



Monitoring Occupancy of Nesting Areas and Reproductive Success of Golden Eagles (*Aquila chrysaetos*) in Denali National Park and Preserve, Alaska, 2008.

Version 1.1 (Annual progress report for the Central Alaska Vital Signs Monitoring Program)

Natural Resource Report NPS/XXXX/NRXX—20XX/XXX



ON THE COVER

Looking north from a well-used raptor perch in the upper Sushana River drainage, April 22, 2008.
Photograph by: Carol McIntyre, Denali National Park and Preserve, Alaska.

**Monitoring Occupancy of Nesting Areas and
Reproductive Success of Golden Eagles
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and Preserve, Alaska, 2008**

***Annual Progress Report for the Central Alaska Vital
Signs Monitoring Program***

Natural Resource Report NPS/XXXX/NRXX—20XX/XXX

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Abstract

From 1988 to 2008, I monitored the annual nesting area occupancy and reproductive success of Golden Eagles (*Aquila chrysaetos*) using data collected during two standardized aerial surveys and additional foot surveys in Denali National Park and Preserve, Alaska. In 2008, occupancy of Golden Eagle nesting areas (87%) was similar to the long-term mean. Despite high numbers of Snowshoe Hare (*Lepus americanus*), all measurements of Golden Eagle reproductive performance in 2008 were lower than the previous two years including nesting rate (68%), success rate (67%), and fledgling production. Fledgling production ($n = 52$) was higher than the long-term average, but 25% lower than the previous two years. During Golden Eagle surveys, I also collected data on the nesting area occupancy of Gyrfalcons (*Falco rusticolus*). In 2008, occupancy of Gyrfalcon nesting areas (38%) was lower than most previous years. Daily counts of Snowshoe Hare were the highest recorded in the study period. We also noted higher than average numbers of non-territorial subadult Golden Eagles in the study area from June through August. Adult and subadult Bald Eagles (*Haliaeetus leucocephalus*) also were noted in the study area in June and July, apparently drawn to the area by the abundance of hare. Results of replicate aerial surveys conducted during the occupancy and productivity surveys indicated that the detection rates for both occupied and successful nests were high.

Acknowledgments

I thank the Vital Signs Monitoring Program of the Central Alaska Network, National Park Service and Denali National Park and Preserve for funding this project. Special thanks to Chris Mauer and Rick Swisher, Quicksilver Air, Fairbanks, Alaska for providing great piloting during aerial surveys, and Mark Paulson, NPS, for help during ground surveys. I also thank Jesse Miller of the Murie Science and Learning Center for reporting a previously undocumented Golden Eagle nest in the Polychrome area, Tom Meier for help with ground surveys in April, and the Technical Committee of the CAKN for recommending additional funding for the replicate aerial surveys.

Introduction

Golden Eagles (*Aquila chrysaetos*) are large, diurnal raptors that nest across the Northern Hemisphere (Watson 1997). Although this species occurs across a wide geographical range, it is most often found in open landscapes dominated by short vegetation in mountainous regions that offer hunting opportunities (Watson 1997). In North America, Golden Eagles are most common in the West, usually near open spaces that provide hunting habitat (Kochert et al. 2002). The distribution of Golden Eagles in Alaska is not well documented, but larger concentrations of nesting populations occur in the Alaska Range and the Brooks Range (Kochert et al. 2002).

Golden Eagles occur in relatively high densities in the northeastern region of Denali National Park and Preserve, Alaska (Denali) (Kochert et al. 2002, McIntyre et al. 2006c). In 1988, the National Park Service initiated a long-term program to monitor Golden Eagle nesting area occupancy and reproductive success (McIntyre and Adams 1999, McIntyre et al. 2006c). This monitoring program grew out of increasing interest in this species after the discovery of a large nesting population in this area in 1987 (McIntyre et al. 2006c). Before 1987, Denali park managers knew little about the distribution or size of the nesting population of Golden Eagles in Denali, and often relied on information provided by Murie (1944) to make inferences about this species in Denali. Results from a Golden Eagle nesting population inventory in 1987 provided new and exciting information about this species in Denali (McIntyre et al. 2006c). For instance, the 1987 inventory updated the number of known nesting areas from approximately 15 to more than 60, a four-fold increase in the number of documented nesting areas. The inventory also highlighted the importance of this aerial predator in Denali's ecosystems (McIntyre et al. 2006c).

In 2004, the Central Alaska Monitoring Network (CAKN) selected *Fauna Distribution and Abundance* as one of its top three Vital Signs (along with *Climate/Weather*, and *Vegetation Structure and Function*) (MacCluskie and Oakley 2005). The *Fauna Distribution and Abundance* Vital Sign included monitoring efforts for a suite of vertebrate species including Golden Eagles in Denali (MacCluskie and Oakley 2005). Golden Eagles were selected as a Vital Sign monitoring component because they are a high trophic level predator that responds quickly to changes in their habitat and prey supplies (Watson 1997) and several aspects of nesting populations can be monitored using highly efficient methods. Denali is one of the best places to watch Golden Eagles in North America; hence, Denali's visitors are also very interested in seeing and learning about this predator.

Currently, long-term studies in Denali provide the only contemporary data on reproductive characteristics of a large migratory population of Golden Eagles in northwestern North America (Kochert et al. 2002, Kochert and Steenhof 2002). Results from the Denali Golden Eagle monitoring program and ensuing research projects have increased our understanding of Golden Eagle ecology in North America, particularly for northern migratory populations (McIntyre and Adams 1999, Kochert and Steenhof 2002, Kochert et al. 2002, McIntyre 2002, McIntyre and Collopy 2006, McIntyre et al. 2006a,b,c). Further, data collected in Denali is directly comparable to the only other large (>30 pairs), long-term (>30 years) data set for this species in North America, collected in the Snake River Birds of Prey National Conservation Area (McIntyre et al.

2006c) and provide a unique opportunity for comparing and contrasting the ecology of migratory and resident populations of Golden Eagles.

