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ABUNDANCE AND DISTRIBUTION OF NESTING GOLDEN EAGLES IN HUDSON BAY, QUÉBEC

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ABSTRACT.—Golden eagles (*Aquila chrysaetos*) were surveyed between 1990 and 1993 in a 19 500 km² area in the Hudson Bay region of northern Québec. We found 20 nesting areas containing 31 nests. This doubles the number of known nesting pairs in eastern North America. Pair density was 1.04 per 1000 km² and appears to be lower than in other northern regions. All nests were on cliffs and 87.1% were exposed toward the south or southwest. Sixteen nests (53.3%) had overhangs. Nest and cliff heights averaged respectively 37.2 and 71.9 m. Productivity seems to be lower than that of other populations in North America.

KEY WORDS: *abundance; golden eagle; Hudson Bay; Québec; reproduction.*

Abundancia y distribución de *Aquila chrysaetos* nidificando en Bahía Hudson, Québec

RESUMEN.—Se estudió a *Aquila chrysaetos* entre 1990 a 1993, en un área de 19 500 km² en la región de Bahía Hudson al norte de Québec. Encontramos 20 áreas de nidificación con un total de 31 nidos. Esta observación dobla el número conocido de parejas nidificantes en el este del Norte America. Todos los nidos estaban ubicados en riscos, el 87.1% se encontraba expuesto hacia el sur o el suroeste. 16 nidos (53.3%) estaban sobresalientes. La altura promedio de nidos y riscos se encontraba a 37.2 y a 71.9 m, respectivamente. La productividad parece ser más baja que en otras poblaciones de Norte America.
[Traducción de Ivan Lazo]

In North America, the golden eagle (*Aquila chrysaetos*) is abundant in the West, notably New Mexico, Colorado, and Wyoming (Boeker 1974). In eastern United States the situation is somewhat different. No current estimation of its numbers exists; however, Spofford (1971) and Lee and Spofford (1990) believed that the golden eagle was never very numerous in the Appalachians. In the northeastern U.S., less than 30 nesting territories have been recorded previously, and only one nesting pair has been observed since 1983 (Todd 1989). The golden eagle is now recognized as an endangered species in Maine, New Hampshire, and New York (Todd 1989). In the southeastern U.S., there were no confirmed nestings as of 1989 (Lee and Spofford 1990).

In Canada east of Manitoba, the number of known territories was less than 20, distributed in Ontario, Québec, and Labrador (Snyder 1949, Baillie 1955, Spofford 1959, Millsap and Vana 1984, Todd 1989). Recently, the golden eagle was declared endangered in Ontario (Ontario Ministry of Natural Resources 1992).

Reports of migrating eagles in southeastern Canada and the northeastern U.S. (Spofford 1971, Bednarz et al. 1990), as well as winter counts in the eastern U.S. (Millsap and Vana 1984) indicated the presence of a substantial population in winter. The majority of these birds probably originated in the eastern part of Arctic Canada, mostly the province of Québec (Snyder 1949, Spofford 1971, Todd 1989). Captures of young eagles banded as nestlings in this region support this hypothesis (Millsap and Vana 1984).

According to Todd (1989) and Bednarz et al. (1990), the origin of the migrating eagles and their current population numbers and limiting factors

constitute the most urgently needed information for the conservation of the golden eagle in eastern North America. Hence, we present the results of four years of observations of golden eagles relative to their abundance, population density, nesting habits, and reproduction in the Hudson Bay region of northern Québec.

METHODS

The study area comprised the eastern shore of Hudson Bay, extending from the mouth of the Great Whale River (55°17'N, 77°47'W) to that of the Nastapoka River (56°55'N, 76°33'W) and covered approximately 19 500 km² (Fig. 1).

