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Source: The Auk, 129(1) : 168-176

Published By: American Ornithological Society

URL: https://doi.org/10.1525/auk.2011.11078

Commentary

The Auk 129(1):168–176, 2012

Printed in USA.

STATUS, BIOLOGY, AND CONSERVATION PRIORITIES FOR NORTH AMERICA'S EASTERN GOLDEN EAGLE (*AQUILA CHRYSAETOS*) POPULATION

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THE GOLDEN EAGLE (*Aquila chrysaetos*) population in North America is declining (Hoffman and Smith 2003, Smith et al. 2008). This species is enigmatic, indicative of broad conservation value (Sergio et al. 2005), and, for the most part, poorly known. Populations west of the Mississippi River in the lower 48 states number approximately 21,000–35,000 individuals (Good et al. 2004, 2007). However, this estimate is based on limited sampling effort and on broad-scale extrapolation to unsampled habitats, and it does not include Canadian or Alaskan birds.

A much smaller population, which has been estimated at 1,000–2,500 individuals, exists east of the Mississippi River. These "Eastern Golden Eagles" were almost completely unknown to ornithologists until the 1930s, when significant numbers were first reported migrating south past Hawk Mountain Sanctuary

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The Auk, Vol. 129, Number 1, pages 168–176. ISSN 0004-8038, electronic ISSN 1938-4254. DOI: 10.1525/auk.2011.11078

(Broun 1935). Today, there still is little information on the basic ecology, demography, and size of this population. What is known suggests declines over the past century and recent (1974–2004) short-term increases (Farmer et al. 2008a).

In response to apparent ongoing Golden Eagle population declines, the U.S. Fish and Wildlife Service (USFWS) is now re-evaluating its interpretation of the Bald and Golden Eagle Protection Act (BGEPA) to more effectively manage this species. The USFWS has recognized that Golden Eagle populations east of the Mississippi are different and less well understood than others in North America. Currently, the USFWS is not issuing permits for take of Golden Eagles east of 100°W longitude (USFWS 2009). This is because of the small number, potentially high demographic vulnerability, and geographically specific conservation problems confronting birds in the East. For example, although wind turbines are a known source of eagle mortality in the western United States (Smallwood and Thelander 2008) and are thought to be a growing threat elsewhere, no Golden Eagles have been reported killed by turbines in the East. By contrast, biologists in the East consider incidental trap mortality and lead poisoning to be among the most serious threats to eagles (T. Katzner and C. Maisonneuve pers. obs.).

Here we review the status, biology, threats, and conservation priorities for the eastern population of Golden Eagles. This commentary is an effort of the recently formed Eastern Golden Eagle Working Group (EGEWG), an international collaborative effort among scientists and managers from across eastern North America. The vision of the EGEWG is to ensure the long-term sustainability of Eastern Golden Eagle populations, ultimately making the species a flagship species for conservation. The group's objectives include (1) collaboratively 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 based on our collective research; (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 Golden Eagles in the East.

Eastern Golden Eagle Distribution, Ecology, and Demography

Historical context.—Golden Eagles historically bred in eastern Canada (Ontario, Quebec, and Labrador) and the northeastern United States (Table 1). Breeding records for the species in New England and New York date back hundreds of years. However, in spite of historical summer observations from the southern Appalachian Mountains, there is scant evidence of Golden Eagles breeding south of New York (Lee and Spofford 1990; we consider Beck's [1924] record from Pennsylvania to be of questionable value). Notwithstanding the paucity of historical breeding data, there have been repeated translocations, releases, and hackings in an attempt to "re-establish" breeding Golden Eagles in the southern Appalachians. Presumably these activities, which occurred between 1930 and 2005, were permitted at the state and federal levels.

Known present status, distribution, and trends.—The Golden Eagle population in eastern North America has undergone long-term declines over the past century (Bednarz et al. 1990), with an apparent recovery since the end of the DDT era (Farmer et al. 2008a, b). In eastern Canada, populations presently are considered "stable," and breeding pairs are most numerous in Quebec, with less-well-known and presumably smaller populations in Labrador and Ontario (Tables 1 and 2). There are no breeding records and only occasional migration-season reports from insular Newfoundland or the Maritime Provinces (Tuck 1968).