Gyrfalcons (*Falco rusticolus*) also nest in relatively high densities in Denali (Swem et al. 1994). Gyrfalcons are the largest falcon in the world and occupy a Holarctic Range throughout the Northern Hemisphere (Clum and Cade 1994). Gyrfalcons nest sympatrically with Golden Eagles in Denali, often using Golden Eagle nest structures for their own nesting attempts. Unlike the Golden Eagles that nest in Denali, adult Gyrfalcons are residents and live in the area throughout the year. The nesting seasons of Gyrfalcons and Golden Eagles overlap in Denali, but Gyrfalcon nestlings usually fledge several weeks earlier than most Golden Eagles. In Denali, the nesting season diets of both species overlap with Arctic Ground Squirrel (*Spermophilus parryii*) and Willow Ptarmigan (*Lagopus lagopus*) making up much of the nesting season diets for both species. Despite high regional interest in Gyrfalcons, few monitoring or research efforts are focusing on this species in Alaska. As such, data collected on Gyrfalcons in Denali via the Golden Eagle monitoring program provide important information on this species in Alaska. Although CAKN did not select Gyrfalcons as a component of the Vital Signs Monitoring program, we continued to collect data on the nesting area occupancy and reproductive success of Gyrfalcons at historic nesting sites concurrently with the Golden Eagle monitoring program.

In addition to providing contemporary information on the reproductive success of Golden Eagles and Gyrfalcons, this project provides park managers with contemporary information on the location and status of occupied nesting areas and nest sites of these species in Denali. This information is essential for protecting these sites from direct human disturbance during the nesting season.

This annual progress report summarizes results of monitoring activities for Golden Eagles and Gyrfalcons in Denali in 2008, summarizes some of our anecdotal observations, highlights some of the project's outreach achievements, and outlines plans for 2009.

Methods

Study area

The study area was in the northern foothills of the Alaska Range in northeastern Denali in central Alaska (63° 36'N, 149° 39'W) (Figure 1). The study area contained one of the highest reported densities of nesting Golden Eagles in North America (Kochert et al. 2002) and a relatively high density of nesting Gyrfalcons (Swem et al. 1994). Rugged mountainous terrain interspersed by broad glacial valleys and upland areas characterized the 2,100 km² study area. Elevations in the area ranged from 427 m in the lowlands and river bottoms to 1,372 m along the foothill summits.

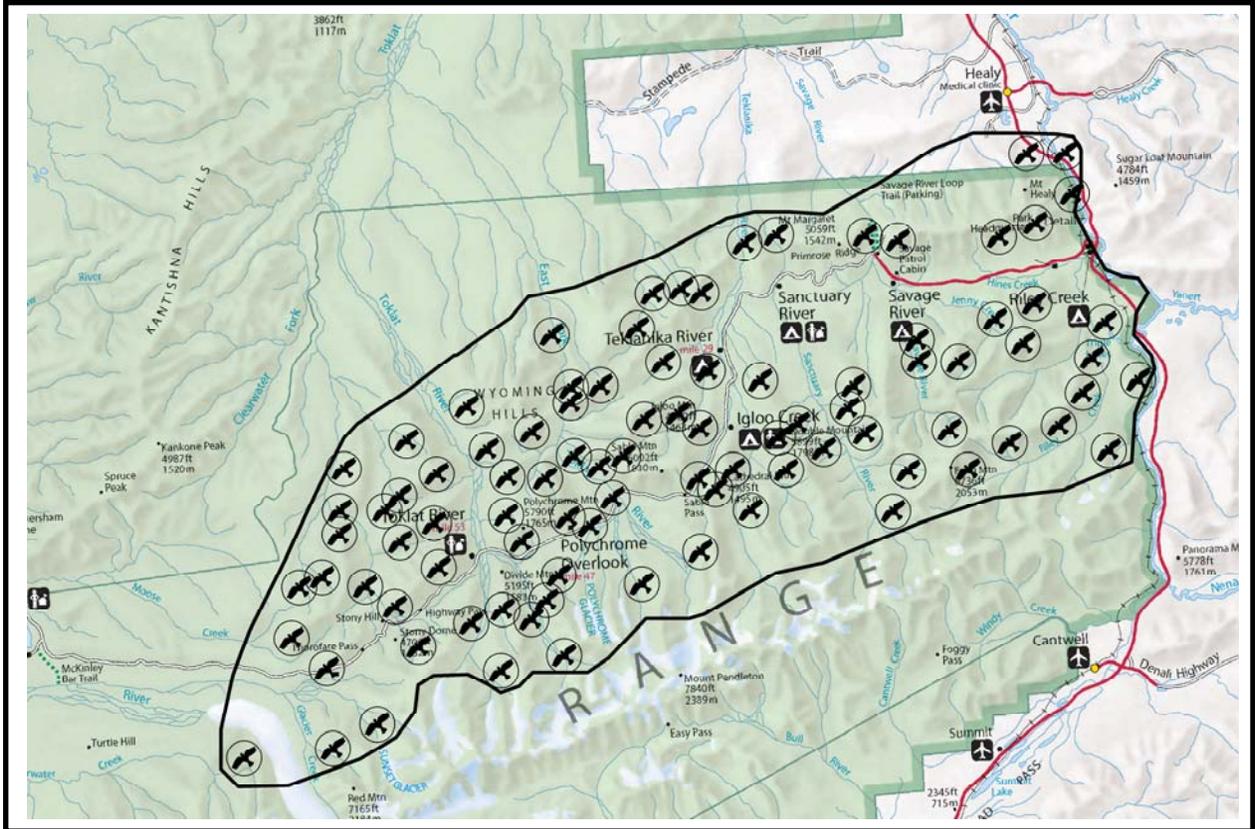


Figure 1. General location of Golden Eagle monitoring project study area (within the solid black line) in the northeastern corner of Denali National Park and Preserve, Alaska (shown as shaded on the map). The eagle symbols within the open circles show the approximate distribution of Golden Eagle nesting areas within the study area. The study area is approximately 2,100 km².

Objectives

This project has two primary measurable objectives:

1. Estimate annual nesting area occupancy and nesting activities at all known nesting areas.
 - a. Revisit all known nesting areas and verify their occupancy.
 - b. Search for new and previously unknown nesting areas and verify their occupancy.
 - c. Record egg laying at occupied nesting areas.
 - d. Record number of nesting pairs that successfully raised \geq one fledgling.
 - e. Record the number of fledglings and calculate the number of fledglings produced per territorial pair and successful pair.
2. Estimate annual nesting phenology.
 - a. Estimate age of nestlings during nest visits or the productivity survey.
 - b. Calculate estimated dates of egg-laying, hatching, and fledging.

