, E. Dominguez-Villegas, D. Driscoll, B. W. Smith, M. J. Lockhart, D. McRuer, T. A. Miller, P. A. Ortiz, K. Rogers, M. Schwarz, N. Turley, B. Woodbridge, M. E. Finkelstein, C. A. Triana, C. R. DeSorbo, and T. E. Katzner. 2022. Demographic implications of lead poisoning for eagles across North America. Science 375:779–782.

Smith, G. J. 2013. U.S. Geological Survey Bird Banding Laboratory: an integrated scientific program supporting research and conservation of North American birds. U.S. Geological Survey, Washington, DC.

Snow, D., C. M. Perrins, and R. Gillmor. 1998. Non-passerines. Pages 376-379 *in* The birds of the Western Palearctic: concise edition (C. M. Perrins, Ed.). Oxford University Press, Oxford, UK and New York, NY.

Sovacool, B. 2013. The avian benefits of wind energy: a 2009 update. Renewable Energy. 49:19–24.

Spiess, J., D. A. McGranahan, G. Whippo, B. Poling, A. L. M. Daigh, and T. Hovick. 2019. Bird and invertebrate communities appear unaffected by fracking traffic along rural roads despite dust emissions. Ambio 49:605–615.

Spofford, W. R. 1971a. The breeding status of the Golden Eagle in the Appalachians. American Birds 25:3–7.

Spofford, W. R. 1971b. The Golden Eagle: rediscovered. Conservationist 26:6–8.

Stallknecht, D.E., Nagy, E., Hunter, D.B. and Slemons, R.D., 2007. Avian influenza. Pages 108 – 130 *in* Infectious diseases of wild birds (N. J. Thomas, D. B. Hunter, and C. T. Atkinson, Eds). Blackwell, Ames, IA.

Steenhof, K., L. Bond, and L. Dunn. 2008. The midwinter bald eagle survey results and analysis 1986 - 2005. U.S. Geological Survey, National Biological Information Infrastructure, and Northwest Alliance for Computational Science and Engineering. Available at http://gis.nacse.org/eagles/.

Steenhof, K., J. L. Brown, and M. N. Kochert. 2014. Temporal and spatial changes in Golden Eagle reproduction in relation to increased off highway vehicle activity. Wildlife Society Bulletin 38:682–688.

Steenhof, K., M. N. Kochert, and T. L. Mcdonald. 1997. Interactive effects of prey and weather on Golden Eagle reproduction. Journal of Animal Ecology 66:350–362.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. Journal of Wildlife Management 57:271–281.

Sullivan, B. L., C. L. Wood, M. J. Iliff, R. E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation 142:2282–2292.

Taucher, J., T. Librandi Mumma, and W. Capouillez. 2012. Pennsylvania Game Commission wind energy voluntary cooperation agreement: third summary report. Pennsylvania Game Commission, Harrisburg, PA.

Tell, L. A. 2005. Aspergillosis in mammals and birds: impact on veterinary medicine. Medical Mycology 43, Issue Supplement 1:S71—S73.

Theoi Project. 2017. Eagle of Zeus. https://www.theoi.com/Ther/AetosDios.html. Accessed 27 Nov 2022.

Therrien, J. F., N. Lecomte, T. Zgirski, M. Jaffré, A. Beardsell, L. J. Goodrich, J. Bêty, A. Franke, E. Zlonis, and K. L. Bildstein. 2017. Long-term phenological shifts in migration and breeding-area residency in eastern North American raptors. Auk: Ornithological Advances 134:871–881.

Todd, C. S. 1989. Golden Eagle. Pages 65–70 *in* Proceedings of the Northeast Raptor Management Symposium and Workshop (B. G. Pendleton, W. N. Le Franc Jr., M. B. Moss, C. E. Ruibal, M. A. Knighton, and D. L. Krabe,Eds.). National Wildlife Federation, Washington, DC.

Todd, C. S. 2000. Golden Eagle assessment. Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Trail, P. 2006. Avian mortality at oil pits in the United States: a review of the problem and efforts for its solution. Environmental Management 38:532–544.

USDA (US Department of Agriculture). 2023. 2022–2023 detections of highly pathogenic avian influenza in wild birds. https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-wild-birds. Accessed 3 January 2023.

USFWS (U.S. Fish and Wildlife Service). 2012. Land-based wind energy guidelines. U.S. Fish and Wildlife Service, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 2013. Eagle conservation plan guidance: module 1 - land-based wind energy, version 2. Division of Migratory Bird Management, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 2016a. Bald and Golden Eagles: population demographics and estimation of sustainable take in the United States: 2016 update. Division of Migratory Bird Management, Washington DC.

USFWS (U.S. Fish and Wildlife Service). 2016b. Programmatic environmental impact statement for the eagle rule revision. U.S. Fish and Wildlife Service, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 2016c. Record of decision for the programmatic environmental impact statement for the eagle rule revision. U.S. Fish and Wildlife Service, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 2022. Permits for incidental take of eagles and eagle nests. FWS-HQ-MB-2020-0023. U.S. Fish and Wildlife Service, Washington, DC.

Van Buskirk, J. 2012. Changes in the annual cycle of North American raptors associated with recent shifts in migration timing. Auk 129:691–698.

van Riper III, C., and D. J. Forrester. 2007. Avian pox. Pages 131–176 *in* Infectious diseases of wild birds (N. J. Thomas, D. B. Hunter, and C. T. Atkinson, Eds.). Blackwell, Ames, IA.

Viverette, C. B., S. Struve, L. J. Goodrich, and K. L. Bildstein. 1996. Decreases in migrating Sharp-shinned Hawks (*Accipiter striatus*) at traditional raptor-migration watch sites in eastern North America. Auk: Ornithological Advances 113:32–40.

Vukovich, M., K. L. Turner, T. E. Grazia, T. Mims, J. C. Beasley, and J. C. Kilgo. 2015. Wintering Golden Eagles on the coastal plain of South Carolina. Journal of Field Ornithology 86:337–344.

Warner, T. A., T. A. Miller, I. P. La Puma, L. A. Nolan, N. S. Skowronski, and A. E. Maxwell. 2022. Exploring Golden Eagle habitat preference using lidar-based canopy bulk density. Remote Sensing Letters 13:556–567.

Watson, J. 2010. The Golden Eagle. Second edition. T. & A. D. Poyser, London, UK.

Watson, J.W., and R.W. Davies. 2015. Lead, mercury, and DDE in the blood of nesting golden eagles in the Columbia Basin, Washington. Journal of Raptor Research 49:217-221.

Watson, J., S. R. Rae, and R. Stillman. 1992. Nesting density and breeding success of Golden Eagles in relation to food supply in Scotland. Journal of Animal Ecology 61:543–550.

Wheeler, M. 2014. The genetics of conservation translocations: a comparison of North American Golden eagles (*Aquila chrysaetos canadensis*) and Bald eagles (*Haliaeetus leucocephalus*). Dissertation, Duquesne University, Pittsburgh, PA.

Wickham, J. D., P. Bohall Wood, M. C. Nicholson, W. Jenkins, D. Druckenbrod, G. W. Suter, M. P. Strager, C. Mazzarella, W. Galloway, and J. Amos. 2013. The overlooked terrestrial impacts of mountaintop mining. Bioscience 63:335–348.

Wickham, J. D., K. H. Ritters, T. G. Wade, M. Coan, and C. Homer. 2007. The effect of Appalachian mountaintop mining on interior forest. Landscape Ecology 22:179–187.

Winegrad, G., 2004. Wind turbines and birds. Pages 22–24 *in* Proceedings of the Wind Energy and Birds/Bats Workshop: understanding and resolving bird and bat impacts (Susan Schwartz, Ed.). Resolve, Washington, DC.