Populations of Golden Eagles in northern New England have been more closely monitored, and their declines are relatively well documented. Maine and New York supported territorial breeding Golden Eagles until the late 1990s, and most of the remainder of New England also once supported breeding pairs (Table 1). These populations have all been extirpated. Nesting attempts also were documented in north-central Tennessee and northwestern Georgia in the 1990s following the previously mentioned hacking and translocation efforts (S. Somershoe and J. Ozier pers. comm.).

Golden Eagles wintering in the East are found in Appalachian high country, but sightings are recorded regularly in other regions (e.g., western Tennessee and Kentucky; the Virginia, Delaware,

Table 1. Dates of earliest records and last known resident, breeding, and successful breeding by Golden Eagles in eastern North America. Table does not include states where records are questionable or breeding in the southern Appalachian Mountains by translocated or hacked birds (see text for details).

State or province	Earliest records	Last known			Data sources
		Residents	Breeding	Fledglings	
Ontario	1950s	Current	Current	Current	Peck and James 1999
Quebec	1915	Current	Current	Current	Raine 1890, Baillie 1955
Newfoundland and Labrador	1860	Current	Current	Current	Townsend and Allen 1907
Maritime Provinces	1872	None	None	None	Gilpin 1873
Maine	1689	1997	1996	1984	Palmer 1988, Todd 2000
New Hampshire	Undated	1962	1955	1955	Forbush 1929, Spofford 1971a, R. S. Palmer pers. comm.
Vermont	Undated	1973	Unknown	Unknown	W. R. Spofford pers. comm., Eaton 1914, Forbush 1929
New York	1770s	1995	1979	1970	Eaton 1914, Ford 1957, Spofford 1971b, Singer 1974, B. Loucks pers. comm.
Massachusetts	Undated	1880s	1880s	Unknown	Brewster 1884, Howe and Allen 1901, Forbush 1929

and North and South Carolina Coastal Plains; and the Okefenokee National Wildlife Refuge in Georgia; Millsap and Vanna 1984).

There are no breeding records for this species from Minnesota, Wisconsin, Michigan, or Iowa. In all four states, there are widespread spring, fall, and winter records from most counties (Roberts 1932, Granlund et al. 1994, Kent and Dinsmore 1996, Mueller and Kowalchuk 2009). Kent and Dinsmore (1996) noted that the average number of winter records reported annually in Iowa rose steadily, from an average of 2.2 in the 1960s to 3.1 in the 1970s, 7.1 in the 1980s, and 11.0 in the 1990s. Millsap and Vana (1984) considered Crex Meadows Wildlife Area in Wisconsin (7 records from 1963–1977) and Crab Orchard National Wildlife Refuge in Illinois (5 records from 1957–1980) as "regular wintering sites." Records of Golden Eagles on fall migration over Hawk Ridge in Duluth, Minnesota, date back to 1951 (Hofslund 1966).

Breeding-season ecology.—Like their counterparts in Alaskan and western Canadian populations, Eastern Golden Eagles are migratory (Morneau et al. 1994, Watson 2010). Nests are built primarily on cliffs but are sometimes found in trees in the Gaspé Peninsula of southeastern Quebec and in northern Ontario (Lumsden 1964, Brodeur and Morneau 1999).

Breeding habitat use by Golden Eagles in eastern North America is diverse and consistent with that of some other populations of this species (Kochert et al. 2002). In northern Quebec, Ontario, and Labrador, breeding birds are found at the interface of tundra, boreal forest, and wet meadows, often on the edge of, but generally avoiding, heavily forested areas (Fig. 1). On the Gaspé Peninsula and in the former U.S. breeding range, nests are in forested habitats but eagles forage in open landscapes created by disturbances and wetlands (J. A. Tremblay and C. Maisonneuve pers. obs.).