Terminology

I used methods and terminology recommended by Steenhof and Kochert (1982) and Steenhof (1987) to assess and describe occupancy of nesting areas and reproductive success (Appendix A; Figure 2). I calculated two measurements of annual productivity to compare our results with other Golden Eagle studies in North America: 1) fledglings per territorial pair (as recommended by Steenhof 1987) and 2) fledglings per successful pair (or mean brood size).

Surveys and Data Collection

I used two aerial surveys to assess nesting area occupancy and reproductive success of Golden Eagles and Gyrfalcons in Denali in 2008. I conducted the first aerial survey (the occupancy survey) after most clutches were completed, before most nest failures occurred, and before eggs hatched. The objectives of the occupancy survey were to document occupancy and nesting activity at nesting areas. I conducted the second aerial survey (productivity survey) after most nestlings reached 80% of their age at fledging, but before they left the nest (fledge). The objectives of the productivity survey were to count the number of nestlings and fledglings, and to document reproductive success.

Occupancy survey

I started planning for the occupancy survey in early January 2008 when I contacted an aircraft contractor (Quicksilver Air, Fairbanks, Alaska) and scheduled a helicopter and pilot for the survey. This is a critical step of this program because there are a limited number of Robinson R-44 helicopters and pilots available for this work. Several weeks before the survey, I reviewed the database and prepared a comprehensive map (1:250,000 scale) of the survey area containing the locations of all known Golden Eagle and Gyrfalcon nesting areas and nest sites in the study area. One week before the survey, I studied the map and developed a survey strategy based on location of nesting areas. I used this map for navigation and recording my observations during the aerial surveys. Weather is the main factor affecting the ability to carry off a successful survey; thus, the survey strategy was flexible to deal with weather conditions on the day of the survey. This included scheduling several additional days of survey time in the event that surveys were shut down due to high winds, extreme turbulence or precipitation (i.e., snow).

I conducted the occupancy survey over four days between 21 and 24 April 2008 from a Robinson R-44 helicopter (Quicksilver Air, Fairbanks, Alaska) piloted by Chris Mauer. Surveys started at approximately 7:30 am and ended at approximately 6:30 pm. I used 10 x 40 image-stabilizing binoculars during all aerial surveys. The 2008 occupancy survey required 15 hours of flight time. I based the occupancy surveys out of the Denali park airstrip and refueled at this airstrip. We could not refuel out of the Kantishna airstrip in April 2008 because fuel was not available. We also had to obtain three barrels of Avgas from Nenana Heating and Oil in Nenana, Alaska due to a shortage of Avgas at the Denali park airstrip.

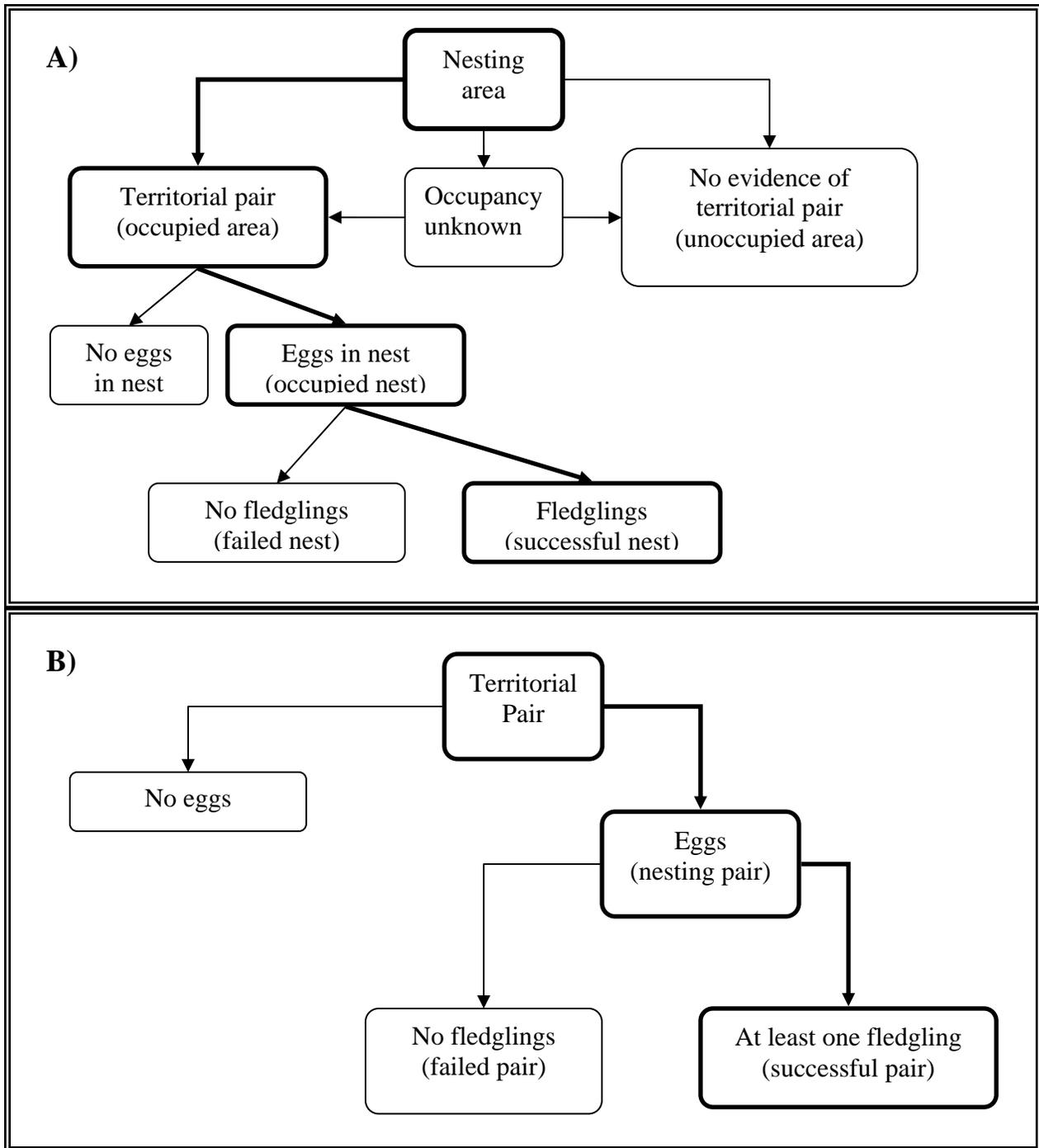


Figure 2. Decision tree for assessing and describing occupancy of nesting areas and breeding success of Golden Eagles in Denali National Park and Preserve, Alaska. Chart A refers to the nesting area and nest structure and Chart B refers to the pair of Golden Eagles or Gyrfalcons. The lines and boxes in bold trace the pathways to a successful nest and a successful nesting pair.