Wingfield, G. A. 1991. Central plains buteos and Golden Eagle. Pages 60–68 *in* Proceedings of the Midwest Raptor Management Symposium and Workshop (B. L. G. Pendleton and D. L. Krahe, Eds.). National Wildlife Federation, Washington, DC.

Wünschmann, A., D. Rejmanek, P. A. Conrad, N. Hall, L. Cruz-Martinez, S. B. Vaughn, and B. C. Barr. 2010. Natural fatal *Sarcocystis falcatula* infections in free-ranging eagles in North America. Journal of Veterinary Diagnostic Investigation 22:282–289.

Wünschmann, A., N. Timurkaan, A. G. Armién, I. Bueno-Padilla, A. Glaser, and P. T. Redig. 2014. Clinical, pathological, and immunohistochemical findings in Bald Eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) naturally infected with West Nile virus. Journal of Veterinary Diagnostic Investigation 26:599–609.

Wyshynski, S. A., and T. L. Pulfer. 2015. Recovery strategy for the Golden Eagle (*Aquila chrysaetos*) in Ontario. Ontario recovery strategy series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, ON, Canada.

TABLES & FIGURES

Table 1. Summary of migration counts and count trends for Eastern Golden Eagles during the period 2004–2019 at sites where trend data were estimated. Count indices are from the Raptor Population Index (RPI), downloadable from NatureCounts (Birds Canada 2018).

Site	Location	Season	USFWS Flyway	Annual Count*	Annual Index†	Trend‡
Allegheny Front	PA, U.S.A.	Fall	Atlantic	193	0.296	+
Allegheny Front	PA, U.S.A.	Spring	Atlantic	67	0.205	+
Derby Hill	NY, U.S.A.	Spring	Atlantic	58	0.117	NS
Franklin Mountain	NY, U.S.A.	Fall	Atlantic	183	0.575	NS
Hawk Mountain	PA, U.S.A.	Fall	Atlantic	127	0.173	NS
Stone Mountain	PA, U.S.A.	Fall	Atlantic	122	0.321	NS
Tussey Mountain	PA, U.S.A.	Spring	Atlantic	182	0.407	NS
Waggoner's Gap	PA, U.S.A.	Fall	Atlantic	228	0.309	NS
Hawk Ridge	MN, U.S.A.	Fall	Mississippi	183	0.586	NS
Holiday Beach	ONT, CAN	Fall	Mississippi	73	0.137	-
Whitefish Point	MI, U.S.A.	Spring	Mississippi	69	0.160	NS

**"Annual Count" denotes the mean number of individuals recorded annually.*
†"Annual Index" denotes the mean of the annual count indices that incorporated annual variation in site coverage.
‡Direction of trend during the study period, whether positive (+), negative (-), or not significant (NS), as determined by a Mann-Kendall (non-parametric) test ($p < 0.05$).

Table 2. Conservation status of Golden Eagles by jurisdiction in Canadian provinces of eastern North America. NatureServe does not list conservation statuses for the species in New Brunswick, Nova Scotia, or Prince Edward Island.

Jurisdiction	NatureServe Status	Flyway
Canada (country-wide)	N4N5B, N4N5N	
Manitoba	S1B, S2N	Mississippi
New Brunswick	-	Atlantic
Newfoundland and Labrador	S2B, SUM	Atlantic
Northwest Territories	S4	Central/Pacific
Nova Scotia	-	Atlantic
Nunavut	S3B	Atlantic
Ontario	S1B, S4N	Atlantic
Prince Edward Island	-	Atlantic
Saskatchewan	S3B, S4M, S3N	Mississippi
Québec	S3B	Atlantic

[*]NatureServe status given as N = national, or S = state/province; status of H = possibly extirpated, 1 = critically imperiled, 2= imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure, NA = not applicable, U = unrankable; seasonal qualifier of B = breeding, N = non-breeding, M = migrant (NatureServe 2021).

Table 3. Conservation status of Golden Eagles by jurisdiction in the eastern U.S.A. NatureServe does not list a status for the species in the District of Columbia, North Carolina, or Rhode Island.

Jurisdiction	NatureServe Status	Flyway
United States of America (country-wide)	N5B, N5N	
Alabama	SNRN	Mississippi
Arkansas	S3N	Mississippi
Connecticut	SNA	Atlantic
Delaware	SNA	Atlantic
District of Columbia	-	Atlantic
Florida	SNA	Atlantic
Georgia	S1	Atlantic
Illinois	SNA	Mississippi
Indiana	S1N	Mississippi
Iowa	SNA	Mississippi
Kentucky	SXB, S2N	Mississippi
Louisiana	S1N	Mississippi
Maine	S1B, S1N	Mississippi
Maryland	S1N	Atlantic
Massachusetts	S1N	Atlantic
Michigan	SNRN	Mississippi
Minnesota	SNRN, SNRM	Mississippi
Mississippi	S1N	Mississippi
Missouri	SNRN	Mississippi
New Hampshire	SHB	Atlantic
New Jersey	S4N	Atlantic
New York	SHB, S1N	Atlantic
North Carolina	-	Atlantic
Ohio	SNA	Mississippi
Pennsylvania	S5N, S4M	Atlantic
Rhode Island	-	Atlantic
South Carolina	S1N	Atlantic
Tennessee	S1	Mississippi
Vermont	SNA	Atlantic
Virginia	SHB, S1N	Atlantic
West Virginia	S3N	Atlantic
Wisconsin	S2N	Mississippi

[*]NatureServe status given as N = national, or S = state/province; status of H = possibly extirpated, 1 = critically imperiled, 2= imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure, NA = not applicable, NR = unranked, X = presumed extirpated; seasonal qualifier of B = breeding, N = non-breeding, M = migrant (NatureServe 2021).

Table 4. Summary of laws relevant to Eastern Golden Eagle, by U.S. state, within the range of the population, and as of 2022. SSC = Species of Special Concern; SSS = Special Status Species; DNM = Deemed in Need of Management; SGCN = Species of Greatest Conservation Need in the State Wildlife Action Plan (SWAP); SINC = Species in Need of Conservation, NSS = no special status. Legal status: E = Endangered (and, in NY, extirpated), T = threatened

State	Status	Laws and Regulations (citations)	SWAP Status
Alabama	NSS	Covered under the protect nongame species - statute 220-2-.92	SGCN Priority 2 (High Conservation Concern)
Arkansas	NSS	Not known	No status
Connecticut	NSS	Ch. 490, sect. 26-92: No person shall catch, kill or purchase or attempt to catch, kill or purchase, sell, offer, or expose for sale or have in possession, living or dead, any wild bird other than a game bird.	No status
Delaware	NSS	Adoption of federal law that prohibits protected wildlife from hunting, possessing or selling under Delaware Administrative Code Title 7, Sect. 3900, Regulation 3.0.	SGCN
Florida	NSS	Not known	No status
Georgia	NSS	Title 27-1-28: Except as otherwise provided by law, rule, or regulation, it shall be unlawful to hunt, trap, fish, take, possess, or transport any nongame species of wildlife	No status
Illinois	NSS	Chapter 520 ILCS (Illinois Compiled Statutes), Section 5/2.2.: Game Protective Regulation – Wild birds and mammals protected under this Act	No status
Indiana	NSS	IN Code § 14-22-6-2 “Sec. 2. A person may not: (1) take, possess, sell, offer for sale, purchase, or offer to purchase; (2) ship, transport, or carry; or (3) deliver or receive for shipment, transportation, or carriage in any manner outside Indiana; a migratory bird designated in this article or a part, nest, or egg of a migratory bird, except as otherwise permitted by this article.”	No status
Iowa	NSS	Not known	No status
Kentucky	NSS	State protection of native birds	No status
Louisiana	NSS	Not known	No status
Maine	E	Protected under Maine ESA	SGCN Priority 2 (High Priority
Maryland	NSS	Protected from hunting, destroying, or possessing per state law. Maryland Code10-401	SGCN B (High Conservation Status)

