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GOLDEN EAGLES IN THE U.S. AND CANADA: STATUS, TRENDS, AND CONSERVATION CHALLENGES

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ABSTRACT.—We reviewed the literature to assess status and population trends and to identify mortality factors affecting Golden Eagle populations in the U.S. and Canada. Nesting populations in Alaska and Canada are stable, but some nesting populations in the western U.S. have declined. Small but steady declines in the intermountain West have been associated with shrub loss and declining jackrabbit populations; declines in southern California have been attributed to urbanization. Migration counts in the eastern U.S. suggest a decline in Golden Eagles from the 1930s to the early 1970s, with a stable or increasing trend since the early 1970s. No significant trends in migration counts were reported for Golden Eagles in the western U.S. since the mid-1980s. Western migration count sites on the continental divide in the Rocky Mountains at or just north of the U.S.-Canadian border (49–51°N latitude) show potential to provide information on trends of Golden Eagle populations from Alaska and western Canada. Most eagle mortality is human related. This paper illustrates the need for more effective monitoring of Golden Eagle populations in North America.

KEY WORDS: *Golden Eagle*; Aquila chrysaetos; *status*; *monitoring*; *mortality*; *U.S.*; *Canada.*

Aguilas reals en E.U.A. y canadá: estado, tendencias y retos para su conservación

RESÚMEN.—Revisamos la literatura para evaluar el estado y las tendencias poblacionales y para identificar los factores de mortalidad que afectan las poblaciones de águila real en E.U.A. y Canadá. Las poblaciones que anidan en Alaska y Canadá están estables, pero algunas poblaciones que anidan en el oeste de E.U.A. han declinado. Pequeñas, pero continuas declinaciones en el oeste íntermontañoso han sido asociadas con la perdida de arbustos y con el decline en las poblaciones de liebres; el declive en el sur de California ha sido atribuido a la urbanización. Conteos migratorios en el este de E.U.A. sugieren un decline en las águilas reales desde los años 1930s hasta principios de los 1970s, con una tendencia estable o a incrementar desde el principio de los 1970s. Ninguna tendencia significativa en conteos de migratorios fue reportada para las águilas reales en el oeste de E.U.A. desde mediados de los 1980s. Los sitios de conteo de migración del oeste sobre la divisoria continental en las montañas rocosas en o justo al norte de la frontera E.U.A.-Canadá (49–51° latitud N) tiene potencial para proveer de información sobre las tendencias de las poblaciones de águilas reales de Alaska y el oeste de Canadá. La mayoría de la mortalidad de las águilas esta relacionada con los humanos. Este articulo ilustra la necesidad de un monitoreo mas efectivo de las poblaciones de águila real en Norte América.

[Traducción de César Márquez y Victor Vanegas]

Until recently Golden Eagles (*Aquila chrysaetos*) were considered abundant in North America with stable populations (Hamerstrom et al. 1975, Palmer 1988). However, some studies, particularly those from migration count sites in the U.S. (e.g., Bednarz et al. 1990, Hoffman et al. 1992), have raised questions about trends of Golden Eagle populations. Only four nesting Golden Eagle pairs are known in the eastern U.S in Maine, Tennessee, and Georgia with two pairs the result of introduction efforts in Tennessee and Georgia (Kochert et al. 2002). In addition, recent requests by Native Americans to the U.S. Fish and Wildlife Service to harvest Golden Eagles for religious purposes have prompted the need to assess the status of the species in North America and to assess threats to populations (Bart et al. 1999). In this paper, we report information on the status and trends of Golden Eagle populations in the U.S. and Canada, and we discuss mortality factors affecting eagle populations.

METHODS

We obtained information from published and unpublished literature and personal interviews with individuals

Table 1. Trends in number of occupied nesting territories at four long-term survey areas in the U.S.

LOCATION	YEARS	N[a]	TREND	SOURCE
Interior Alaska	1988–99	58–76	Stable	McIntyre and Adams 1999, McIntyre 2001
Southwestern Idaho	1971–99	28–35	Decline*	Steenhof et al. 1997, USGS, unpubl. data
Northeast Colorado	1972–90	7–10	Decline	Leslie 1992
Southern California	1895–1999	40–85	Decline	Bittner and Oakley 1999

[a] Number of territories.
* $P < 0.001$.

conducting long-term surveys of Golden Eagles. We used a variety of data including long-term nesting surveys, the Breeding Bird Survey (Peterjohn 1994), Christmas Bird Counts (Sauer et al. 1996), and migration counts. Other sources included modeling efforts and other literature syntheses.