As we approached each known nesting area during the occupancy survey, I instructed the pilot to fly the helicopter slowly (≤ 30 km per hour) and provided him with details on the exact location of each nest. The pilot generally oriented the helicopter about 100 meters in front of the nest cliff and about 100 meters above the nest, and I looked directly out my window into each nest to observe its contents. During nest observations, the pilot flew the helicopter as slowly as possible and often hovered. As soon as I detected evidence of occupation (i.e., incubating eagle, eggs, nest construction or nest decoration), I instructed the pilot to fly out of the nesting areas and I recorded my observations on the survey map. I also recorded the number of passes required to document occupancy and if an incubating eagle flushed off the nest as we passed by. In cases where I detected an incubating eagle before we approached within 300 meters of the nest, I immediately instructed the pilot to leave the area to avoid disturbing the incubating eagle and we proceeded to the next nesting area.

If I could not document occupancy of a nesting area from the helicopter, I returned to the area later that day to resurvey the area after I completed making aerial observations at other nesting areas. I used this survey strategy to take advantage of good survey weather early in the morning before the build-up of afternoon turbulence. During the return visits, I instructed the pilot to fly slowly in front of cliffs and rock outcroppings near the known nests as I looked for previously undiscovered or new nests and made repeated observations of all known nests. If I could not find any evidence of occupation from the air during the return visit, I instructed the pilot to land at a nearby vantage point and made observations from the ground. During ground observations, I searched the immediate area for perched and flying eagles. If I located a perched or flying eagle, I maintained visual contact with it. These observations often led to finding evidence of occupation (i.e., copulation, territorial display, nest construction, territorial behavior). If I could not find evidence of occupancy after two consecutive hours of ground observations, I defined the area as “occupancy unknown” and revisited the area later in the nesting season to assess occupancy.

Foot surveys

From late May through mid-July, I made additional observations of nesting areas visible or easily accessible (within 5 miles) from the Denali park road and State Highway 3. I also made repeated observations at occupied nests to calibrate my estimates of nesting phenology and to document occupancy in areas where occupancy was not detected during the occupancy surveys.

Productivity survey

I started planning for the productivity survey in January 2008 when I contacted the aircraft contractor (Quicksilver Air, Fairbanks, Alaska) and scheduled a helicopter and pilot for the survey. This is a critical step of this program because of the limited number of Robinson R-44 helicopters and pilots available for this work. Several days before the survey, I reviewed the survey map that I used during the occupancy survey and any other observations made after the occupancy survey, and developed a productivity survey strategy. I also used this map for navigation and to record my observations during the productivity survey. I conducted the productivity survey on 29 July 2008 from a Robinson R-44 helicopter (Quicksilver Air, Fairbanks, Alaska) piloted by Rick Swisher. During this survey, I made observations at all nests

where I documented egg-laying during the occupancy survey and at all nesting areas where I could not document occupancy earlier in the season. At each occupied nest, I counted the number of nestlings and estimated their age to the nearest week based on their size and feather development. I also recorded the presence and number of addled (unhatched) eggs. I used 10 x 40 image-stabilizing binoculars during all aerial surveys. The productivity survey required 8.6 hours of flight time. I based the productivity survey out of the Denali park airstrip.

Documenting new nest sites and nesting areas

During all surveys and fieldwork, I searched for new or previously undocumented nest sites and recorded their location (latitude and longitude) using a Global Positioning System (GPS) and noted their location and general site characteristics on my survey map and in my field notes.

Documenting age structure of territorial population

I recorded the age class (adult or subadult) of all free-flying Golden Eagles observed during surveys using plumage characteristics described by Ligor (2004). I did not intentionally flush incubating Golden Eagles off their nests to verify their age class.

Calculating annual abundance indices for snowshoe hare and Willow Ptarmigan

I counted the number of adult snowshoe hare and adult Willow Ptarmigan that I observed during routine fieldwork from 15 April through 30 June 2008 and used the number of individuals observed per field day per year as an index of their annual abundance (McIntyre and Adams 1999). I generated these indices to examine the response of Golden Eagles and Gyrfalcons to broad-scale changes in their primary spring prey resources, snowshoe hare and Willow Ptarmigan (McIntyre and Adams 1999).

Assessing detectability of occupied and successful nests

I conducted replicate aerial surveys at a subsample of 12 nesting areas in the upper Savage and Sanctuary Rivers during the occupancy and productivity surveys to assess the detectability of occupied and successful nests. I selected this area for replicate flights because it contained a relatively high density of nesting areas and was relatively close to the airstrip; thus, flight time to the area was shorter and was less expensive than flying to more remote regions of the study area. For this exercise, I assumed that the probability of detecting occupancy and nest success was equal among all nesting areas.

I conducted the replicate occupancy survey flight one day after the initial flight and the replicate productivity flight five hours after the initial flight. A detection history was constructed for each of the 12 nesting areas during the occupancy survey, with a “0” applied to nesting areas where occupancy was not documented and a “1” applied to nesting areas where occupancy was documented. A detection history was also constructed for each of the 12 nesting areas during the productivity survey, with a “0” assigned to nesting areas that were not successful and a “1” assigned to nesting areas that were successful. The number of fledglings at each successful nest was also recorded during the replicate surveys.

Other observations

I recorded all birds observed during all aerial and ground surveys in my field notes. During the occupancy survey, I recorded locations and numbers of grizzly bears (*Ursus arctos*) and Dall

sheep (*Ovis dalli dalli*) that I observed during the surveys. When I found a group of Dall sheep ewes, I made specific observations to verify if lambs were present.

Optical equipment

I used Canon® 10 x 40 image stabilizing binoculars during all aerial surveys, Zeiss® 10 x 40 binoculars during all ground observations, and a Kowa® spotting scope with a 20 to 60-zoom power eyepiece during all ground observations.