State	Status	Laws and Regulations (citations)	SWAP Status
Massachusetts	NSS	Birds of prey are protected: No person shall take, molest, disturb, destroy, or have in his possession the nest or eggs of any such bird unless otherwise authorized by the director. Mass. Section Chapter 131, 75A	None, may be added as a priority species during next SWAP revision
Michigan	NSS	Not known	No status
Minnesota	NSS	Not known	No status
Mississippi	NSS	No laws specific to Golden Eagles. Miss. Code Ann. § 49-5-7 states that “no wild bird…shall be pursued, taken, wounded, killed, captured, possessed or exported at any time, dead or alive; no person shall molest, take or destroy or attempt to molest, take or destroy….”.	SGCN Tier II (Conservation Action)
Missouri	NSS	No state protections	No status
New Hampshire	E	Listed as NH state endangered so protected under NH Endangered Species Act (RSA 212 A.). Also protected under a state Bald and Golden Eagle Act.	SGCN
New Jersey	NSS	N.J.A.C. 7:25-4.17 Section 7:25-4.17 List providing conservation status of New Jersey's indigenous nongame wildlife species	SGCN Priority
New York	E	11-0537. It shall be unlawful to knowingly or with wanton disregard for the consequences of this act to take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or in any manner, any Bald Eagle commonly known as the American Eagle, or any Golden Eagle, alive or dead, or any part, nest, or egg thereof of the foregoing eagles without a permit from a lawful authority.	SGCN
North Carolina	NSS	No state protections	None, listed as a Knowledge Gap Species
Ohio	NSS	State law that prohibits ‘take’ of any wild animal unless permitted by the Chief of Wildlife. Ohio revised code, section 1531.02	No status
Pennsylvania	NSS	Title 34 Game and Wildlife Code (Chapter 21; Subchapter A; General Provisions; Section 2103; and other applicable sections of Title 34/58) applies federal laws	SGCN
Rhode Island	NSS	Not known	No status

State	Status	Laws and Regulations (citations)	SWAP Status
South Carolina	NSS	SECTION 501110. Adopts the federal Migratory Bird Treaty Act as the law of the state SECTION 5011820. Unlawful to kill, catch, have in possession, or offer or expose for sale resident or migratory wild bird; exception. SECTION 5011830. Unlawful to sell or have in possession for sale plumage, skin, or body of protected bird. SECTION 5011840. Destroying active wild bird nest or eggs; permit for removal. SECTION 5011852. Unlawful to molest or kill birds of prey; Bald Eagles; penalties. 123-160 Vultures, Kites, Hawks, Eagles, Ospreys, Falcons, and Owls possession, transport, etc. 123-170 South Carolina State Falconry Regulations.	No status
Tennessee	T	State mostly defers to federal regulations for laws for the species	SGCN Tier I (Species in Need of Management)
Vermont	NSS	All birds protected from incidental take V.S.A, Section 4902	No status
Virginia	NSS	Code of Virginia § 29.1-521. Unlawful to hunt, trap, possess, sell or transport wild birds and wild animals except as permitted.	SGCN Tier I (Critical Conservation Need)
West Virginia	NSS	State protection under state code, 20-2-5c (https://code.wvlegislature.gov/20-2-5C/).	SGCN Priority 1
Wisconsin	NSS	Not known	No status

Table 5. Summary of provincial laws relevant to Eastern Golden Eagle, by Canadian province in the range of the population. NSS = no special status.

Province	Legal Status	Additional Laws & Regulations
Manitoba	Protected as Falconiform	Wildlife Act (C.C.S.M. c. W130)
New Brunswick	NSS	Fish and Wildlife Act (SNB1980 Chapter F-14.1)
Newfoundland and Labrador	Protected as Raptor	Part V of the WildLife Act (O.C. 96-809)
Nova Scotia	NSS	
Nunavut	Protected as Falconiform	Consolidation of Wildlife Act (SNu 2003, c. 26)
Ontario	Protected as Endangered	Endangered Species Act, 2007 (S.O. 2007, c. 6)
Prince Edward Island	NSS	
Saskatchewan	NSS	
Québec	Protected as Vulnerable	Act Respecting Threatened and Vulnerable Species; Act Respecting the Conservation and Development of Wildlife (CQLR c. C-61.1)