The study area comprised two large physiographic zones: a sloping shoreline and an interior plateau. The former, characterized by cuesta relief, is roughly 25-km wide and covers nearly half of the study area. The hills average approximately 200 m high, but they do reach 445 m in altitude west of Richmond Gulf. Their even slopes are interrupted by denuded cliffs that generally face southeast. Many of the abundant cliffs are more than 100 m in height and 5 km long. The continental plateau, extending eastward from the shoreline, varies from 200–400 m in elevation. Topography consists of lines of rocky hills separated by deep valleys (<200 m). Cliffs in this area are numerous, but are not high, rarely rising more than 50 m.

The climate is sub-polar. Average April temperature at Kuujjuarapik-Whapmagoostui is −7.3°C (Canada, Service de l'Environnement Atmosphérique [Can., SEA] 1982a). The prevailing winds between April and June are from the north (Can., SEA 1982b). Snow cover and ice on the lakes extends from October to mid-May.

Three vegetation zones have been identified in the study area (Payette 1983). Boreal forest covers the southeast part up to the Little Whale River. Forest tundra encompasses more than half of the study area, extending northward from the southwest sloping shoreline. Tundra covers less than 10% of the area studied, following the Hudson Bay shoreline northwest to Richmond Gulf.

Surveys were conducted using an A-Star 350 helicopter. The survey team consisted of two or sometimes three observers. The search effort focused primarily on cliffs and the immediate surrounding area. The helicopter was flown several meters below the cliff summits at a distance of 20 m away from the face and at a speed of 30–70 km/hr. To thoroughly cover the highest cliffs, two or more passes were made, beginning at the top (see Kochert 1986). All flights were made in good weather with clear visibility and low winds.

Each cliff was examined carefully to detect eagles, their nests and other signs of occupancy (e.g., feces or prey remains). The following information was collected for each nest discovered: height of cliff and of the nest, nest orientation, and presence of an overhang. The first two variables were measured by recording the helicopter altimeter at the appropriate heights. The number of eagles present and the nest contents (eggs and/or young) were noted. The age of nestlings was determined after Mathieu (1985) from the helicopter and the nesting phenology was estimated retroactively using 45 d for incubation and 64 d for the nestling stage prior to first flight (Steenhof 1987). The distance between adjacent occupied nests during a season was measured on topographical maps.

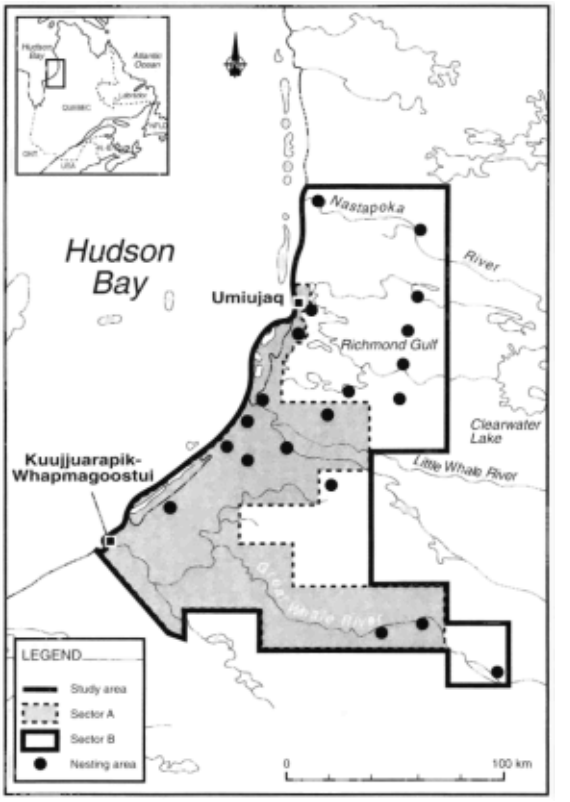

Figure 1. Study area and golden eagle nesting areas in 1990–93.