Data summaries

I calculated rates of nesting area occupancy, nesting and nesting success, and estimated overall population productivity and mean brood size for Golden Eagles in 2008. I calculated nesting area occupancy for Gyrfalcons in 2008. Appendix A contains definitions of metrics used to monitor nesting area occupancy and reproductive success.

Results and Discussion

Survey effort

I monitored 86 Golden Eagle (Table 1) and 16 Gyrfalcon nesting areas in 2008. I observed all known Gyrfalcon nesting areas during the Golden Eagle surveys, but did not search for new or previously undocumented Gyrfalcon nesting areas during the surveys. I did not assess nesting success at all Gyrfalcon sites because the Golden Eagle productivity survey occurred after most Gyrfalcon fledging events. Weather conditions during the occupancy survey were favorable for surveys and observations; however, we encountered severe turbulence in some areas and had to revisit some of these areas later in the occupancy survey. Weather conditions during the productivity survey included scattered rain showers and wind, and ranged from fair to marginal for surveys and observations.

Golden Eagles

Nesting area occupancy and reproductive success

I detected 75 territorial pairs of Golden Eagles in 2008 (Table 1). Of these, 51 pairs (68%) produced eggs (nesting pairs) and 34 produced fledglings (Table 2). Golden Eagle nesting area occupancy in 2008 was similar to 2007 (Table 2). Despite an abundance of Snowshoe Hare, all measures of reproductive success were lower in 2008 than in the previous two years (Table 2).

Nesting phenology

Nesting phenology in 2008 was similar to other years; most Golden Eagles completed egg-laying by mid-April and most fledglings left their nests by early August. An exception to this pattern was noted at a nest in Tattler Creek where two nestlings fledged in late August. This was the latest fledging date recorded in the study area.

Age structure of territorial population of Golden Eagles

I observed 38 adult and 1 sub-adult Golden Eagles during the occupancy survey and 24 adult and 16 sub-adult Golden Eagles during the productivity survey. I could not verify the age of all territorial Golden Eagles in the study area because I did not intentionally flush incubating eagles

Table 1. Summary of Golden Eagle nesting area occupancy and reproductive success, Denali National Park and Preserve, Alaska, 1988 to 2008. The data were collected using two annual aerial surveys; the occupancy survey was conducted in late April to assess occupancy and nesting activities and the productivity survey was conducted in mid- to late July to assess nesting success and fledgling production.

Year	Nesting areas surveyed	Nesting areas occupied	Nesting pairs	Successful pairs	Fledglings
1988	69	60	45	35	50
1989	69	58	51	43	70
1990	73	58	47	34	53
1991	76	62	43	37	56
1992	83	69	39	18	25
1993	85	69	30	20	28
1994 ^a	66	56	20	9	11
1995 ^a	66	55	27	19	25
1996 ^a	69	62	27	24	30
1997	82	69	48	35	58
1998	83	66	35	22	33
1999	83	72	54	42	69
2000	84	70	53	34	49
2001	81	67	43	22	29
2002	83	73	10	4	4
2003	84	71	25	13	19
2004	82	73	32	16	20
2005	86	76	42	28	38
2006	89	81	64	52	79
2007	89	81	59	46	72
2008	86	75	51	34	52

^a I decreased the study area size in 1994, 1995, and 1996 following recommendations of two U.S. Fish and Wildlife Service raptor biologists who suggested that it would be more cost-efficient to limit my surveys to a smaller study area. This proved to be a poor recommendation for several reasons and I resumed surveys in the entire study area in 1997.

Table 2. Summary of nesting area occupancy rates, laying rates, success rates, mean brood size and overall population productivity for Golden Eagles in Denali National Park and Preserve, Alaska, 1988 to 2008.

Year	Occupancy rate (%)	Laying rate (%)	Success rate (%)	Mean brood size	Overall population productivity
1988	88.24	71.67	81.40	1.40	0.82
1989	85.29	87.93	84.31	1.63	1.21
1990	80.56	82.76	70.83	1.56	0.91
1991	82.67	70.97	84.09	1.49	0.89
1992	84.15	56.52	46.15	1.39	0.36
1993	82.76	45.83	69.70	1.70	0.54
1994	84.85	35.71	50.00	1.10	0.20
1995	83.58	48.21	70.37	1.26	0.43
1996	89.71	42.62	88.46	1.22	0.46
1997	83.13	69.57	72.92	1.66	0.84
1998	80.49	51.52	64.71	1.50	0.50
1999	88.89	72.22	80.77	1.64	0.96
2000	85.37	75.71	64.15	1.50	0.73
2001	83.95	64.71	52.27	1.35	0.46
2002	89.02	13.70	40.00	1.00	0.05
2003	85.54	35.21	52.00	1.46	0.27
2004	89.02	43.84	50.00	1.25	0.27
2005	88.37	53.95	68.29	1.36	0.50
2006	90.91	78.75	80.95	1.49	0.95
2007	91.01	74.07	76.67	1.59	0.90
2008	87.21	68.00	66.67	1.53	0.69

off their nests during the occupancy survey and did not observe all territorial eagles during the field season. The lack of sub-adult Golden Eagles in the study area during the early part of the nesting season suggests that the territorial population of Golden Eagles in Denali consists primarily of adults. The presence of sub-adult Golden Eagles in the study area during the later part of the nesting season (May, June, July, and August) suggests that non-breeding, sub-adults visit the study area, but most likely are not part of the territorial population. In 2008, non-territorial sub-adult Golden Eagles were likely attracted to the study area by the abundance of snowshoe hare.

Flushing response of Golden Eagles during aerial surveys

No incubating Golden Eagles flushed off their nests during the occupancy survey in 2008. From 1988 to 2007, the flushing rate of Golden Eagles was 0.80% (6 of 750) and all of the Golden Eagles that flushed off their nest during occupancy surveys returned to their nests and successfully raised fledglings. Additionally, nests where flushing events occurred in one year were often used for a nesting attempt in the following year. Based on the lack of flushing behavior exhibited by incubating Golden Eagles and the success of eagles that flushed off their nests, I assume that our aerial survey technique of slowly approaching nests in full view of the incubating eagle reduces the probability of a flushing or startle response and has no negative effect of Golden Eagle reproduction.

Management activities

No wildlife closures were established near occupied Golden Eagle nesting areas in 2008.