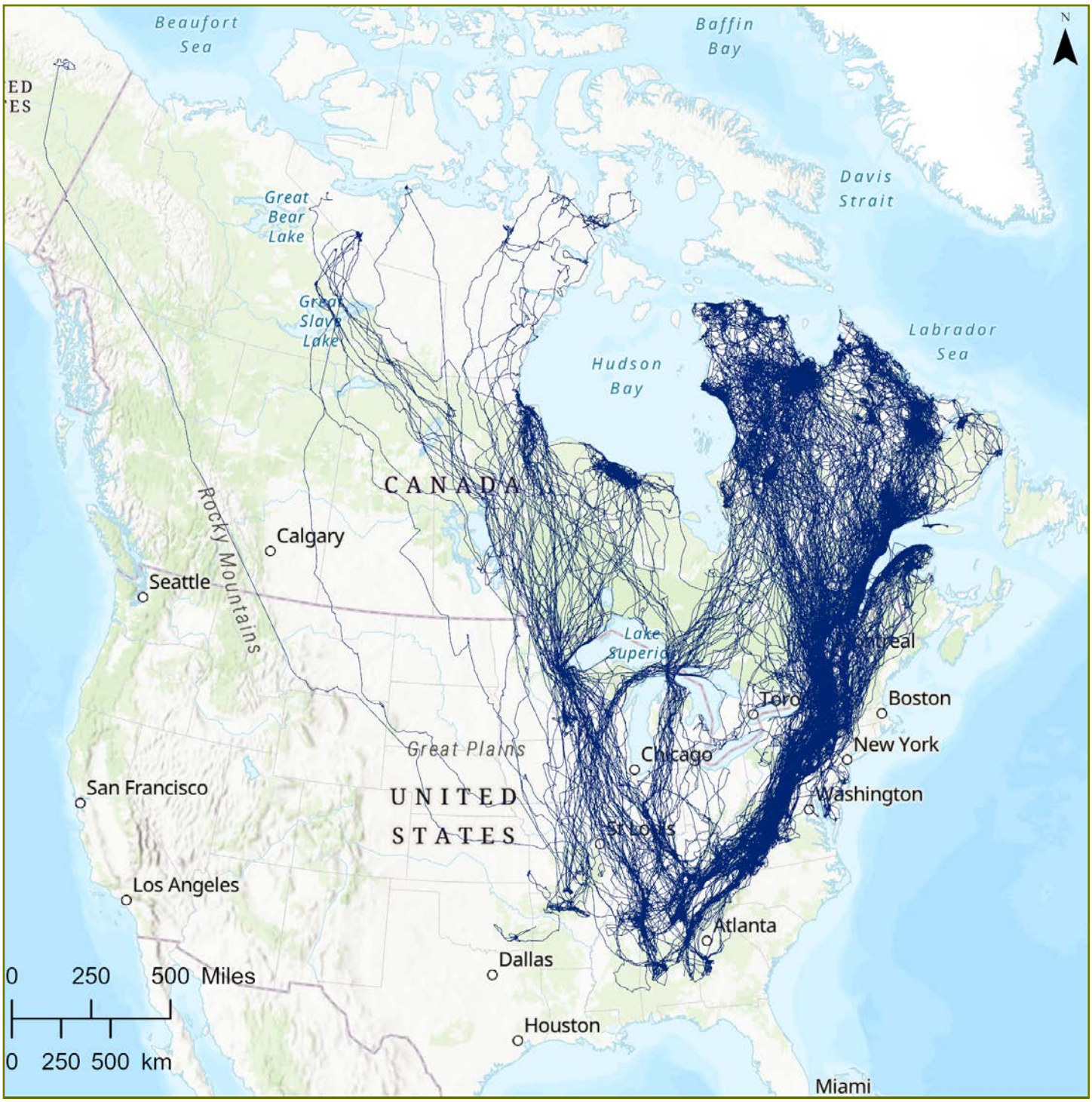


Figure 1. GPS telemetry tracks of 118 Golden Eagles captured in eastern North America. Northern areas (i.e., in Canada) comprise summering grounds, including breeding locations, and southern areas (i.e., in the midwestern and eastern U.S.A.) comprise wintering grounds, including spring and fall migration paths from 2006–2023. Note that this map is not representative of all areas used by Golden Eagles; there are limited telemetry data from areas of the southeast U.S.A. known to support wintering eagles (Vukovich et al. 2015, Kelly and Tomcho 2017).

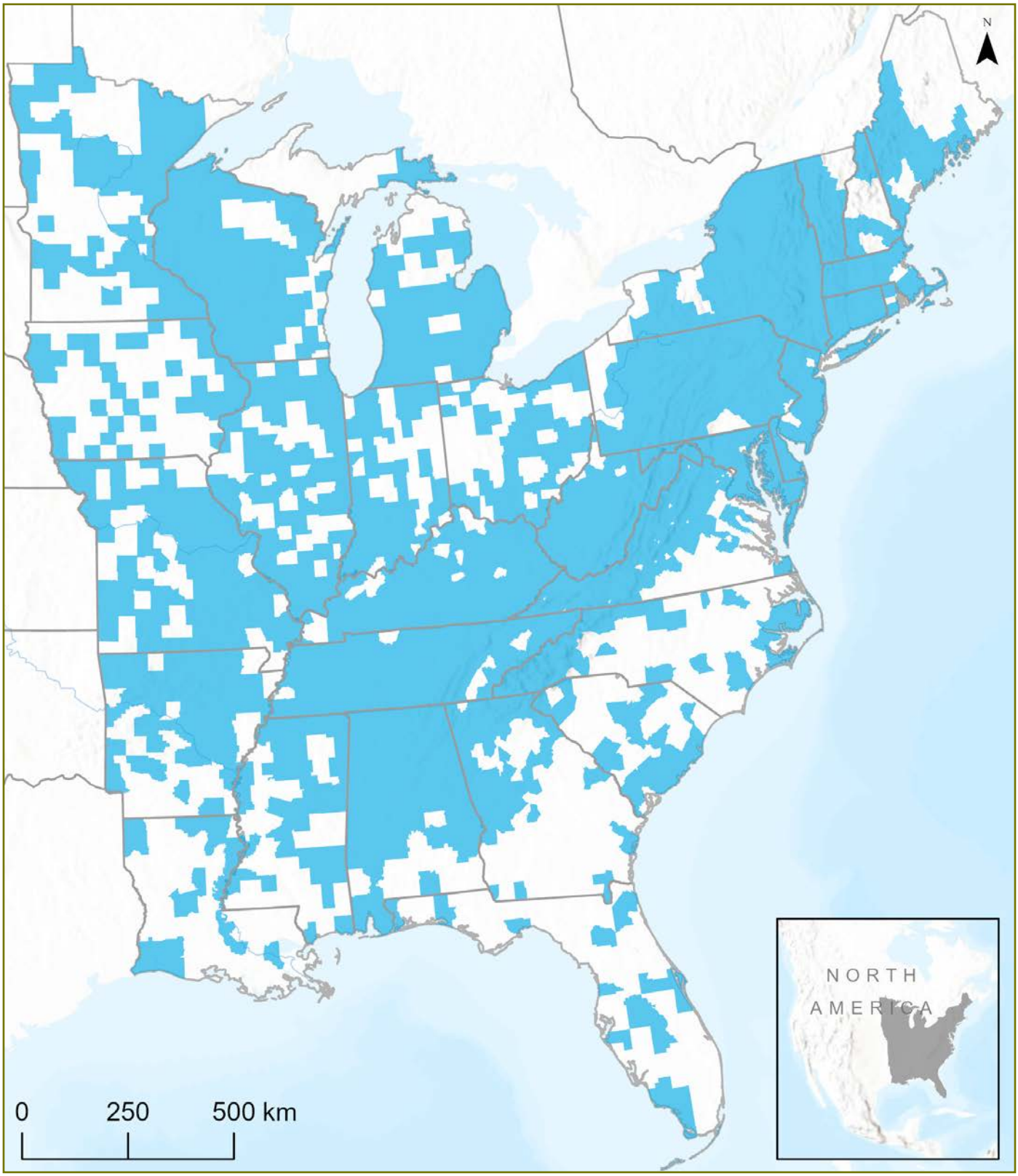


Figure 2. Winter distribution of Golden Eagles in the eastern United States, by county, modified from Miller et al. (2023). Counties shown have at least one Golden Eagle observation. Golden eagle records spanned from 1853 – 2022. Data sources included records obtained from a review of the literature and ornithological records, eBird (Sullivan et al. 2009, eBird 2020), Global Biodiversity Information Facility (GBIF) (GBIF.org 2021), Christmas Bird Count (CBC) (NAS 2020), Midwinter Bald Eagle Survey (MBES) (Steenhof et al. 2008, Eakle et al. 2013), National Eagle Center Golden Eagle Survey (NECGES) (www.nationaleaglecenter.org), Winter Raptor Survey (Grove and Bolgiano 2012), and telemetry data (Eastern Golden Eagle Working Group, 2006 – 2022).

Figure 3. Distribution of selected migration count sites in northeastern North America, including spring (squares), autumn (circles), and both spring and autumn (triangles) sites. Only sites with ≥ 10 years of data were selected for display and inclusion in the analysis. Count data for these and other sites are available at http://hawkcount.org/.