To assess long-term trends in territory occupancy and productivity, we selected studies that spanned more than 10 yr and extended into at least the mid-1980s. Four studies fit the criteria for occupancy (Table 1), and four fit criteria for productivity (Table 2). Continuous studies of both occupancy and productivity occurred only in the Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho (Steenhof et al. 1997, USGS unpubl. data) and in Denali National Park in interior Alaska (McIntyre and Adams 1999, McIntyre 2001). Occupancy data from San Diego County, California span more than 100 yr and were collected by several investigators (Bittner and Oakley 1999), including Dixon (1937) and Scott (1985). Leslie (1992) compared occupancy in northeastern Colorado during two seasons 18 yr apart. We obtained productivity information for Utah from Keller and Smith (1998) and Bates and Moretti (1994) (Table 2). In addition, we used the number of egg-laying pairs during 20 seasons in central Oregon (Anderson 1985).

RESULTS

Nesting Territory Occupancy. Of four areas tracked for long-term occupancy of eagle territories, all except interior Alaska experienced declines (Table 1). The number of occupied territories in southwestern Idaho declined significantly between 1971 and 1994 ($r^2 = -0.54$, $P < 0.001$; Steenhof et al. 1997). Declines of nesting eagles in southwestern Idaho were associated with loss of shrubs and black-tailed jackrabbit (*Lepus californicus*) habitat due to widespread fires (Kochert et al. 1999). Nesting eagles in San Diego County decreased dramatically from an estimated 85 pairs in 1900 to 40 occupied territories in 1999 (Bittner and Oakley 1999). Large-scale declines occurred between 1956–80, and subtle declines occurred through 1999. These declines were related to extensive residential development (Bittner and Oakley 1999). The decline reported for northeastern Colorado (10 to 7 pairs) should be interpreted with caution because of the small sample size and low frequency of sampling (Leslie 1992). The number of nesting attempts in central Oregon declined significantly ($r^2 = -0.69$, $P < 0.001$) between 1966–84 (Anderson 1985). It is not clear if this decline was the result of a decrease in occupancy or in the proportion of pairs that laid eggs.

Eagle Productivity. In contrast to territory occupancy, no long-term trends in productivity were reported except in north-central Utah (Table 2).

Table 2. Trends in Golden Eagle productivity in four long-term survey areas in the U.S. Productivity is young fledged per pair except for north-central Utah where it is young per egg-laying pair.

LOCATION	YEARS	N	TREND	SOURCE
Interior Alaska	1988–99	58–76	None	McIntyre and Adams 1999, McIntyre 2001
Southwestern Idaho	1971–99	28–35	None	Steenhof et al. 1997, USGS unpubl. data
North-central Utah	1977–98	31–240	Decline*	Keller and Smith 1998
Eastern Utah	1981–92	39	None	Bates and Moretti 1994

* $P = 0.02$.

Table 3. Golden Eagle trends from Breeding Bird Surveys, 1966–98.

REGION	TREND	N^a	P
All U.S.[b]	2.4	271	0.23
Pacific region	4.3	99	0.17
Southwest region	−6.6	21	0.25
CMP[c]	2.8	151	0.36
Canada	−7.1	5	0.56
Survey wide	1.9	276	0.33

[a] Number of routes with eagle observations.
[b] Excluding Alaska.
[c] Central mountains and plains.

Table 4. Golden Eagle trends from Christmas Bird Counts, 1959–88.

REGION	TREND	P
Survey wide	−1.0	<0.05
States with declines		
Idaho	−1.4	<0.001
Oregon	−2.4	<0.001
Kansas	−3.7	<0.05

Although eagle productivity has fluctuated with changes in the major prey in Alaska, southwestern Idaho, and eastern Utah, the number of the young fledged per occupied territory showed no trends over time (Bates and Moretti 1994, Steenhof et al. 1997, McIntyre and Adams 1999). However, the proportion of young fledged per egg-laying pair declined slightly but significantly ($r^2 = -0.22$, $P = 0.02$) in the desert (lower elevation) study area of north-central Utah (Keller and Smith 1998). This decline in productivity may reflect loss and degradation of native sagebrush (jackrabbit) habitats (Keller and Smith 1998).