In the Hudson Bay region of northern Quebec, home range varied from 846 to 1,585 km^2 (minimum convex polygon, June–October, n = 3; Brodeur 1994). In the Gaspé Peninsula, breeding home ranges varied from 515 to 2,132 km^2 (fixed kernel estimator, n = 3; J. A. Tremblay and C. Maisonneuve unpubl. data). The few published historical data on the diet of breeding Golden Eagles in eastern Canada suggest that they feed on birds (particularly waterfowl and wading birds) with greater frequency than do eagles in western North America (Spofford 1971a, Brodeur and Morneau 1999). From late autumn to early spring, Golden Eagles are regularly observed feeding on carrion—Caribou (*Rangifer tarandus*), Moose (*Alces alces*), and White-tailed Deer (*Odocoileus virginianus*) (Todd 1940, Spofford 1971a, Singer 1974).

Migration ecology.—Fall migration from northern breeding grounds starts as early as mid-August, although the bulk of migration is from mid-October through mid-December (mean migration dates = 19 October ± 4.4 days to 22 November ± 3.8 days; n = 12 complete telemetry tracks). Spring migration is shorter, extending from late February to mid-May, with the majority of movements occurring during a single week in mid-March (mean starting migration date = 18 March ± 3.4 days; n = 22, including partial tracks; ending date = 4 April ± 5.6 days; n = 10 complete tracks).

Golden Eagles in eastern North America appear to engage in "leapfrog migration" (Baker 1978) and follow one of several autumn migratory pathways (Fig. 1). The majority of birds from northern Quebec and Labrador migrate west of the Gulf of St. Lawrence, cross the St. Lawrence River just to the southwest of Montreal, pass through central New York and into the parallel ridges of eastern and

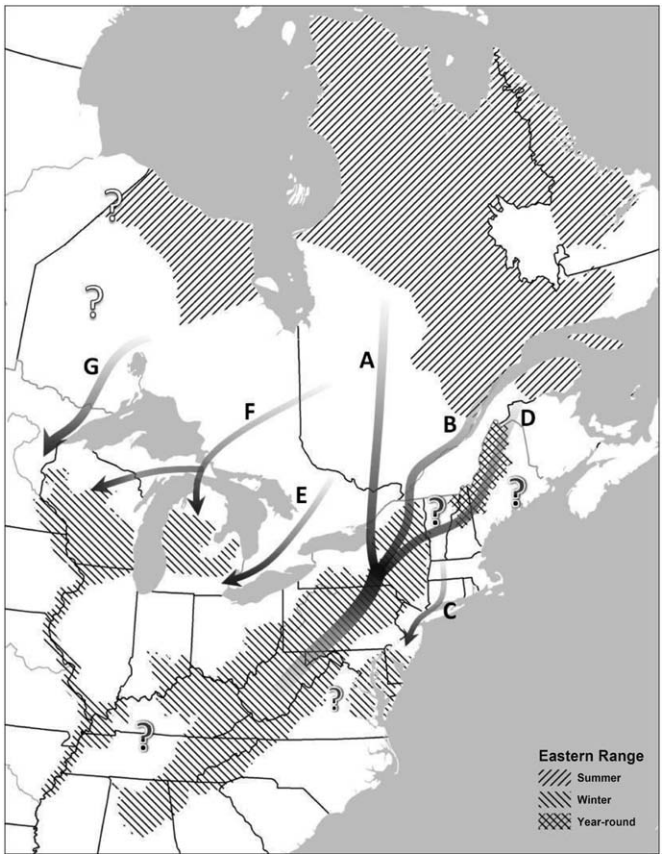

Fig. 1. Distribution of Eastern Golden Eagles, showing known summer and wintering grounds as well as known and suspected southbound migration corridors. Areas where distribution is unclear are indicated with a question mark (open on breeding grounds, filled on wintering grounds). Letters correspond to different suspected southbound migration routes that are described in greater detail in the text.

central Pennsylvania, western Maryland, and eastern West Virginia to inland wintering grounds (routes A and B; Fig. 1). Some younger birds apparently leave, or "overshoot," the ridges and end up on the Atlantic Coast (route C; Fig. 1). Birds that summer on the Gaspé migrate mainly through New England (route D; Fig. 1). Because these individuals winter mainly in New York and Pennsylvania, they may not be counted at raptor migration watch sites. Finally, hawk migration count data suggest that 15–25% of eastern Canada's Golden Eagles migrate through the Great Lakes region. Telemetry data indicate that these birds migrate west of Lake Erie (routes E, F, and G; Fig. 1) (Brodeur et al. 1996, Mehus and Martell 2010). Migratory routes of individuals summering in Ontario are unknown, but these may contribute disproportionately to the Midwestern wintering population.