The study zone was divided into two sectors, A and B (Fig. 1). In sector A, our objective was to locate all pairs and their nests. More than 90% of this area, which covered 10 600 km², was inventoried between 11 and 20 July 1990. The remainder of the sector was completed during 1–30 June 1992 and during 22–31 May 1993. Sector B was covered less intensively, only some of the most suitable cliffs were surveyed over all 4 yr. In 1991 (4–17 June), 1992 and 1993, all of the nests previously discovered were revisited except for the ones of two territories in 1991. In 1992 and 1993, nesting areas with vacant nests were searched for other possible nests that might be occupied by a breeding pair. No ground follow-up surveys were conducted, but in 1992, all nests occupied by a breeding pair in June were examined on 8 August. Sixty hours were spent flying in 1990, 25 in 1992, and about 20 in 1993. In 1991, visits were done during waterfowl surveys.

The terminology describing the status of nest utilization and reproductive parameters followed recommendations

by Steenhof (1987). A "nesting area" is the site where nests (including alternates) are found and where no more than one pair lay eggs at one time. The "territory" includes the nesting area and the foraging area. A nesting area or a nest are "occupied" if a pair of eagles is observed near to it, breeding or not. Occupancy of a nesting area, and therefore a territory, was considered uncertain when no pair were observed. A golden eagle pair was assumed for each nesting area.

RESULTS

Twenty golden eagle nesting areas were occupied by a breeding pair for at least 1 yr throughout the entire study area between 1990 and 1993 (Table 1). Number of known nesting areas and nests increased each year of the study, except for 1991. The maximum number of occupied nesting areas found in a single year was 14 (1993). Annual mean percentage of territories with uncertain occupancy by a pair was 36.2%.

In sector A, the population density of pairs (N = 11), was 1.04 pair per 1000 km^2. Over all 4 yr, the distance between adjacent occupied nests ranged from 9.8–44.7 km ($\bar{x}$ = 26.5, SD = 11.0, N = 16). In sector B, it varied from 12.2–36.1 km ($\bar{x}$ = 20.1, SD = 8.2, N = 6).

We found 31 nests in the 20 nesting areas with a mean number of 1.3 nest per area (1–3). Six nesting areas contained at least one alternate nest (Table 1). In four nesting areas, the alternate nests were within 500 m of the occupied nest on the same cliff. In the other two cases, they were from 1.6–2.2 km apart on separate cliffs. The two most distant nests were confirmed as being part of the same nesting area by observing an adult eagle flying from one nest to the other.

The height of the nests averaged 37.2 m from the cliff bottom (range 9–81 m, SD = 19.0 m, N = 31) on cliffs with a mean height of 71.9 m (range 18–107 m, SD = 26.5 m, N = 17). On average, nests were located midway up the cliff face ($\bar{x}$ = 52.8%, range 19.8–83.1%, N = 30). Of 31 nests, 27 faced south or southwest, two north, and two northeast. Two of the latter four nests were not occupied during the study. Interestingly, the two occupied nests had overhangs. Of 30 nests, 53.3% had overhangs. Most of the nests were located in valleys overlooking major rivers (45.2%), tributaries (22.7%), or lakes (12.9%).

In 1990, seven nests contained a mean of 1.22 young (range 1–2) over 7-wk-old. We estimated laying took place for these nests between early April and early May and fledging from the end of July to the end of August. In 1992, nine nests examined between 20–30 June contained a mean of 1.22 young (range 1–2), and on 8 August, these nests contained a mean of 0.89 young varying between 7- and 8-wk-old.

DISCUSSION

Our surveys revealed the existence of at least 20 nesting pairs in the study area. This number doubles the number of known nesting pairs in eastern North America and reveals the existence of a significant golden eagle nesting population east of Hudson Bay. It is not likely that pairs that used one nesting area during the study moved to another area because of the great distance between adjacent nesting areas and due to the strong homing responses exhibited in this species (Phillips et al. 1991). The number of golden eagle pairs and nesting areas discovered is likely less than the actual number present because the study area had never been surveyed previously, sector A was covered only once, and sector B was not surveyed entirely.

Several factors could account for the relatively high percentage of uncertainty in yearly occupancy of territories by a pair. Surveys were performed at the nestling stage while some nests could have already been deserted. Also all nests were not visited each year. In some nesting areas, all alternate nests were not found during a single survey, and it is likely that others are still to be discovered. Uncertainty about occupancy could also result from non-egg-laying pairs or mortality of eagles.