Breeding Bird Surveys. Breeding Bird Surveys (BBS) show no trend for nesting Golden Eagles on either a regional or continental scale from 1966–98 (Table 3). Long-term data from BBS routes are available only in the southern portions of the Canadian provinces, and these results may not be reliable because only five routes had eagle observations (Table 3). Data from Alaska and the Yukon and Northwest Territories of Canada where Golden Eagles are abundant (Kirk and Hyslop 1998, McIntyre 2001) were not included in these analyses because BBS did not establish routes in these regions until the 1980s (Peterjohn 1994) and the number of routes and routes with eagle sightings are low. Most BBS routes follow roads (Peterjohn 1994) and because Golden Eagles generally nest in remote areas (Palmer 1988), the BBS is not the most reliable method to assess trends of nesting Golden Eagles.

Trends Based on Other Information. Golden Eagle nesting populations and productivity in Canada are likely stable; evidence for this assessment includes considerable unpublished information (Kirk and Hyslop 1998). In eastern Canada, nesting populations have been found recently at Hudson Bay in northern Quebec (Morneau et al. 1994) and in the Labrador Peninsula. Nesting populations in southwestern Saskatchewan and the Yukon Territory are stable, with the latter being a large population (estimated 900–1000 pairs). Long-term productivity of eagles in the Northwest Territories is also stable (Kirk and Hyslop 1998). White (1994) reported that the status of Golden Eagles in the western U.S. was variable: stable in some areas and possibly declining in others. Hunt et al. (1999) modeled the breeding Golden Eagle population at Altamont Pass in central California and concluded that the population was either stable or decreasing.

Winter Surveys. According to results of Christmas Bird Counts, Golden Eagles declined significantly throughout the U.S. and Canada (Ontario and British Columbia) from 1959–88 (Table 4). Counts in Idaho, Oregon, and Kansas declined significantly, while other survey regions showed no significant trend. However, Christmas Bird Counts have limited value for detecting Golden Eagle trends because of the low number of individuals counted on each survey, inconsistencies among years in survey efforts and area surveyed, and the fact that most surveys are in suburban, exurban, or rural settings where eagles are least likely to occur.

Aerial surveys coordinated by the U.S. Fish and Wildlife Service (USFWS) provide potentially useful information on wintering Golden Eagle densities and adult:immature ratios (USFWS unpubl. data). Between 1972–80, 124 000 km^2 were sampled from random transects in Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming during January–February. Only the area in southern Idaho was surveyed after 1980 and for more than 10 yr (Kochert et al. 1984). This 18 000-km^2 area was also surveyed in October from 1972–78. Counts averaged 2.56 more eagles during midwinter than in October, suggesting an influx of migrant birds. The southern Idaho area contained both resident

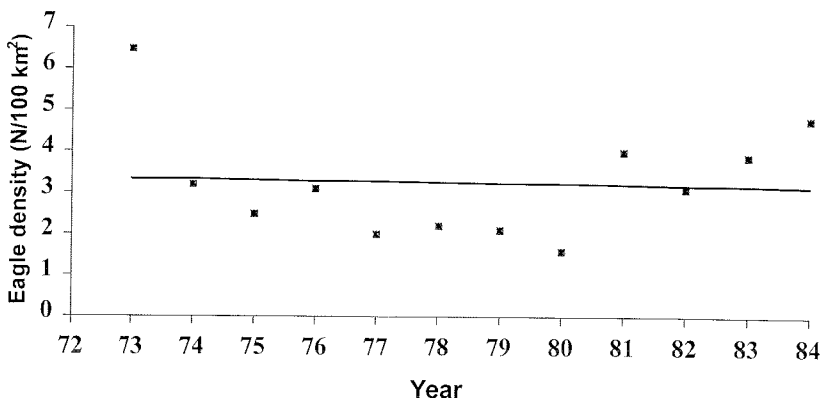

Figure 1. Densities of Golden Eagles wintering in southern Idaho, 1973–84.

birds and migrants from Alaska and Canada during the winter (Fuller et al. 1995, Craig and Craig 1998, McIntyre 2000). Wintering densities in southern Idaho correlated strongly with black-tailed jackrabbit abundance (Kochert 1980). Because jackrabbit populations cycle about every 10 yr (Johnson and Peek 1984), inferences from data sets covering less than 10 yr can be misleading. Eagle counts from 1973–80 showed a significant decline in southern Idaho ($r = -0.80$; $P = 0.02$) that coincided with a jackrabbit decline (Kochert 1980), but longer-term analyses that included the jackrabbit recovery showed that winter eagle densities were stable from 1973–84 (Fig. 1).