Spring migration routes are less well known than fall routes. Most of the known routes cross through the western Appalachian Ridge and Valley Province, the Allegheny Plateau and the Adirondack region, with birds crossing into Canada via southern Quebec (Brandes and Ombalski 2004). Spring migration routes in the Great Lakes region are poorly known but include movements along the western edge of Lake Superior and the southern shore of Lake Ontario (www.hawkcount.org).

Winter ecology.—Telemetry and camera-trapping data suggest that Golden Eagles are found in greatest numbers during winter in the north-central Appalachian Mountains of Pennsylvania, West Virginia, and Virginia (T. Miller and T. Katzner unpubl. data). Birds are regularly reported in the mountains of neighboring states (Kentucky, Tennessee, North Carolina, and New York), as far north as southern Quebec and as far south as Alabama. Likewise, a small portion of the population winters in the Piedmont and Coastal Plains of several eastern and southeastern states, and in the "driftless" (i.e., unglaciated) area of the upper Mississippi River Valley.

Habitat use, relative density, and the overall distribution of these eagles during winter are poorly understood and of high priority for future study. Preliminary observations suggest that winter home ranges of Golden Eagles in eastern North America vary dramatically (13–33,553 km^2; kernel density estimator, n = 11 birds), the smallest home range being in the mid-Atlantic Coastal Plain and the largest in the Appalachian Highlands of Kentucky and West Virginia (D. Kramar et al. unpubl. data). In the mountains, birds used large blocks of woodlands most heavily, with 74% of tracking data points found in forested habitat (U.S. Geological Survey, Gap Analysis Program 2010). The remaining observations were in agricultural, disturbed, and wetland areas.

Demography.—Numbers of breeding Eastern Golden Eagles are highest in Quebec, where most of the estimated 300 to 500 breeding pairs nest above 50°N (Brodeur and Morneau 1999, J. A. Tremblay and C. Maisonneuve unpubl. data). Dispersion of breeding territories in the northern part of the range is largely unknown. On the Gaspé Peninsula in the south, nests are spaced at approximately 13–20 km, generally far apart for Golden Eagle territories (e.g., Watson 2010), which suggests that habitat in the region is of low quality for this species. Known reproductive output of eagles is low and varies from 0.17 to 1.17 nestlings per occupied territory per year in the Côte-Nord area (F. Morneau et al. submitted) to approximately 0.33 to 0.67 nestlings per known occupied territory per year in the Gaspé Peninsula (J. A. Tremblay and C. Maisonneuve unpubl. data). There are probably fewer than 50 territories each in Labrador (T. Chubbs unpubl. data) and Ontario (Ontario Breeding Bird Atlas; www.birdsontario.org).

The most robust and longest-term estimates of population trends come from counts at migration watch sites in the central Appalachians of Pennsylvania and southern New York. Evidence suggests long-term declines in counts of eastern North America's Golden Eagle populations from the 1930s through the mid-1980s, followed by short-term increases after the banning of DDT (Bednarz et al. 1990, Titus and Fuller 1990). Hussell and Brown (1992) noted no change in autumn counts in Minnesota from the mid-1970s to late 1980s but a simultaneous significant annual increase of 8% in spring counts in Ontario. Over the 30-year period between the mid-1970s and 2004, most eastern hawk counts show significant annual increases of 2–5% (Farmer et al. 2008a). Finally, recent short-term trends are largely positive, with significant 2–6% annual increases from 1994 to 2004, although there also are nonsignificant indications of declines in counts in the eastern Great Lakes and Quebec (Farmer et al. 2008b).