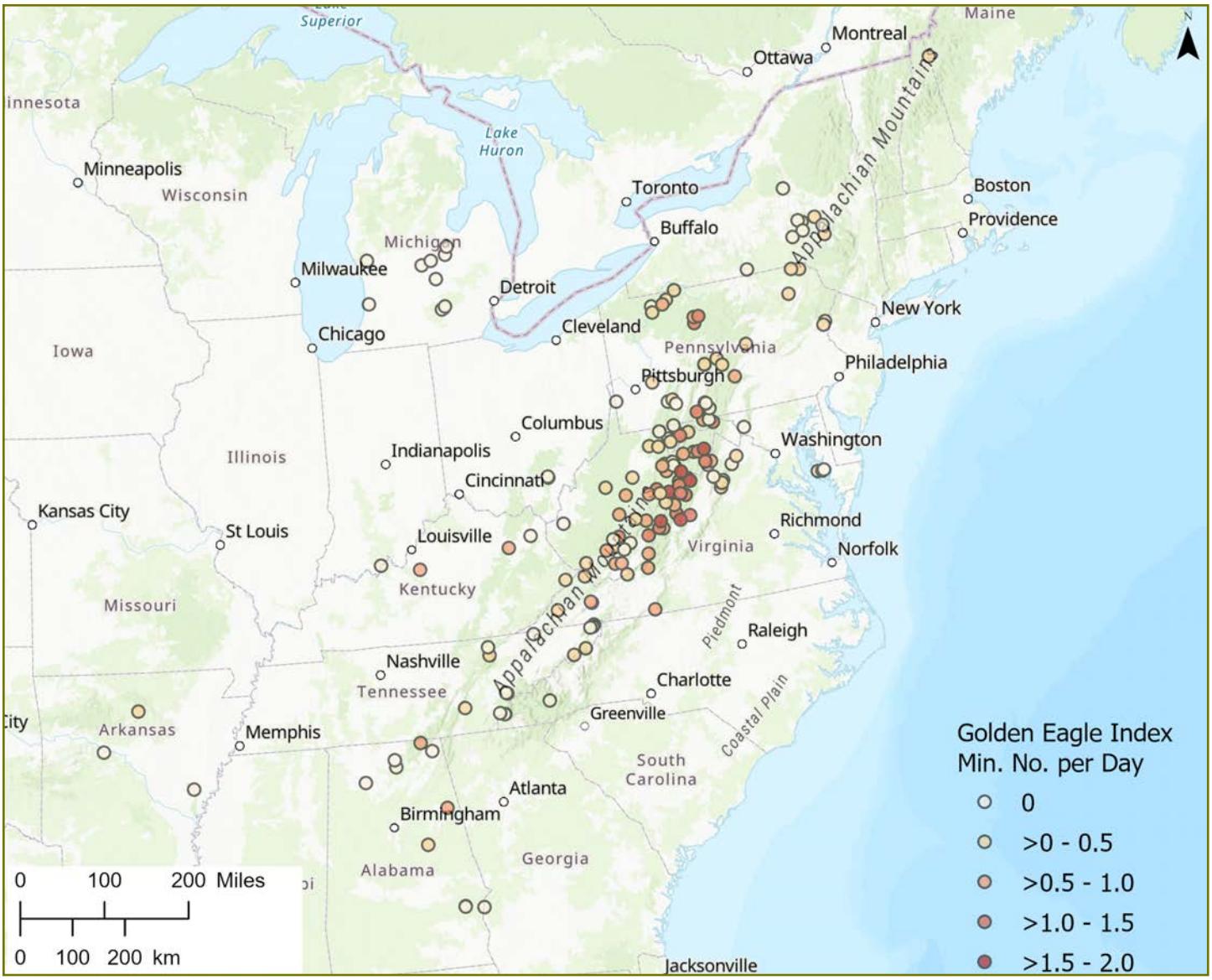


Figure 4. Index of Golden Eagle abundance at camera trap sites operated in January and February from 2008 to 2013 in eastern North America. Though not depicted here, camera traps also captured images of wintering Golden Eagles in southeastern Minnesota and southwestern Wisconsin (Mehus and Martell 2010) as well as others wintering in North Carolina and South Carolina (Vukovich et al. 2015, Kelly and Tomcho2017).

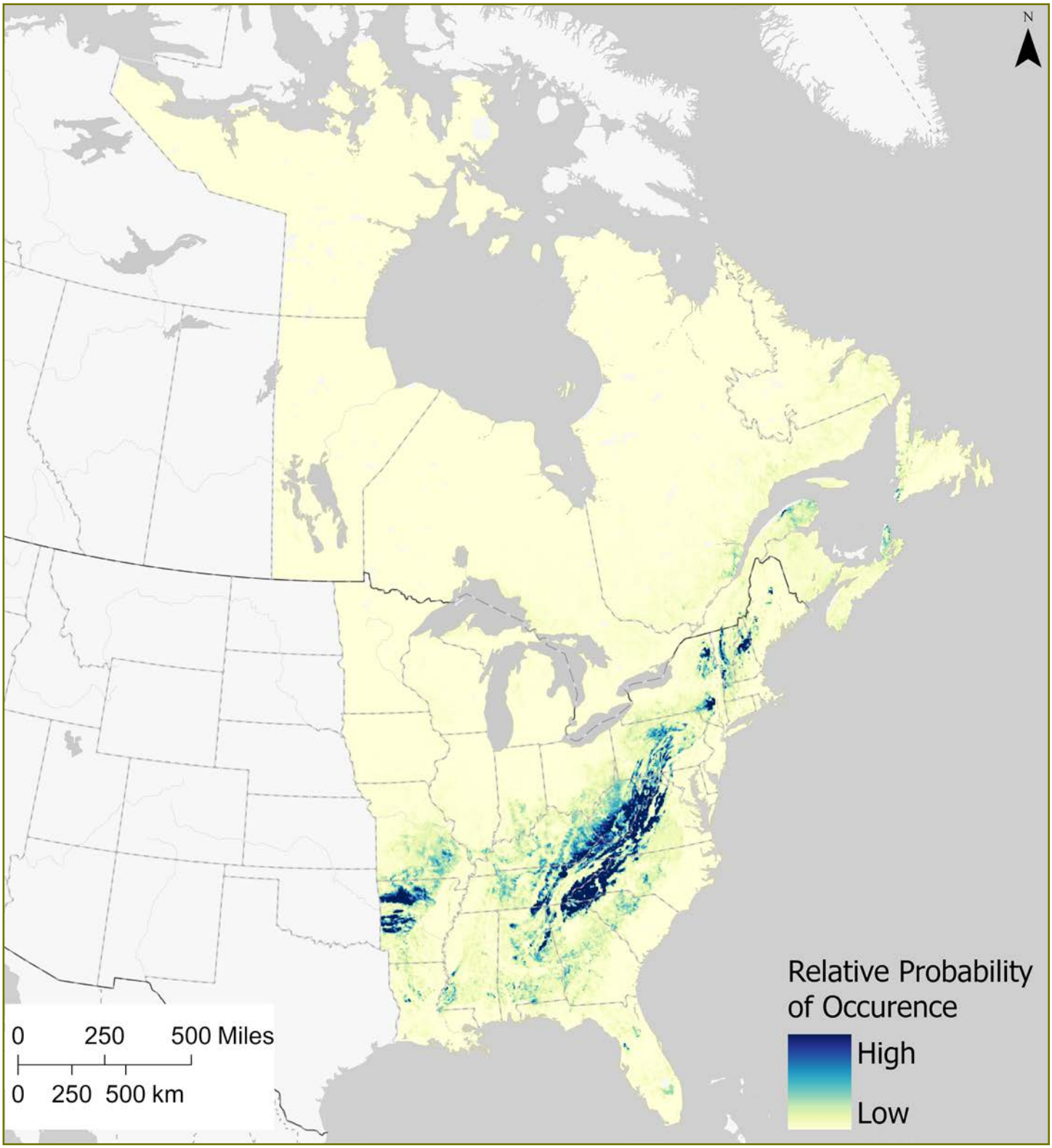


Figure 5. Predictions of Golden Eagle relative probability of occurrence for the month of January across eastern North America (adapted from McCabe et al. 2021).

BIBLIOGRAPHY

This bibliography contains known peer-reviewed research papers, conference proceedings, and dissertations on Golden Eagles in eastern North America. Documents are presented in chronological order. Readers who notice missing articles should contact the authors; we will add additional references as we are made aware of them.

1884
Brewster, W. 1884. Notes on the summer birds of Berkshire County, Massachusetts. Auk 1:5–16.

1887
Brewster, W. 1887. The Golden Eagle in Eastern Massachusetts. Auk 4:75.

1890
Rives, W. C. 1890. A catalogue of the birds of the Virginias. Proceedings of Newport Natural History Society 1889–90. Newport, RI. 7.

1891
Worthington, W. W. 1891. Golden Eagle at Shelter Island New York. Auk 8:113.

1892
Raub, M. W. 1892. The Golden Eagle in Pennsylvania. Auk 9:200
Oberholser, H. C. 1892. The Golden Eagle in Ohio. Auk 9:200.