Migration Count Sites in the Eastern U.S. and Canada. We assessed trends of migrating Golden Eagles in the eastern U.S. and Canada from six migration count sites (Table 5). Passage rates (number of Golden Eagles per 10 hr of observation) declined significantly at Hawk Mountain, Pennsylvania between 1934–72 but remained relatively stable between 1973–86 (Bednarz et al. 1990). From 1987–99, trends for Golden Eagles at Hawk Mountain have been stable or increasing (L. Goodrich pers. comm., Hawk Mountain Sanctuary unpubl. data). Data from Ontario (Hussell and Brown 1992) and five migration sites in the eastern U.S. (Titus and Fuller 1990) suggest at least a stable trend for Golden Eagle counts from the early 1970s to the late 1980s.

Migration Count Sites in the Western U.S. and Canada. Unlike migration count sites in the eastern U.S., continuous counts in the western U.S. span little over a decade (Table 6). Passage rates at four migration count sites showed no trend from the mid-1980s to late 1990s (Table 6). These sites occur south of 42°N latitude, and eagles that pass through them are probably a mix of northern migrants and dispersing resident birds or short-distance migrants (J. Smith pers. comm.). These Hawkwatch International sites report possible changes in eagle age ratios that may reflect deteriorating conditions in the western U.S. (J. Smith pers. comm.). Passage rates of immature Golden Eagles at the Wellsville Mountains in northern Utah were significantly lower from 1987–97 than from 1977–79.

Raptor migration count sites on the continental divide in the Rocky Mountains just north of the U.S.-Canadian border show potential for monitor-

Table 5. Golden Eagle trends at migration count sites in the eastern U.S. and Canada.

LOCATION	YEARS	SEASON	TREND	SOURCE
Hawk Mountain, Pennsylvania	1934–72	Autumn	Decline	Bednarz et al. 1990
	1973–86	Autumn	None	Bednarz et al. 1990
Niagara Peninsula, Ontario	1975–90	Autumn	Increase	Hussell and Brown 1992
5 Eastern U.S. sites[a]	1972–87	Autumn/Spring	None	Titus and Fuller 1990

[a] Includes Hawk Mountain, Pennsylvania; Hawk Ridge, Minnesota; Whitefish Point, Michigan; Derby Hill, New York; and Cape May, New Jersey.

Table 6. Golden Eagle population trends at four migration count sites in the western United States.[a]

LOCATION	SEASON	YEARS	TREND
Wellsvilles, Utah	Autumn	1987–97	none[b]
Goshutes, Nevada	Autumn	1983–97	none
Manzanos, New Mexico	Autumn	1985–97	none
Sandias, New Mexico	Spring	1985–98	none

[a] Source: Hoffman et al. unpubl. data, J. Smith, pers. comm.
[b] Passage rates for immatures were significantly lower from 1987–97 than from 1977–79.

ing trends because of the large number of eagles that pass over them (Sherrington 1993). For example, fall counts at Mount Lorette (50°58′N) in southern Alberta averaged 4014 Golden Eagles (range 3706–4599) between 1993–96, and spring counts averaged 3707 (range 2461–4213) between 1993–98 (Sherrington 1998, 1999). Although counts have been conducted since 1984 at Windy Point (50°40′N) and 1992 at Mount Lorette (Sherrington 1998), data have not been analyzed for trends.

Conservation Challenges. The greatest conservation challenge in managing Golden Eagle populations is offsetting the adverse effects of human activity. Of Golden Eagles found dead from the early 1960s to the mid-1990s, 73% died from human-related causes, including accidental trauma (27%), electrocution (25%), shooting (15%), and poisoning (6%; Franson et al. 1995). Accidental trauma included collisions with cars, fences, wires, and wind turbines. At least 28–43 Golden Eagles are killed each year by turbine blade strikes in the Altamont Pass Wind Resource Area in west-central California; of 61 eagle deaths investigated in the Diablo Range between 1994–97, 37% resulted from turbine strikes, 5% from car strikes, and 3% from fence collisions (Hunt et al. 1999). Golden Eagles continue to be electrocuted in the western U.S and Canada where Harness (1997) reported 272 eagle electrocutions between 1986–96. Electrocution accounted for 16% of the Golden Eagle deaths in the Diablo Range, California between 1994–97 (Hunt et al. 1999).