Genetics.—Populations of Eastern Golden Eagles exhibit some degree of geographic isolation from their western counterparts and historically may have been genetically distinct. However, the recent history of repeated reintroduction of western birds in the southern Appalachians may have compromised the integrity of the eastern gene pool. Beginning in 1984, 111 nestlings, mostly from Wyoming, were hacked into Georgia (Touchstone 1997). In another effort from 1980 to 1986, multiple agencies, including the Tennessee Valley Authority, the USFWS, and the North Carolina Wildlife Resources Commission coordinated the release of 24 western nestlings into North Carolina (Roberts 1985, C. Kelly et al. pers. comm.). Forty-seven captive nestlings were hacked into Tennessee by private organizations from 1995 to 2006; at least some of these birds were later observed attempting to breed in central Tennessee (S. Somershoe pers. comm.). Finally, at least six birds of unknown but presumably western U.S. origin were released into Pennsylvania from 1983 to 1990 (T. Becker pers. comm.).

Preliminary evaluation of contemporary genetic samples provides some insight into phylogeographic patterns of extant North American Golden Eagle populations (M. Wheeler and B. Porter unpubl. data). Analysis of 10 microsatellite markers with the Bayesian analysis program STRUCTURE (K = 2) suggests no population structure between 44 eastern and 25 western modern North American Golden Eagles. Similarly, sequencing of 1,101 base pairs of the mitochondrial cytochrome-*b* gene shows no differentiation between 12 western and 23 eastern birds. Average uncorrected nucleotide divergence was 0.003 (0.3%), with the greatest sequence divergence (1.02%) occurring between two eastern birds. There was one common haplotype shared by five western and eight eastern birds.

Critical next steps in this analysis include (1) more clearly defining existing geographic populations and (2) including historical samples from museum specimens to determine how contemporary population characteristics may have been influenced by past introduction history.

Conservation Status and Legal and Regulatory Protection

Conservation status.—Although professional and amateur ornithologists monitor migration of large numbers of Golden Eagles along the Appalachian Mountains and the Great Lakes (e.g., www.hawkcount.org), many in the ornithological research community and the general public remain largely unaware that the species breeds, migrates, and winters in eastern North America. Furthermore, government agencies vary in their awareness and published recognition of the conservation significance of this Golden Eagle population, particularly in the central and southern Appalachian Mountains (Table 2). Most eastern State Wildlife Action Plans (SWAPs) are geared toward breeding species; consequently, Golden Eagles are recognized in only 5 of 23 such documents. Unless Golden Eagles are designated as a Species in Greatest Need of Conservation (SGNC) in a SWAP, proactive conservation measures for them are rarely possible.

Legal and regulatory protection.—Golden Eagles in eastern North America are generally afforded little U.S. or Canadian federal legal protection beyond that of the Migratory Bird Treaty Act (MBTA) and, in the United States, BGEPA (Table 2). In the eastern United States, Golden Eagles have additional regulatory status in only 6 of 23 states. In eastern Canada, three of four provinces recognize a legal status for this population (Table 2).

Table 2. Biological, conservation, and legal status of Eastern Golden Eagles (EGE) throughout their U.S. and Canadian range in eastern North America. States are listed north to south within the two main regions (East and Midwest). Use by eagles is as follows: B = breeding, M = migration, W = wintering, and A = accidental. NatureServe ranks are as follows: SXB = Subnational Extirpated, Breeding; SHB = Subnational Possibly Extirpated, Breeding; S1 = Subnational Critically Imperiled; S1B = Subnational Critically Imperiled, Breeding; S1N = Subnational Critically Imperiled, Nonbreeding; S2N = Subnational Imperiled, Nonbreeding; S3 = Subnational Vulnerable; S3B = Subnational Vulnerable, Breeding; S3N = Subnational Vulnerable, Nonbreeding; SNA = Subnational Not Applicable; SNR = Subnational Unranked; and SNRN = Subnational Unranked, Nonbreeding. Dash indicates that there is no NatureServe ranking for this state or province. SGCN = Species of Greatest Conservation Need in State Wildlife Action Plan. (Source: www.natureserve.org/explorer/servlet/.)