1894
Surber, T. 1894. Capture of the Golden Eagle at Covington, Virginia. Auk 11:77.

1895
Sage, J. H. 1895. The Golden Eagle in New Jersey. Auk 12:179.

1896
Braislin, W. C. 1896. The Golden Eagle in New Jersey. Auk 13:81–82.
Brock, H. H. 1896. Recent capture of the Golden Eagle near Portland, Maine. Auk 13:256.
Knight, O. W. 1896. The Golden Eagle in Maine. Auk 13:82.
Stone, W. 1896. Golden Eagles in Virginia. Auk 13:256–257.

1897
Bagg, E. 1897. Some new records from central New York. Auk 14:226–227.
Rawson, C. L. 1897. Another Golden Eagle in Connecticut. Auk 14:215–216.
Verrill, A. E. 1897. Golden Eagle (*Aquila chrysaetos*) taken near New Haven, Conn. Auk 14:89.

1898
Chapman, F. M. 1898. Golden Eagle in New Jersey. Auk 15:54.

1899
Purdy, J. B. 1899. The Golden Eagle and Barn Owl at Northville, Wayne Co., Mich. Auk 16:77.

1902
Henninger, W. F. 1902. A preliminary list of the birds of middle southern Ohio. Wilson Bulletin 14:77–93.
Purdy, J. B. 1902. Snowy Owl and Golden Eagle at Plymouth, Michigan. Auk 19:80.

1903
Henninger, W. F. 1903. Golden Eagle in middle southern Ohio. Auk 20:67.

1905
Eifrig, C. W. G. 1905. The Golden Eagle (*Aquila chrysaetos*) near Ottawa. Auk 22:310.

1907
Fisher, G. C. 1907. A Golden Eagle in Miami County, Ohio. Wilson Bulletin 19:30–31.

1908
Fisher, G. C. 1908. A Golden Eagle taken in Alabama. Wilson Bulletin 20:55.
McConnell, H. B. 1908. Notes from Cadiz, Ohio. Wilson Bulletin 20:214–215.

1909
Burns, F. L. 1909. Golden Eagle (*Aquila chrysaetos*). Wilson Bulletin 21:48.

1910
Fisher, G. C. 1910. Golden Eagle taken in West Florida. Auk 27:80.

1912
Bolt, B. F. 1912. Capture of a Golden Eagle at Kansas City, MO. Auk 29:102.
Smyth, E. A. 1912. Birds observed in Montgomery County, Virginia. Auk 29:508–530.

1915
Swales, B. H. 1915. Golden Eagle (*Aquila chrysaëtos*) in Ohio. Wilson Bulletin 27:288.

1917
Morris, R. O. 1917. Golden Eagle (*Aquila chrysaetos*) at Springfield, Mass. Auk 34:477.

1919
Raynor, H. M. 1919. Golden Eagle at East Moriches, N. Y. Auk 36:421.

1922
Lano, A. 1922. Golden Eagle (*Aquila chrysaetos*) and Porcupine. Auk 39:258–259.
Wilson, G. 1922. Birds of Bowling Green, Kentucky. Auk 39:233–243.

1924
Holt, E. G. 1924. Golden Eagle (*Aquila chrysaetos*) in Alabama. Auk 41:601–602.

1925
Weston Jr., F. M. 1925. Golden Eagle near Pensacola, Florida. Auk 42:443.

1928
Bishop, S. C. 1928. The Golden Eagle (*Aquila chrysaëtos*) in Columbia Co., New York. Auk 45:212.

Perkins III, S. E. 1928. The Golden Eagle in Indiana. Wilson Bulletin 40:196.
Sutton, G.M. 1928. Abundance of the Golden Eagle in Pennsylvania in 1927–1928. Auk 45: 375.

1931
Jaques, H. E. 1931. The Golden Eagle in southeastern Iowa. Wilson Bulletin 43:58.
Shelley, L. O. 1931. The Golden Eagle (*Aquila chrysaetos*) in Cheshire County, New Hampshire. Auk 48:118.

1933
Holt, E. G. 1933. Golden Eagle in Louisiana. Auk 50:355.
Murray, J. J. 1933. Additions to the Virginia avifauna since 1890. Auk 50:190–200.

1934
Brooks, M. 1934. The Golden Eagle in West Virginia. Auk 51: 370.
Campbell, J. S. 1934. The Golden Eagle in Northern Louisiana. Wilson Bulletin 46:116.
Clark, A. H., and L. F. Clark. 1934. The Golden Eagle in North Carolina. Auk 51:80.

1935
Broun, M. 1935. The hawk migration during the fall of 1934, along the Kittatinny Ridge in Pennsylvania. Auk 52:233–248.
Holt, E. G. 1935. Golden Eagle in Louisiana: A correction and a reaffirmation of a positive record. Auk 52:183.

1937
Black, C. T. 1937. Additional Illinois Golden Eagle records. Auk 54:385–388.
Brodkorb, P. 1937. Golden Eagle in Illinois. Auk 54:100.

1938
Roads, K. M. 1938. Four Ohio records of Golden Eagle. Wilson Bulletin 50:64.
Roads, K. M. 1938. The Golden Eagle again noted in Ohio. Wilson Bulletin 50:202.

1939
Eliot, S. A., Jr. 1939. Golden Eagle at Chilmark, Massachusetts. Auk 56:75.

1946
Spofford, W. R. 1946. Observations on two Golden Eagles. Auk 63:85–87.

1955
Baillie, J. L. 1955. The Golden Eagle nesting in the Gaspé Peninsula, Québec. Canadian Field-Naturalist 69:13–14.

1964
Lumsden, H. G. 1964. Golden Eagle nesting in Ontario. Auk 81:91.
Spofford, W. R. 1964. Golden Eagle 509-50214. Bird Banding 35:123–124.

1971
Spofford, W. R. 1971. The breeding status of the Golden Eagle in the Appalachians. American Birds 25:3–7.
Spofford, W. R. 1971. The Golden Eagle—rediscovered. Conservationist 26:6–8.

1974

Singer, F. J. 1974. Status of the Osprey, Bald Eagle and Golden Eagle in the Adirondacks. New York Fish and Game Journal 21:18–31.

1984

Millsap, B. A. and S. L. Vana. 1984. Distribution of wintering Golden Eagles in the eastern United States. Wilson Bulletin 94:692–701.

1989

Todd, C. S. 1989. Golden Eagle. Pages 65–70 in Proceedings of the Northeast Raptor Management Symposium and Workshop (B. G. Pendleton, M. N. LeFranc, Jr., M. B. Moss, C. E. Ruibal, M. A. Knighton, and D. L. Krahe, Eds.). National Wildlife Federation, Washington, DC.

1990

Bednarz, J. C., D. Klem, Jr., L. J. Goodrich, and S. E. Senner. 1990. Migration counts of raptors at Hawk Mountain, Pennsylvania, as indicators of population trends, 1934–1986. Auk 107:96–109.

Lee, D. S. and W. R. Spofford. 1990. Nesting of Golden Eagles in the central and southern Appalachians. Wilson Bulletin 102:693–698.

1994

Brodeur, S. 1994. Domaines vitaux et déplacements migratoires d'aigles royaux nichant dans la région de la baie d'Hudson au Québec. Master's thesis, McGill University, Montreal.

Morneau, F., S. Brodeur, R. Décarie, S. Carrière, and D. M. Bird. 1994. Abundance and distribution of Golden Eagles in Hudson Bay, Québec. Journal of Raptor Research 28:220–225.