Lead accounted for most poisoning deaths of Golden Eagles. Elevated lead levels (>0.20 ppm) occurred in 36% of 162 eagles sampled in 1985–86 from southern California (Pattee et al. 1990). Elevated levels also occurred in 46% of 281 wintering eagles captured in southeastern Idaho between 1990–97 (Craig and Craig 1998), and 56% of 86 spring migrants in Montana trapped between 1985–93 (Harmata and Restani 1995). Sources of lead have not been documented definitively, but are likely from lead shot or bullets in hunter-killed upland game birds and mammals (Wayland and Bollinger 1999), particularly deer (Pattee et al. 1990) and ground squirrels (Harmata and Restani 1995) with waterfowl as a secondary source. Mortality from ingested shot and bullet fragments occurs occasionally (P. Redig pers. comm.). Blood lead levels of recaptured wintering individuals in Idaho did not decrease over 1–5 yr, suggesting repeated or continual exposure to lead in the environment (Craig and Craig 1998). Four (13%) of 31 dead Golden Eagles examined from 1990–96 from the Canadian Prairie Provinces had been poisoned and three (10%) were sublethally exposed to lead (Wayland and Bollinger 1999). In Idaho, seven of 16 dead Golden Eagles necropsied between 1977–86 were lead poisoned (Craig et al. 1990). Agricultural pesticides, mainly organophosphates and carbamates, accounted for most of the remaining poisoning deaths. In the latter cases, eagles often died by consuming other animals that were poisoned or by consuming baits placed to kill other wildlife.

DISCUSSION

Nesting Golden Eagles. Although data provide conflicting evidence on population trends, available information suggests that nesting populations in Alaska and Canada are stable and, for the most part, doing well. The status of nesting Golden Eagles in the western U.S. is less clear. Although some data, such as the BBS, suggest stable populations throughout the western U.S., some populations have declined. Areas like the Snake River Birds of Prey National Conservation Area may have experienced a decrease in carrying capacity (Steenhof et al. 1997). Shrub loss and declining jackrabbit populations have been associated with small, but steady, declines in the intermountain West; declines in southern California have been attributed to urbanization. Although some nesting populations in the western U.S. have decreased, productivity has not declined, except in one population. This agrees with observations of other eagle species where lower quality (or less productive) territories are abandoned in some declining popula-

tions before productivity at higher quality territories declines (Ferrer and Donazar 1996).

Conclusions from Migration Counts. Migration counts in the eastern U.S. suggest a decline in Golden Eagles from the 1930s to the early 1970s, with a stable or increasing trend since the early 1970s. No significant trends were reported for Golden Eagles in the West since the mid-1980s. However, recent increases in adult detection rates and a decrease in migratory immatures have raised concern about conditions for breeding birds and possible lowered reproduction of Golden Eagles in parts of the western U.S. (J. Smith pers. comm.).

Golden Eagle population trends from migration counts should be assessed judiciously because of inconsistencies in data collection among years and count sites, inconsistencies and biases in assessing passage rates, and variability in counts and passage rates caused by weather and eagle behavior (Gould and Lewis 1998, Fuller and Bates 1999). In addition, the origins and destinations of most birds seen at migration count sites are unknown. Significant declines at a migration site could reflect problems throughout the range or merely at an isolated nesting or wintering area. It is difficult to develop management strategies to address possible causes of declines.

Western migration count sites on the continental divide in the Rocky Mountains at or just north of the U.S.-Canadian border (49–51°N latitude) show potential to provide information on trends of Golden Eagle populations from Alaska and western Canada. Large numbers of Golden Eagles pass through these sites, and information from satellite telemetry studies suggests these migration count sites may be on a flight path for Golden Eagles migrating from Alaska and western Canada (Fuller et al. 1995, McIntyre 2000).