This population is probably not isolated because there have been several recent observations of golden eagles within 100 km north and northeast of the study area (F. Morneau and S. Brodeur unpubl. data). A pair was seen at Lacs des Loups Marins, and two unoccupied nests were discovered at the headwaters of the du Gué River (57°00′N, 71°25′W). Further east, two nests occupied by breeding golden eagles were found in 1990 in the valley of the Caniapiscau River (F. Morneau unpubl. data) and three nesting territories were located in Labrador (J. Brazil pers. comm.). Several nests exist in the Ungava Bay region (Spofford 1959, Millsap and Vana 1984, J.D. Weaver and D.M. Bird unpubl. data). These data suggest that golden eagle distribution covers a large part of the Québec–Labrador peninsula.

The mean distance (20 km) between neighboring occupied nests appears to be greater than reported elsewhere in the northern latitudes of Europe and

Table 1. Use of golden eagle nesting areas and nests during 1990–93, in Hudson Bay, Québec, Canada.

Nesting Area[a]	Year of Record			
	1990	1991	1992	1993
1a	Breeding[b]	Breeding	Vacant	Vacant
2a	Vacant	Vacant	Vacant	Vacant
2b	Breeding	Breeding	Lone adult	Breeding
3a	Unknown	Unknown	Vacant	Vacant
3b	Unknown	Unknown	Vacant	Vacant
3c	Unknown	Unknown	Unknown	Breeding
4a	Vacant	Not examined	Vacant	Vacant
4b	Unknown	Unknown	Breeding	Vacant
4c	Breeding	Vacant	Vacant	Breeding
5a	Breeding	Not examined	Breeding	Breeding
6a	Lone adult	Vacant	Pair	Breeding
7a	Lone adult	Breeding	Breeding	Lone adult
8a	Unknown	Unknown	Vacant	Vacant
8b	Breeding	Breeding	Vacant	Vacant
8c	Unknown	Unknown	Unknown	Breeding
9a	Unknown	Unknown	Breeding	Pair
10a	Unknown	Unknown	Breeding	Vacant
11a	Unknown	Unknown	Breeding	Pair
12a	Unknown	Unknown	Breeding	Breeding
13a	Unknown	Unknown	Breeding	Vacant
14a	Unknown	Unknown	Vacant	Vacant
14b	Unknown	Unknown	Vacant	Vacant
14c	Unknown	Unknown	Breeding	Vacant
15a	Breeding	Breeding	Vacant	Vacant
16a	Breeding	Vacant	Vacant	Breeding
17a	Vacant	Not examined	Lone adult[c]	Vacant
17b	Vacant	Not examined	Lone adult	Breeding
17c	Breeding	Not examined	Lone adult	Vacant
18a	Unknown	Unknown	Vacant	Breeding
19a	Unknown	Unknown	Unknown	Breeding
20a	Unknown	Unknown	Unknown	Breeding
Total of breeding plus pair	8	5	10	14

[a] Numbers refer to nesting areas. Letters refer to alternate nests in the same nesting area.

[b] Nest status: Breeding = nest occupied by a breeding pair; Pair = empty nest but one pair seen near it; Lone adult = empty nest but one adult seen near it; Vacant = empty nest, no adult seen around; Not examined = nest not examined; Unknown = nest not discovered yet.

[c] One adult was flying over the three alternate nests which were located within 30 m on the same cliff.

North America: Scotland, 5.4–5.8 km (Watson and Rothery 1986); Kisaralik River, Alaska, 6.0 km (Weir 1982); central Canadian Arctic, 10.4 km (Poole and Bromley 1988); Porcupine River, Alaska, 15.3 km (Ritchie and Curatolo 1982); west Norway, 16.0 km (Bergo 1987). The same pattern is seen in eagle densities: northeast Scotland, 9.7 adult pairs per 1000 km^2 (Watson et al. 1989); northern Sweden, 1.7–2.3 (Tjernberg 1983).