Assessing Detectability

The detection rates during replicate flight during both the occupancy and productivity flight were identical and equal to 1.00 (Tables 3 and 4). Although Golden Eagles are large birds that build relatively large nests, it cannot be assumed that detectability of occupied or successful nests is always equal to 1.00. For instance, detection probabilities for occupied nests in Denali ranged from 0.90 to 1.00 from 1988 to 2007 (J. Martin, unpublished data). Although detection rates are high, replicate surveys should be completed annually and when primary observers change to assess detectability of both occupied and successful nesting areas and efforts should be made to provide estimates of precision for fledgling counts.

In 2008, documenting the occupancy of four nesting areas not in the replicate subsample required two visits and ground observations. At three of these nesting areas, occupancy was documented after finding previously undocumented nests. At one of these nesting areas, occupancy was documented after finding an incubating eagle on a nest that was missed during the initial aerial survey.

Gyrfalcons

Gyrfalcon nesting area occupancy in 2008 was similar to 2006 and 2007 (Figure 7). The apparent decline in the occupancy rate of Gyrfalcons in Denali between 1988 and 2008 may result from monitoring only documented historic sites and not searching for new or undocumented nest sites, rather than from an actual decline in the number of territorial Gyrfalcons in the study area.

Table 3. Summary statistics for replicate aerial surveys to assess the detectability of occupied Golden Eagle nesting areas, Denali National Park and Preserve, Alaska, 2008.

Nesting area	Flight 1	Flight 2	Observation
Savage River North	Occupied	Occupied	Incubating bird
Savage River South	Occupied	Occupied	Incubating bird
Savage River South 2	Occupied	Occupied	Incubating bird
Sanctuary Caribou	Occupied	Occupied	Incubating bird
Sanctuary East Canyon	Occupied	Occupied	Nesting materials
Sanctuary River Toms North	Occupied	Occupied	Incubating bird
Sanctuary River Toms South +1	Occupied	Occupied	Incubating bird
Fang Valley	Occupied	Occupied	Incubating bird
Sanctuary River Upper East	Occupied	Occupied	Incubating bird
Sanctuary River Upper West	Occupied	Occupied	Incubating bird
Sanctuary West	Occupied	Occupied	Incubating bird
Double Mountain SE	Occupied	Occupied	Incubating bird
Areas observed	12	12	
Areas occupied	12	12	

Table 4. Summary statistics for replicate aerial surveys to assess the detectability of successful Golden Eagle nesting areas and fledgling production, Denali National Park and Preserve, Alaska, 2008.

Nesting area	Number of nestlings	
	Flight 1	Flight 2
Savage River North	1	1
Savage River South	1	1
Savage River South 2	1	1
Sanctuary Caribou	1	1
Sanctuary East Canyon	0	0
Sanctuary River Toms North	0	0
Sanctuary River Toms South +1	2	2
Fang Valley	1	1
Sanctuary River Upper East	0	0
Sanctuary River Upper West	0	0
Sanctuary West	0	0
Double Mountain SE	1	1
Areas observed	12	12
Successful nests	7	7
Number of fledglings	8	8

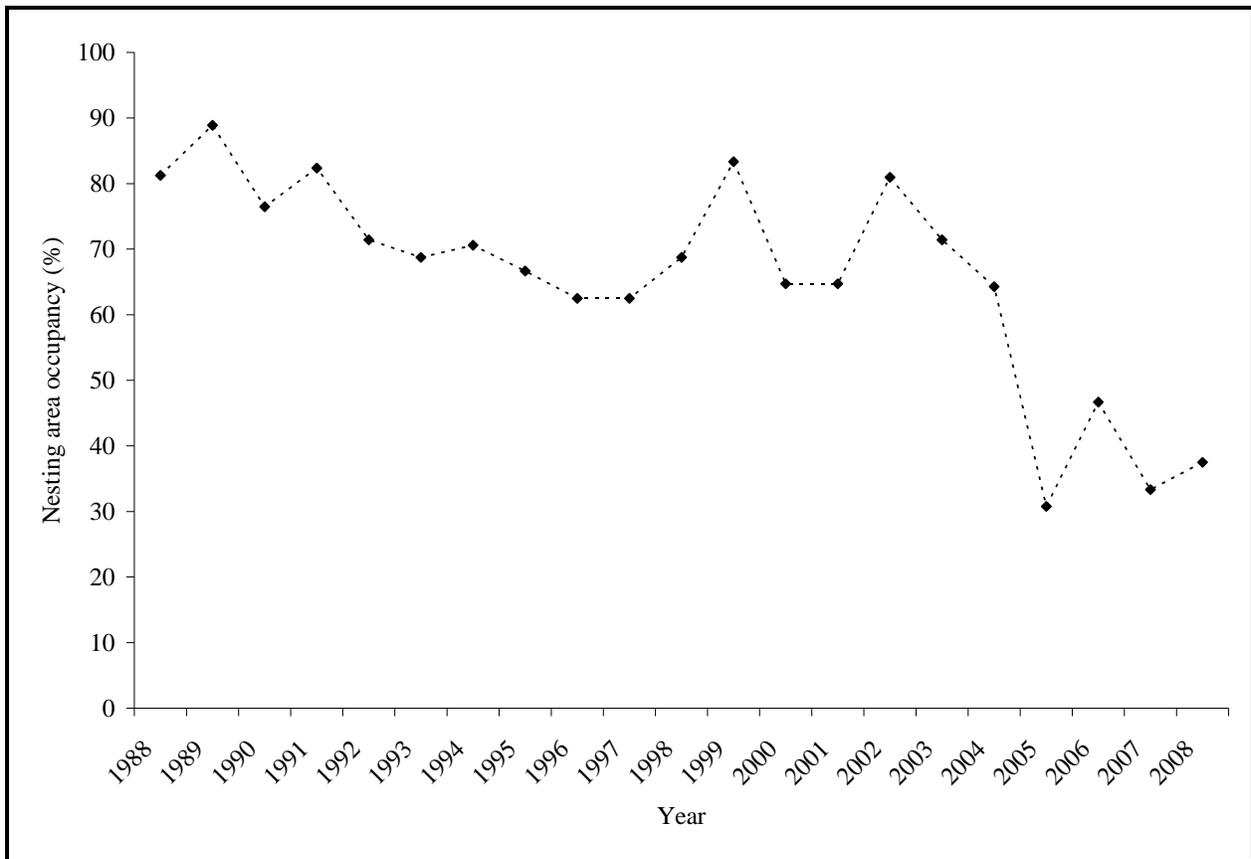


Figure 3. Annual Gyrfalcon nesting area occupancy, Denali National Park and Preserve, Alaska, 1988 to 2008. Nesting area occupancy was calculated as the number of occupied nesting areas per nesting areas surveyed.