	Use by EGE		Population estimate			Legal status			
State/Province	Present	Historical	Breeding	Migration	Wintering	NatureServe	Status	Other	Monitoring
(A) Eastern United States									
Maine	M, W	B, M, W	0	Unknown	Unknown	S1B, S1N	Endangered	High-priority SGCN	Monitor historical sites
New Hampshire	M, W	B, M, W	0	Unknown	Unknown	SHB	Endangered	SGCN	Same
Vermont	M, W	B(?), M,W	0	Unknown	Unknown	SNA[a]	None	None	None
Massachusetts	M, W	B(?), M, W	0	Unknown	Unknown	S1N	None	None	None
Connecticut	M, W	B(?), M, W	0	Unknown	Unknown	SNA	None	None	None
Rhode Island	M, W	M, W	0	Rare	Unknown	—	None	None	None
New York	M, W	B, M, W	0	Unknown	>15	SHB, S1N	Endangered	SGCN	Winter telemetry, migration counts
Pennsylvania	M, W	M, W	0	~1000 per year	>50	SBX	None	WAP	Migration counts, telemetry, wind coop agreement
West Virginia	M, W	M, W	0	Unknown	>200	S3N	None	State BGEPA	Trail camera surveillance, winter telemetry,migration count
Maryland	M, W	M, W	0	Unknown	~10	S1N	None	SGCN	Trail camera surveillance, migration count
Virginia	M, W	M, W	0	Unknown	>150	SHB, S1N	None	Wildlife Law	Migration count, trail camera surveillance, telemetry
North Carolina	M, W	M, W	0	Unknown	Unknown	SXB	None	None	Trail camera surveillance
Tennessee	M, W	M, W	0	Unknown	Unknown	S1	Threatened	SGCN	None
Kentucky	M, W	M, W	0	Unknown	>15	SXB, S2N	None	None	Trail camera surveillance
South Carolina	M, W	M, W	0	Unknown	Unknown	—	None	None	None
Alabama	M, W	M, W	0	Unknown	Unknown	SNR	Moderate Conservation Concern	None	None
Georgia	M, W	M, W	0	Unknown	Unknown	S1	Special Concern	Wildlife Law	None
Florida	W	W	0	Unknown	Rare	SNA	None	None	None
(B) Midwestern United States									
Minnesota	M, W	M, W	0	~200	~30	SNA	None	None	Migration counts, winter telemetry
Wisconsin	M, W	M, W	0	Unknown	>60	S2N	None	None	Migration counts, winter telemetry
Michigan	M, W	M, W	0	Unknown	Unknown	SNRN	None	None	None
Iowa	M, W	M, W	0	Unknown	>10	SNA	None	None	None
Illinois	M, W	M, W	0	Unknown	Unknown	SNA	None	None	None
Indiana	M, W	M, W	0	Unknown	Unknown	S1N	None	None	None
Ohio	A	A	0	<5	<5	SNA	None	None	None

(Continued)

Table 2. Continued.

State/Province	Use by EGE: Present	Use by EGE: Historical	Population estimate: Breeding	Population estimate: Migration	Population estimate: Wintering	NatureServe	Legal status: Status	Legal status: Other	Monitoring
(C) Canadian provinces, west to east									
Ontario	B, M, W	B, M, W	<20 pairs	Unknown	Unknown	S2B	Endangered		
Quebec	B, M, W	B, M, W	~300–500 pairs	Unknown	Unknown	S3B	Vulnerable	Threatened and Endangered Species Law	Summer telemetry, territory monitoring, migration counts, wind energy, and nest protection guidelines
Newfoundland	A	A	0	0	0	S3B	Protected	Not at risk	
Labrador	B, M	B, M	20–50 pairs	Unknown	0	S3B	Protected	Not at risk	Historical nesting surveys, environmental assessment surveys
Maritime Provinces	M, W	B, M, W	0	Unknown	Unknown		None		
(D) Federal level									
U.S. Government							BGEPA		
Canadian Government								None	
Appalachian Mountains Joint Venture								High-priority	

[a] Vermont Natural Heritage was in the process of updating their NatureServe rank at the time of this publication; rank in table reflects pending update.