1996

Allen, P. E., L. J. Goodrich, and K. L. Bildstein, 1996. Within-and among-year effects of cold fronts on migrating raptors at Hawk Mountain, Pennsylvania, 1934–1991. Auk 113:329–338.

Brodeur, S., R. Decarie, D. M. Bird, and M. Fuller. 1996. Complete migration cycle of Golden Eagles breeding in northern Québec. Condor 98:293–299.

1997

Touchstone, T. H. 1997. Golden Eagle recovery techniques and success in the southern Appalachian region. Master's thesis, State University of West Georgia, Carrollton, GA.

1999

Brodeur, S. and F. Morneau. 1999. Rapport sur la situation de l'aigle royal (*Aquila chrysaetos*) au Québec. Société de la faune et des parcs du Québec, Direction de la faune et des habitats, Québec, Canada.

2000

Todd, C. S. 2000. Golden Eagle assessment. Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

2004

Brandes, D., and D. W. Ombalski. 2004. Modeling raptor migration pathways using a fluid-flow analogy. Journal of Raptor Research 38:195–207.

2007

Farmer, C. J., D. J. T. Hussell, and D. Mizrahi. 2007. Detecting population trends in migratory birds of prey. Auk: Ornithological Advances 124:1047–1062.

2008

Farmer, C. J., R. J. Bell, B. Drolet, L. J. Goodrich, E. Greenstone, D. Grove, D. J. T. Hussell, D. Mizrahi, F. J. Nicoletti, and J. Sodergren. 2008. Trends in autumn counts of migratory raptors in eastern North America, 1974–2004. Pages 179–215 in State of North America's Birds of Prey (K. L. Bildstein, J. P. Smith, and E. Ruelas I., and R. R. Veit, Eds.). Series in Ornithology, No. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

Farmer, C. J., L. J. Goodrich, E. Ruelas I., and J. P. Smith. 2008. Conservation status of North America's birds of prey. Pages 303– 419 in State of North America's Birds of Prey (K. L. Bildstein, J. P. Smith, and E. Ruelas I., and R. R. Veit, Eds.). Series in Ornithology, No. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

2010

Mehus, S. and Martell, M., 2010. A wintering population of Golden Eagles in southwestern Wisconsin and southeastern Minnesota. Passenger Pigeon 72:135–41.

2012

Bohrer, G., D. Brandes, J. T. Mandel, K. L. Bildstein, T. A. Miller, M. Lanzone, T. Katzner, C. Maisonneuve, and J. A. Tremblay. 2012. Estimating updraft velocity components over large spatial scales: contrasting migration strategies of Golden Eagles and turkey vultures. Ecology Letters 15:96–103.

Duerr, A. E., T. A. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, and T. Katzner. 2012. Testing an emerging paradigm in migration ecology shows amsurprising differences in efficiency between flight modes. PLoS ONE 7: e35548.

Katzner, T. E., D. Brandes, T. Miller, M. Lanzone, C. Maisonneuve, J. A. Tremblay, R. Mulvihill, and G. T. Merovich, Jr. 2012a. Topography drives migratory flight altitude of golden eagles: implications for on-shore wind energy development. Journal of Applied Ecology 49:1178–1186.

Katzner, T. E., B. W. Smith, T. A. Miller, D. Brandes, J. Cooper, M. J. Lanzone, D. W. Brauning, C. Farmer, S. Harding, D. E. Kramar, C. Koppie, C. Maisonneuve, M. Martell, E. K. Mojica, C. Todd, J. A. Tremblay, M. Wheeler, D. F. Brinker, T. E. Chubbs, R. Gubler, K. O'Malley, S. Mehus, B. Porter, R. P. Brooks, B. D. Watts, and K. L. Bildstein. 2012b. Status, biology, and conservation priorities for North America's eastern Golden Eagle (*Aquila chrysaetos*) population. Auk 129:168–176.

Lanzone, M.J., T. A. Miller, P. Turk, D. Brandes, C. Halverson, C. Maisonneuve, J. Tremblay, J. Cooper, K. O'Malley, R. P. Brooks, and T. Katzner. 2012. Flight responses by a migratory soaring raptor to changing meteorological conditions. Biology Letters 8:710–713.

Miller, T. A. 2012. Movement ecology of golden eagles (*Aquila chrysaetos*) in eastern North America. Dissertation, Pennsylvania State University, State College, PA.

Morneau, F., B. Gagnon, S. Poliquin, P. Lamothe, N. D'Astous, and J. A. Tremblay. 2012. Breeding status and population trends of Golden Eagles in northeastern Québec, Canada. Avian Conservation and Ecology 7:4.

2013

Asselin, N. C., M. S. Scott, J. Larkin, and C. Artuso. 2013. Golden Eagles (*Aquila chrysaetos*) breeding in Wapusk National Park, Manitoba. Canadian Field-Naturalist 127:180–184.

2014

Fitzgérald, G., J. A. Tremblay, J. Lemaître, J. and A. St-Louis. 2014. Captures accidentelles d'aigles royaux et de pygargues à tête blanche par les trappeurs d'animaux à fourrure au Québec. Le Naturaliste canadien 139:82–89.

Miller, T. A., R. P. Brooks, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. A. Tremblay, A. Duerr, and T. Katzner. 2014. Assessing risk to birds from industrial wind energy development via paired resource selection models. Conservation Biology 28:745–755.

Wheeler, M. 2014. The genetics of conservation translocations: a comparison of North American Golden eagles (*Aquila chrysaetos canadensis*) and Bald eagles (*Haliaeetus leucocephalus*). (Dissertation, Duquesne University, Pittsburgh, PA.

2015

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2015. Integrating citizen-science data with movement models to estimate the size of a migratory Golden Eagle population. Biological Conservation 184:68–78.

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2015. Modeling autumn migration of a rare soaring raptor identifies new movement corridors in central Appalachia. Ecological Modelling 303:19–29.

Duerr, A. E., T. A. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. A. Tremblay, T. Katzner, and C. Franklin. 2015. Flight response of slope soaring birds to seasonal variation in thermal generation. Functional Ecology 29:779–790.

Jachowski, D. S., T. Katzner, J. L. Rodrigue, and W. M. Ford. 2015. Monitoring landscape-level distribution and migration phenology of raptors using a volunteer camera-trap network: raptor camera-trapping. Wildlife Society Bulletin 39:553–63.

Katzner, T., T. A. Miller, J. Rodrigue, and S. Shaffer. 2015. A most dangerous game: death and injury to birds from porcupine quills. Wilson Journal of Ornithology 127:102–108.

Katzner, T. E., P. J. Turk, A. E. Duerr, T. A. Miller, M. J. Lanzone, J. L. Cooper, D. Brandes, J. A. Tremblay, and J. Lemaître. 2015. Use of multiple modes of flight subsidy by a soaring terrestrial bird, the golden eagle *Aquila chrysaetos*, when on migration. Journal of the Royal Society Interface 12:20150530.

Morneau, F., J. A. Tremblay, C. S. Todd, T. E. Chubbs, C. Maisonneuve, J. Lemaître, and T. E. Katzner. 2015. Known breeding distribution and abundance of Golden Eagle in eastern North America. Northeastern Naturalist 22:236–247.

Morneau, F., J. A. Tremblay, and J. Lemaître. 2015. Abondance et répartition de l'aigle royal au Québec. Le Naturaliste Canadien 139:38-43.

Nelson, D. M., M. Braham, T. A. Miller, A. E. Duerr, J. Cooper, M. Lanzone, J. Lemaître, and T. Katzner. 2015. Stable hydrogen isotopes identify leapfrog migration, degree of connectivity, and summer distribution of Golden Eagles in eastern North America. Condor: Ornithological Applications 117:414–429.