Management activities

Temporary wildlife closures were established around two occupied Gyrfalcon nesting area in 2008. Both temporary wildlife closures were removed after the Gyrfalcons fledged young or failed in their nesting attempt.

Abundance of Snowshoe Hare and Willow Ptarmigan

Numbers of snowshoe hare and Willow Ptarmigan observed per field day in 2008 were higher than in the past two years (Figure 4). Many park staff, shuttle bus and tour bus drivers, professional photographers, and local community members also noticed the high numbers of snowshoe hare in the area. Winter hare browse was extensive, particularly in portions of Sable Pass and the Sanctuary River valley. New efforts to develop a long-term monitoring program for snowshoe hare in Denali (Maggie MacCluskie, NPS, personal communication) are underway and should be useful for monitoring the abundance of snowshoe hare in the future.

Noteworthy anecdotal observations during June and July

Golden Eagles

We noted high numbers of non-territorial sub-adult Golden Eagles in the study area from June through August this year, and observed several aggressive interactions between them and breeding adult Golden Eagles during July and August. Additionally, several adult and sub-adult Bald Eagles (*Haliaeetus leucocephalus*) were observed in the study area in June and July 2008; these eagles apparently were hunting snowshoe hare.

Great-horned and Northern Hawk Owls

We found 13 occupied Great-horned Owls (*Bubo virginianus*) and 6 occupied Northern Hawk Owl () nests in the eastern portion of the study area in 2008. One pair of nesting Great-horned Owls raised two fledglings in a nest within 100-m of the Sanctuary River Bridge in a nest built and used by nesting Common Ravens in 2007. We also found one pair of nesting Great-horned Owls using a nest originally built by and used by Golden Eagles along the Toklat River.l

Presentations, manuscripts, and outreach activities

Presentations

McIntyre, C.L. Natural history of Golden Eagles in Alaska. Natural History of Alaska class, University of Alaska-Fairbanks, November 2007.

McIntyre, C. L. Long-term Golden Eagle studies in Denali. Arctic Audubon seminar series, Fairbanks, Alaska. January 2008.

McIntyre, C.L., M.W. Collopy, and D.C. Douglas. Comparing winter and summer movement patterns of juvenile Golden Eagles. Presented at Alaska Bird Conference, Fairbanks, Alaska, March 2008.

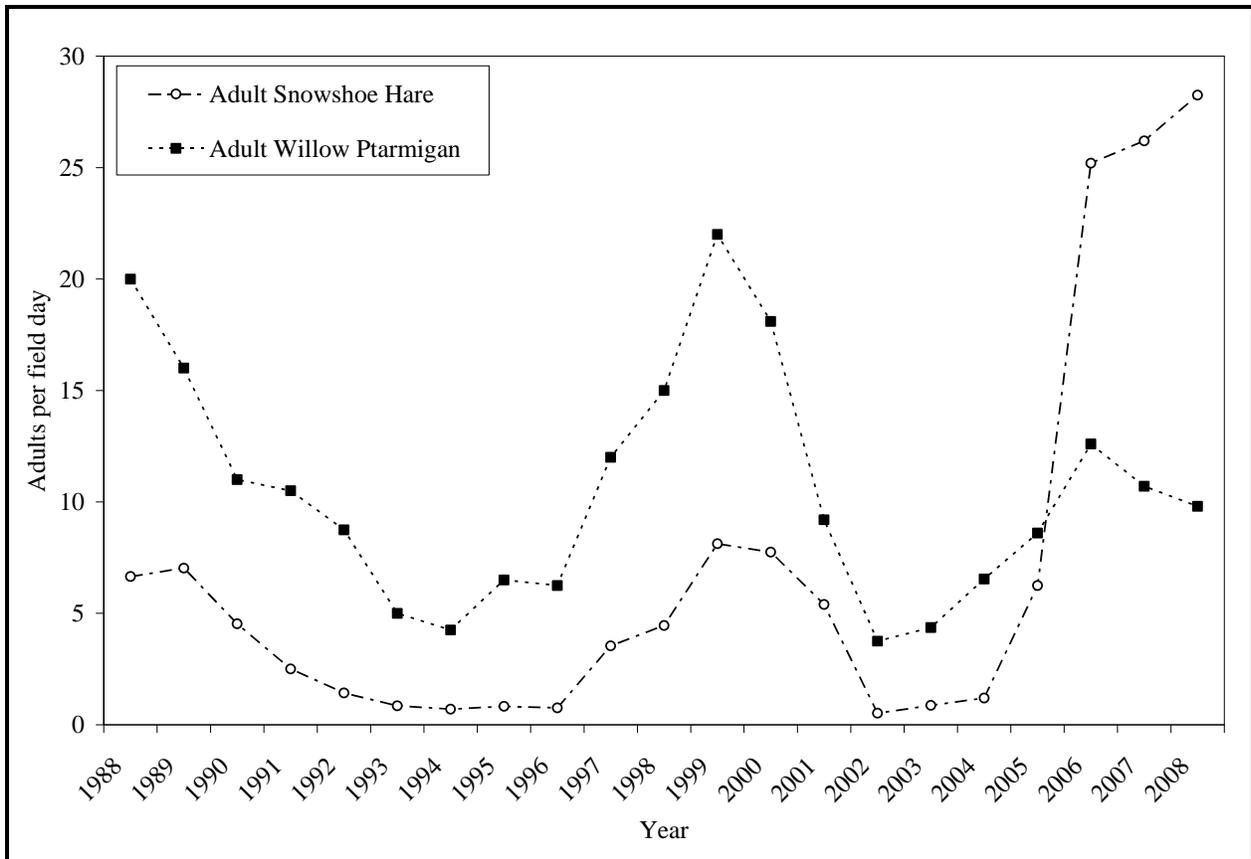


Figure 4. Annual abundance indices of snowshoe hare (dashed line with open circles) and Willow Ptarmigan (solid line with solid squares), Denali National Park and Preserve, Alaska, 1988 to 2008.