No tree nests were found in the study area. However, in Alaska and Sweden, trees are also used (Ritchie and Curatolo 1982, Weir 1982, Tjernberg 1983). Tjernberg (1983) stated that spruce trees are generally not strong enough to support eagle nests. This likely explains the selection of cliff sites in our study area, even though spruce trees are abundant in the southeastern part.

It is likely that weather conditions at the beginning of the nesting season constitute a critical factor in the choice of nest site location. Therefore, selecting

a site facing southward is an appropriate strategy to minimize exposure to inclement weather (McGahan 1968, Mosher and White 1976, Poole and Bromley 1988). Overhangs protect nests from rain, snow and ice formation which have been known to cause nest abandonment (Poole and Bromley 1988).

Unfortunately, there are no historical data with which to compare the eagle density we discovered. Nevertheless, a decrease in the number of migrating golden eagles in the fall at Hawk Mountain was observed in the period from 1940–70 (Spofford 1971, Bednarz et al. 1990). Since then, the number of immature eagles has increased, while the number of adults has remained stable (Bednarz et al. 1990). These birds likely originate partly from Québec (Millsap and Vana 1984).

In North America, the principal factors influencing golden eagle numbers are prey abundance, availability of suitable nesting sites (Phillips et al. 1990), direct persecution by humans or disturbance from human activities (Postovit and Postovit 1987), and incidental trapping (Bortolotti 1984). The distribution and abundance of prey are not known for the study area, but the abundance of cliffs in the region would preclude nest sites as being a limiting factor. Human disturbance is probably negligible due to the remoteness of the area. However, native people inhabiting the region do kill the eagles in some areas (D. Chevrier pers. comm.), but the extent of this problem is unknown.

The reproductive performance of this eagle population (0.89–1.22 young/successful pair) seems to be lower than that elsewhere in North America. All young were above the prescribed minimum age of 51 d for determining nest success (see Steenhoff 1987). In Arctic Canada, the mean number of young fledged per successful pair was 1.14–1.50 (Poole and Bromley 1988), in Alaska, 1.3–1.6 (Ritchie and Curatolo 1982), in Montana, 1.56 (McGahan 1968) and in Wyoming, 1.1–1.8 (Phillips et al. 1990).

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LITERATURE CITED

BAILLIE, J.L. 1955. The golden eagle nesting in the Gaspé Peninsula, Quebec. *Can. Field-Nat.* 69:13–14.

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.

BERGO, G. 1987. Territorial behaviour of golden eagles in western Norway. *Br. Birds* 80:361–376.

BOEKER, E.L. 1974. Status of golden eagle surveys in the western states. *Wildl. Soc. Bull.* 2:46–49.

BORTOLOTTI, G.R. 1984. Trap and poison mortality of golden and bald eagles. *J. Wildl. Manage.* 48:1173–1179.

CANADA, SERVICE DE L'ENVIRONNEMENT ATMOSPHÉRIQUE. 1982a. Canadian climate normals, 1951–1980 = Normales climatiques au Canada, 1951–1980. Vol. 2. Temperature = Température. Downsview, Ont.: Programme climatologique canadien.

———. 1982b. Canadian climate normals, 1951–1980 = Normales climatiques au Canada, 1951–1980. Vol. 2. Wind = Vent. Downsview, Ont.: Programme climatologique canadien.

KOCHERT, M.N. 1986. Raptors. Pages 313–349 *in* A.Y. Cooperrider, R.J. Boyd and H.R. Stuart [EDS.], Inventory and monitoring of wildlife habitat. USDI Bur. Land Manage. Denver, CO U.S.A.

LEE, D.S. AND W.R. SPOFFORD. 1990. Nesting of golden eagles in the central and southern Appalachians. *Wilson Bull.* 102:693–698.

MCGAHAN, J. 1968. Ecology of the golden eagle. *Auk* 85:1–12.

MATHIEU, R. 1985. Développement du poussin d'Aigle royal (*Aquila chrysaetos*) et détermination de l'âge dans la nature par l'observation éloignée. *Bièvre* 7:71–86.