At the U.S. federal level, MBTA and BGEPA are the regulatory statutes that protect Golden Eagles from "take." Under BGEPA, take is defined as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest or disturb individuals, their nests and eggs." In delisting the Bald Eagle from the Endangered Species Act (ESA) in 2007, the USFWS issued a final rule to introduce and define a new term, "disturb," described as "to agitate or bother a Bald or Golden Eagle to a degree that causes…injury to an eagle, reduced productivity, or nest abandonment." In 2009, two new permit rules provided a framework to authorize nonpurposeful take including disturbance, injury and death (50 CFR 22.26) or intentional take of nests (50 CFR 22.27), where necessary to alleviate a safety hazard to people or eagles, to ensure public health and safety, to restore functionality to a human-engineered structure, or where the activity or mitigation for the activity will provide a net benefit to eagles. The new rules provide a mechanism where take of eagles can be authorized legally, with the caveat that the take is compatible with preservation of the eagle, defined as "consistent with the goal of stable or increasing breeding populations."

Threats to Eastern Golden Eagles

Eastern Golden Eagles face both direct and indirect threats. Direct threats include incidental capture, shooting, collision, and poisoning. Indirect threats are largely tied to habitat loss, decline in breeding-season prey base resulting from habitat change, and the demographic consequences of changes in population structure from direct threats.

Incidental captures in leg-hold traps and snares set for mammals have been known for more than a century as a source of mortality for Golden Eagles in eastern North America (Eifrig 1905, Sutton 1928). In the years 2007 to 2010, Quebec, West Virginia, and Virginia each reported multiple incidental captures (Quebec reported 2–7 per year; Brodeur and Morneau 1999). An anonymous survey of trappers in Quebec suggested that the actual number of birds killed may be twice that reported (Ministère des Ressources naturelles et de la Faune [MRNF] unpubl. report). Additionally, between 1960 and 1995, at least 15% of known Golden Eagle deaths in the United States resulted from illegal shooting (Franson et al. 1995), another century-old problem in the East (Surber 1894). The demographic impact of these threats, direct or indirect, is all but unknown.

Electrocution and collision with structures that obstruct flight paths (towers, power lines, buildings, etc.) are the leading known causes of direct mortality for Golden Eagles in the western United States (Franson et al. 1995, Tetra TechEC unpubl. data). With increasing numbers of industrial-scale wind energy facilities at high elevations in breeding, migratory, and wintering ranges, Golden Eagles in eastern North America will likely face similar threats.

Poisoning can have both lethal and sublethal affects, and several toxins affect eagles. Lead poisoning from ingestion of spent lead ammunition in hunter-shot game is of particularly high concern for Golden Eagle populations (Kramer and Redig 1997). Although lead shotgun shot has been partially banned in most states and provinces, lead shot is still used to hunt upland game and lead rifle bullets are still used for big-game hunting nearly continent-wide. Golden Eagles in the northwestern United States showed toxic lead levels in blood (>0.20 ppm) at the end of the big-game hunting season (Stauber et al. 2010). Likewise, numerous Bald and

Golden eagles captured in the wild and brought to rehabilitation facilities in eastern North America have shown clinical blood lead levels of >0.25 ppm (West Virginia Division of Natural Resources, Virginia Department of Game and Inland Fisheries, MRNF unpubl. data). Sublethal lead poisoning may predispose eagles to exposure to other threats, especially collision.

Polychlorinated biphenyls (PCBs) and organochlorines, especially dichloro-diphenyl-trichloroethane (DDT), have contributed to Golden Eagle population decline in the northeastern United States (Todd 1989). Records from Maine show that territorial eagles preyed on Double-crested Cormorants (*Phalacrocorax auritus*) and herons (Ardeidae) that concentrated DDT residues (Spofford 1971a). An addled egg collected in 1996 exhibited levels of p,p' DDE, total PCBs, and mercury suggestive of potential reproductive impairment (Todd 2000). Finally, carcasses laced with poisons for other predators (e.g., coyotes) kill Golden Eagles in the western United States and, if used, may substantially affect Golden Eagles in the East as well (Henny et al. 1984, Kochert and Steenhof 2002).