Vukovich, M., K. L. Turner, T. E. Grazia, T. Mims, J. C. Beasley, and J. C. Kilgo. 2015. Wintering Golden Eagles on the coastal plain of South Carolina. Journal of Field Ornithology 86:337–344.

2016

Miller, T. A., R. P. Brooks, M. Lanzone, D. Brandes, J. Cooper, C. Maisonneuve, J. Tremblay, J. Wilhelm, A. Duerr, and T. Katzner. 2016. Limitations and mechanisms influencing migratory performance of soaring birds. Ibis 158:116–134.

2017

Dennhardt, A. J., A. E. Duerr, D. Brandes, and T. E. Katzner. 2017. Applying citizen-science data and mark-recapture models to estimate numbers of migrant Golden Eagles in an Important Bird Area in eastern North America. Condor: Ornithological Applications 119:817–831.

Kelly, C. A., and J. Tomcho, Jr. 2017. A camera-trap survey documents widespread distribution of over-wintering Golden Eagles in western North Carolina. The Chat 81:60–79.

Miller, T. A., R. P. Brooks, M. J. Lanzone, J. Cooper, K. O'Malley, D. Brandes, A. Duerr, and T. E. Katzner. 2017. Summer and winter space use and home range characteristics of Golden Eagles (*Aquila chrysaetos*) in eastern North America. Condor: Ornithological Applications 119:697–719.

Rus, A. I., A. E. Duerr, T. A. Miller, J. R. Belthoff, and T. E. Katzner. 2017. Counterintuitive roles of experience and weather on migratory performance. Auk: Ornithological Advances 134:485–497.

2018

Taylor, L. and K. Slakard. 2018. Winter distribution of Golden Eagles (*Aquila chrysaetos*) in Kentucky. The Kentucky Warbler 94:4–49.

Pirotta, E., T. Katzner, T. A. Miller, A. E. Duerr, M. A. Braham, and L. New. 2018. State space modelling of the flight behaviour of a soaring bird provides new insights to migratory strategies. Functional Ecology 32:2205–2215.

2019

Anctil, A., Potvin-Leduc, D., Lemaître, J. 2019. Suivi de l'aigle royal dans le Nord-du-Québec — Connaître la population pour mieux la protéger, 2018, ministère des Forêts, de la Faune et des Parcs, Gouvernement de Québec, Canada.

Duerr, A. E., M. E. Braham, T. A. Miller, J. L. Cooper, J. T. Anderson, and T. E. Katzner. 2019. Roost- and perch-site selection by Golden Eagles (*Aquila chrysaetos*) in eastern North America. Wilson Journal of Ornithology 131:310–328.

2020

Équipe de Rétablissement des Oiseaux de Proie Du Québec EROP (2020). Plan de rétablissement de l'aigle royal (*Aquila chrysaetos*) au Québec — 2020–2030, produit pour le ministère des Forêts, de la Faune et des Parcs, Direction générale de la gestion de la faune et des habitats, 58 p.

Katzner, T. E., M. N. Kochert, K. Steenhof, C. L. McIntyre, E. H. Craig, and T. A. Miller. 2020. Golden Eagle (*Aquila chrysaetos*), version 2.0. Birds of the World (P. G. Rodewald and B. K. Keeney, Eds.). Cornell Lab of Ornithology, Ithaca, NY.

Kenney, M. L., J. R. Belthoff, M. Carling, T. A. Miller, and T. E. Katzner. 2020. Spatial and temporal patterns in age structure of Golden Eagles wintering in eastern North America. Journal of Field Ornithology 91:92–101.

Slabe, V. A., J. T. Anderson, J. Cooper, T. A. Miller, B. Brown, A. Wrona, P. Ortiz, J. Buchweitz, D. McRuer, E. Dominguez Villegas, S. Behmke, and T. Katzner. 2020. Feeding ecology drives lead exposure of facultative and obligate avian scavengers in the eastern United States. Environmental Toxicology and Chemistry 39:882–892.

2021

Dumandan, P. K. T., K. L. Bildstein, L. J. Goodrich, A. Zaiats, T. T. Caughlin, and T. E. Katzner. 2021. Shared functional traits explain synchronous changes in long-term count trends of migratory raptors. Global Ecology and Biogeography 30:640–650.

Marneweck, C. J., T. E. Katzner and D. S. Jachowski. 2021. Predicted climate-induced reductions in scavenging in eastern North America. Global Change Biology 27:3383–3394.

McCabe, J. D., J. D. Clare, T. A. Miller, T. E. Katzner, J. Cooper, S. Somershoe, D. Hanni, C. A. Kelly, R. Sargent, E. C. Soehren, C. Threadgill, M. Maddox, J. Stober, M. Martell, T. Salo, A. Berry, M. J. Lanzone, M. A. Braham, and C. J. W. McClure. 2021. Resource selection functions based on hierarchical generalized additive models provide new insights into individual animal variation and species distributions. Ecography 44:1756–1768.

2022

Dumas, P-A., P. Côté, and J. Lemaître. 2022. Analyse des tendances des populations d'oiseaux de proie diurnes du Québec, ministère des Forêts, de la Faune et des Parcs, Direction de l'expertise sur la faune terrestre, l'herpétofaune et l'avifaune, Service de la conservation de la biodiversité et des milieux humides, gouvernement du Québec, Québec, 82 p. + annexes.

Équipe de Rétablissement des Oiseaux de Proie du Québec (EROP). 2022. Accidental capture of eagles: what to do to avoid them and how to act when they occur. Gouvernement Québec, Canada.

Maynard, L. D., J. F. Therrien, J. Lemaître, T. Booms, T. A. Miller, T. Katzner, S. Somershoe, J. Cooper, R. Sargent, and N. Lecomte. 2022. Interannual consistency of migration phenology is season- and breeding region-specific in North American Golden Eagles. Ornithology 139, ukac029.

Slabe, V. A., J. T. Anderson, B. A. Millsap, J. L. Cooper, A. R. Harmata, M. Restani, R. H. Crandall, B. Bodenstein, P. H. Bloom, T. Booms, J. Buchweitz, R. Culver, K. Dickerson, R. Domenech, E. Dominguez-Villegas, D. Driscoll, B. W. Smith, M. J. Lockhart, D. McRuer, T. A. Miller, P. A. Ortiz, K. Rogers, M. Schwarz, N. Turley, B. Woodbridge, M. E. Finkelstein, C. A. Triana, C. R. DeSorbo, and T. E. Katzner. 2022. Demographic implications of lead poisoning for eagles across North America. Science 375:779–782.

Warner, T. A., T. A. Miller, I. P. La Puma, L. A. Nolan, N. S. Skowronski, and A. E. Maxwell. 2022. Exploring Golden Eagle habitat preference using lidar-based canopy bulk density. Remote Sensing Letters 13:556–567.

2023

Bodenstein, B.L., Lankton, J.S., Russell, R.E., and Schwarz, M.S., 2023, *Haliaeetus leucocephalus* (bald eagle) and *Aquila chrysaetos* (golden eagle) mortality and exposure to lead, mercury, and anticoagulant rodenticides in eight western and midwestern States, 2014-17: U.S. Geological Survey Open-File Report 2023–1016, 23 p.

Miller, T.A., M.J. Lanzone, M.A. Braham, A.E. Duerr, J. Cooper, S. Somershoe, D. Hanni, E.C. Soehren, C. Threadgill, M. Maddox, J. Stober, C. Kelly, T. Salo, A. Berry, M. Martell, S. Mehus, B. Dirks, R. Sargent, and T.E. Katzner. 2023. Winter distribution of Golden Eagles (*Aquila chrysaetos*) in the eastern USA. Journal of Raptor Research. 57:522-532.