MILLSAP, B.A. AND S.L. VANA. 1984. Distribution of wintering golden eagles in the eastern United States. *Wilson Bull.* 96:692–701.

MOSHER, J.A. AND C.M. WHITE. 1976. Directional exposure of golden eagle nests. *Can. Field-Nat.* 90:356–359.

ONTARIO, MINISTRY OF NATURAL RESOURCES. 1992. Rare, threatened, endangered, extirpated or extinct species of Ontario. Fact sheet. Ministry of natural resources. Toronto, Canada.

PAYETTE, S. 1983. The forest tundra and present treelines of the northern Quebec-Labrador Peninsula. Pages 3–23 *in* P. Morisset and S. Payette [EDS.], Tree-line ecology. Proc. northern Quebec tree-line conf. Centre d'études nordiques. Quebec, Qc, Canada.

PHILLIPS, R.L., J.L. CUMMINGS AND J.D. BERRY. 1991. Responses of breeding golden eagles to relocation. *Wildl. Soc. Bull.* 19:430–434.

PHILLIPS, R.L., A.H. WHEELER, J.M. LOCKHART, T.P. MCENEANEY AND N.C. FORRESTER. 1990. Nesting

ecology of golden eagles and other raptors in southeastern Montana and northern Wyoming. USDI Fish Wildl. Serv., Tech. Rep. 26. Washington, DC U.S.A.

POOLE, K.G. AND R.G. BROMLEY. 1988. Interrelationships within a raptor guild in the central Canadian Arctic. *Can. J. Zool.* 66:2275–2282.

POSTOVIT, H.R. AND B.C. POSTOVIT. 1987. Impact and mitigation techniques. Pages 183–213 *in* B.A.G. Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird [EDS.]. Raptor management techniques manual. Natl. Wildl. Fed., Sci. Tech. Ser. 10. Washington, DC U.S.A.

RITCHIE, R.J. AND J.A. CURATOLO. 1982. Notes on golden eagle productivity and nest site characteristics, Porcupine River, Alaska. *J. Raptor Res.* 16:123–128.

SNYDER, L.L. 1949. On the distribution of the golden eagle in eastern Canada. *Can. Field-Nat.* 63:39–41.

SPOFFORD, W.R. 1959. Nesting of the golden eagle at Sugluk Inlet, Ungava, Quebec. *Can. Field-Nat.* 73:177.

———. 1971. The breeding status of the golden eagle in the Appalachians. *Am. Birds* 25:3–7.

STEENHOF, K. 1987. Assessing raptor reproductive success and productivity. Pages 157–170 *in* B.A.G. Pendleton, B.A. Millsap, K.W. Cline and D.M. Bird [EDS.], Raptor management techniques manual. Natl. Wildl. Fed., Sci. Tech. Ser. 10. Washington, DC U.S.A.

TJERNBERG, M. 1983. Habitat and nest site features of golden eagle *Aquila chrysaetos* (L.), in Sweden. *Swed Wildl. Res.* 12:131–163.

TODD, C.S. 1989. Golden eagle. Pages 65–70 *in* B.G. Pendleton, M.N. LeFranc, Jr., M.B. Moss, C.E. Ruibal, M.A. Knighton and D.L. Krahe [EDS.], Proc northeast raptor management symposium and workshop. Natl. Wildl. Fed., Sci. Tech. Ser. 13. Washington, DC U.S.A.

WATSON, A. AND P. ROTHERY. 1986. Regularity in spacing of golden eagle *Aquila chrysaetos* nests used within years in northeast Scotland. *Ibis* 128:406–408.

WATSON, A., S. PAYNE AND R. RAE. 1989. Golden eagles *Aquila chrysaetos*: land use and food in northeast Scotland. *Ibis* 131:336–348.

WEIR, D.N. 1982. Cliff nesting raptors of the Kisaralik River, western Alaska. Pages 138–152 *in* W.N. Ladd and P.F. Schempf [EDS.], Proc. of a symposium and workshop on raptor management and biology in Alaska and western Canada. USDI Fish Wildl. Serv. Anchorage, AK U.S.A.

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