Of the indirect threats to eagles, habitat loss—especially on migration, wintering, and southern (Gaspé) breeding grounds—is perhaps of the greatest importance. Habitat loss processes are, in many present circumstances, driven by energy development, including that for wind energy and natural gas extraction (i.e., from Marcellus and Utica Shale layers).

Next Steps for Golden Eagle Research and Management

Research priorities.—Conservation of Eastern Golden Eagles demands a thorough understanding of their ecology. Fundamental unanswered questions about this population include the following: How large is the population? What is its distribution? How do distribution and quality of food and habitat resources affect reproductive output and survivorship? What migration corridors do these birds use and which components of these routes are most important to conserve? To what extent do pre-adults disperse and to where do they disperse? Research is also required to understand human effects, direct and indirect, on this species. Key areas of conservation significance are (1) potential effects of and mitigation for development of wind energy and other collision risks; (2) the degree to which lingering pesticide residues and lead toxicity from spent lead ammunition are relevant to populations; (3) the demographic effect of incidental take from bycatch in leg-hold traps and snares; and (4) effects of habitat fragmentation on eagle habitats and persistence.

Management priorities.—Management for Eastern Golden Eagles should focus on threats from collision, lead poisoning, and trapping as well as broader-scale habitat conservation concerns.

It is well documented that operational wind turbines can kill birds, including Golden Eagles (Hunt 2002). The most desirable locations for turbines in Appalachia are, in many cases, the same ridgetops, plateaus, and other topographic features that act as important annual migration corridors or are used for slope-soaring within nesting, wintering, or foraging areas. To minimize wildlife–turbine conflict, the USFWS established voluntary National Wind Energy Guidelines (2003) that recommend an Avian or Avian and Bat Protection Plan (ABPP) for compliance with the Migratory Bird Treaty Act. Revised guidelines recently have been published in draft form (USFWS 2011b). To adequately address the regulatory provisions required under BGEPA to protect and avoid "take" of eagles by wind projects, USFWS also has developed a draft Eagle Conservation Plan Guidance (USFWS 2011a) that includes a tiered process for assessing, avoiding, and mitigating risk. Many eastern states and provinces also have developed guidance for wind energy development as it relates to the take of migratory birds, including Golden Eagles, although in all cases these are apparently nonmandatory.

Additional regulatory protections may be warranted for this species, at the state, provincial, and Canadian federal levels, given the substantial threats to Eastern Golden Eagle populations posed by extrinsic factors and factors inherent to small populations. Efforts are now underway to raise the level of protection in several states. This is important because state laws determine conservation funding allocations and because they supersede federal law when the former are more restrictive than the latter. However, these necessary legal protections at all levels must not inhibit the essential research required to understand the basic natural history and ecology of this population.

Finally, given the historical distribution of Golden Eagles in eastern North America and the potential negative genetic consequences of translocation programs, we recommend that introductions or translocations of western Golden Eagles into states east of the Mississippi be discontinued.

Conclusions

Eastern Golden Eagles appear to be a distinct segment of a declining North American population that is increasingly at risk from threats on breeding, migration, and wintering grounds. With growing interest in energy development throughout the species' range, Canadian and U.S. government agencies are re-evaluating management strategies for its protection. Historical knowledge about Golden Eagle populations in the East is spotty. Although relatively complete in a few areas (especially with regard to migration count data), it is remarkably lacking in information on basic geographic distribution, demography, ecology, and behavior. Many ornithologists are unaware of the significance of and threats to Eastern Golden Eagles. This commentary is intended to summarize the knowledge about this population, increase its prominence for conservationists nationwide, and draw attention to the threats these birds confront.

Acknowledgments

We thank the authors' institutions for their support of the workshop that led to this publication. Additional funding for the workshop was provided by the Virginia Department of Game and Inland Fisheries and the Hawk Mountain Sanctuary Association. Comments from M. Bechard and many colleagues improved the manuscript. This is Hawk Mountain Sanctuary contribution to conservation science number 212.

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Associate Editor: M. Bechard
Received 6 April 2011, accepted 2 November 2011