Recommendations for Monitoring. Information we present in this paper illustrates the need for more effective monitoring of Golden Eagle populations in North America. We recommend that long-term nesting surveys continue, specifically in Denali National Park (McIntyre 2001), the Snake River Birds of Prey NCA (Steenhof et al. 1997), and San Diego County, California (Bittner and Oakley 1999). Continuous data from these areas provide valuable insights about eagle responses to different environmental problems in diverse geographical areas. We recommend that survey areas be developed for monitoring nesting eagles in Canada, particularly in areas that have been surveyed in the past (see Kirk and Hyslop 1998). Long-term data sets from areas such as north-central Utah (Keller and Smith 1998) should be analyzed and evaluated to determine if these areas should become additional long-term monitoring sites. The area in central Oregon studied by Anderson (1985) also should be resurveyed to ascertain if the population is still depressed or whether it has rebounded. We recommend monitoring the major prey (e.g., black-tailed jackrabbits) concurrently with eagle nesting surveys, specifically in those areas with background prey data; i.e., the Snake River NCA (Steenhof et al. 1997) and Denali National Park (McIntyre and Adams 1999).

We recommend that migration counts continue in the western Rocky Mountains >50°N latitude because they have potential to reflect trends in western Canada and Alaska. Counts at raptor migration count sites should continue to be evaluated (e.g., Gould and Lewis 1998, Fuller and Bates 1999) to determine if they provide meaningful data about status and trend of eagle populations. Information also is needed about the origin and destination of eagles passing through migration count sites.

Counts of Golden Eagles along midwinter Bald Eagle (*Haliaeetus leucocephalus*) survey routes also may provide long-term trend data. More than 300 Golden Eagles have been counted annually on 220 standard routes in 28 states since the mid-1980s (USGS unpubl. data). These January counts occur in Bald Eagle wintering habitat, which may not be prime Golden Eagle habitat. The feasibility of using numbers and age classes of Golden Eagles counted on mid-winter Bald Eagle survey routes for trend analyses should be assessed.

Winter aerial surveys along transects also could provide useful information about population trends, if they are conducted over at least 10 yr to span a complete jackrabbit population cycle. Data from USFWS aerial surveys in six states during the 1970s might provide valuable baseline data on winter eagle densities and age ratios, if the surveys were resumed. These surveys are repeatable because they were conducted on random transects and sampled in a consistent fashion each year. They also are relatively inexpensive to conduct; in southern Idaho, we surveyed 1600 km of transects, using 20 hr of aircraft time. These aerial surveys, like the midwinter Bald Eagle counts, sample populations that contain both the resident and mi-

grant birds. It is extremely difficult to attribute whether change in status is a result of a change in the resident or migrant population or both.

An accurate evaluation of eagle population status requires knowledge about status and trend of floaters (nonterritorial, nonbreeding adults) in a population in addition to the nesting segment of the population (Hunt 1998, Hunt et al. 1999, Bart et al. 1999). Stable populations contain an adequate number of floaters that readily replace breeding adults. Although difficult to obtain, accurate assessment of the floating segment is critical for assessing status of populations. Detecting decreases in the proportion of floaters provides early warning of population declines (Hunt 1998, Bart et al. 1999). Research is needed to develop a feasible means to efficiently gather information on the proportion of floaters in populations.

Fall aerial surveys show potential for assessing changes in resident eagle populations in the western U.S. Surveys conducted in the early fall when young are dispersing from their nesting areas and just prior to arrival of migrants include all segments of the population, including floaters, in the survey area. Like the winter aerial surveys, these fall surveys are repeatable and inexpensive, and they should be conducted for at least 10 yr. Fall surveys have potential for migratory populations if surveys are conducted after young disperse, but before migration.

Another way to monitor Golden Eagle populations is to monitor the threats they face. Because most eagle mortality is human-related, monitoring causes of death including electrocution, collisions, and lead levels should continue.

Standard protocols for inventory and monitoring must be established and followed to effectively assess status and trends of North American Golden Eagle populations. We found it difficult to make adequate assessments because of inconsistencies among sites and years and, even worse, inconsistencies among years within sites. The North American Raptor Monitoring Strategy (Anonymous 1997) may provide the necessary vehicle to address these problems. A goal of this strategy is to develop standard protocols for monitoring various raptor species, including Golden Eagles. Local declines of Golden Eagles and a recent request from Native Americans to harvest this species in the southwestern U.S. have prompted the need for a range-wide inventory and long-term monitoring of Golden Eagle populations in North America. Populations must be monitored consistently throughout the species' range, and well-designed inventory and monitoring protocols are essential to ensure the future long-term stability of the Golden Eagle in North America.

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