Peer-reviewed papers

Martin, J., J.D. Nichols, **C.L. McIntyre**, G. Ferraz, and J.E. Hines. *In press*. Perturbation Analysis for Patch Occupancy Dynamics. *Ecology*.

Murie Science and Learning Center Seminars

McIntyre, C.L. Ecology of birds of Denali. Field seminar, Murie Science and Learning Center, Denali Park, Alaska, June 2008.

McIntyre, C.L. Migration ecology of birds. Field seminar, Murie Science and Learning Center, Denali Park, Alaska, August 2008.

Plans for 2009

Fieldwork

Occupancy and productivity surveys for Golden Eagles and Gyrfalcons will continue in Denali in 2009. We will also conduct fieldwork in late April 2009 to assess the probability of detecting an occupied nest. I also will resume feather collecting activities at a sample of occupied nests.

Data management, protocol update, data analysis, manuscripts, and presentations.

Data management

Al Smith, data manager assistant with CAKN, and I made significant progress on completing the updated computerized database for this project.

Data analysis

Josh Schmidt, CAKN data manager, made significant progress on an analysis examining changes in nesting area occupancy and reproductive parameters of Golden Eagles. This analysis will be completed in early 2009 and we will prepare our results as a manuscript for publication.

Dr. Julien Martin and Dr. Jim Nichols, U.S. Geological Survey, are using data from the Denali Golden Eagle monitoring project for developing multistate patch occupancy models (MacKenzie et al. 2002) for assessing changes in nesting area occupancy and reproductive success in relation to potential human disturbance and for building models for a decision-based/adaptive management project. The work has resulted in one peer-reviewed publication and other manuscripts are in preparation.

Data sharing

MoveBank is using satellite-tracking data from the Denali Golden Eagle project in a project describing global raptor migration movements.

The U.S. Fish and Wildlife Service used data from the Denali Golden Eagle project in an assessment of potential effects of harvest of Golden Eagle nestlings on the national population.

Literature Cited

- Clum, N., and T. J. Cade. 1994. Gyrfalcon (*Falco rusticolus*). In *The Birds of North America*, No. 114, A. Poole and F. Gill, editors. The Birds of North America, Inc. Philadelphia, PA.
- 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** (1 Supplement):32-40.
- Kochert, M. N., K. Steenhof, C. L. McIntyre, and E. H. Craig. 2002. Golden Eagle (*Aquila chrysaetos*). In *The Birds of North America*, No. 684, A. Poole and F. Gill, editors. The Birds of North America, Inc. Philadelphia, PA.
- Ligori, J. 2004. How to age Golden Eagles. Techniques for birds observed in flight. *Birding* **32**:278-283.
- MacCluskie, M., and K. Oakley. 2005. Vital Signs Monitoring Plan, Central Alaska Network, Vital Signs Monitoring Plan. August 2005. U.S. Department of the Interior, National Park Service, Fairbanks, AK.
- MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. *Ecology* **83**:2248-2255.
- McIntyre, C. L. 2002. Patterns in nesting area occupancy and reproductive success of Golden Eagles (*Aquila chrysaetos*) in Denali National Park and Preserve, Alaska, 1988-99. *Journal of Raptor Research* **36** (1 Supplement):50-54.
- 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 M. W. Collopy. 2006. The post-fledging dependence period of migratory Golden Eagles (*Aquila chrysaetos*) in Denali National Park and Preserve, Alaska. *Auk* **123**:877-884.
- McIntyre, C. L., M. W. Collopy, and M. S. Lindberg. 2006a. Survival probability and mortality of migratory juvenile Golden Eagles from interior Alaska. *Journal of Wildlife Management* **70**:717-722.
- McIntyre, C. L., M. W. Collopy, J. Kidd, A. Stickney, and J. Paynter. 2006b. Characteristics of the landscape surrounding Golden Eagle nest sites in Denali National Park and Preserve, Alaska. *Journal of Raptor Research* **40**:46-51.
- McIntyre, C. L., K. Steenhof, M. N. Kochert, and M. W. Collopy. 2006c. Long-term studies of Golden Eagle ecology, Denali National Park and Preserve, Alaska. *Alaska Park Science* **5** (1):42-45.

- Murie, A. 1944. The wolves of Mt. McKinley. Mt. McKinley Natural History Association, McKinley Park, Alaska.
- Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pages 157-170 in B.A. Giron Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird, editors. Raptor Management Techniques Manual. Scientific Technical Series No. 10. National Wildlife Federation. Washington, D.C.
- Steenhof, K., and M. N. Kochert. 1982. An evaluation of methods used to estimate raptor nesting success. *Journal of Wildlife Management* **46**:885-893.
- Swem, T., C. L. McIntyre, R. J. Ritchie, P. J. Bente, and D. G. Roseneau. 1994. Distribution, abundance, and notes on the breeding biology of Gyrfalcons (*Falco rusticolus*) in Alaska. Pages 437-444 in B-U. Meyburg and R.D. Chancellor, editors. Raptor Conservation Today, Proceedings of IV World Conference on Birds of Prey and Owls, Berlin, Germany.
- Watson, J. 1997. The Golden Eagle. T& AD Poyser, London, United Kingdom.

Appendix A

TABLE A-1. Terminology used in Denali Golden Eagle and Gyrfalcon monitoring studies (following Steenhof and Kochert 1982, Steenhof 1987).

Term	Definition
Nest	An individual nest structure or scrape.
Occupied nest	A nest occupied by a nesting pair.
Nesting area	A group of nests belonging to a pair of Golden Eagles or Gyrfalcons in a given year.
Surveyed nesting area	A nesting area surveyed in a given year.
Occupied nesting area	A nesting area occupied by a territorial pair of Golden Eagles or Gyrfalcons in a given year.
Unoccupied nesting area	A nesting area not occupied by a territorial pair of Golden Eagles or Gyrfalcons in a given year. Observations must be made for ≥ 2 consecutive hours at a nesting area before categorizing it as unoccupied.
Occupancy unknown	A surveyed nesting area where occupancy could not be documented in a given year.
Occupied-breeding	A nesting area occupied by a pair that produced eggs (nesting pair).
Occupied-breeding successful	A nesting area occupied by a successful pair.
Occupied-breeding failure	A nesting area occupied by an unsuccessful pair.

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