Ornis Fennica 85:2–12. 2008

Territory occupancy and breeding success of the Golden Eagle (*Aquila chrysaetos*) around tourist destinations in northern Finland

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Received 28 May 2007, revised 27 November 2007, accepted 28 November 2007

We examined the potential effects of tourist destinations on territory occupancy and breeding success of the Golden Eagle (*Aquila chrysaetos*) in northern Finland. We gathered information from 12 tourist destinations and from all known Golden Eagle territories surrounding these within a radius of 40 km. According to 2,151 territory records from 1990–2004, the nearest territory was located on average 9.9 km from the centre of the tourist destination whereas the nearest successful nest was located on average 10.3 km away. Both the occupancy rate of territories and breeding success varied between years and tourist destinations. Territory occupancy has decreased during the study years. Territory occupancy rates were lower around large-sized tourist destinations. Disturbance levels at tourist destinations, measured as the length of skiing and snowmobile routes, negatively affected territory occupancy but not breeding success. During the study years, tourism (measured as number of guest nights in accommodation establishments), clear cuts and total area of harvested forest has increased, whereas prey abundance and weather conditions have not changed significantly in northern Finland. We conclude that tourism-related habitat changes and activities might cause increasing pressures for disturbance-sensitive species such as Golden Eagles in the near future and that conservation plans should take into account the effects of such disturbance. Effective conservation of the Golden Eagle requires addressing constraints in the wider environments and multiple factors affecting territory occupancy and breeding success.

1. Introduction

Tourism is one of the largest and fastest-growing industries in the world. The World Tourism Organisation forecasted an increase of international tourism in Europe of 3.1% per year over the period up to 2020. At the same time, tourism increasingly burdens the environment through transportation, use of water, land and energy, the development of infrastructure, buildings and facilities, pollution and waste, land fragmentation and the increasing number of second homes (European Environment Agency 2003). In some popular tourist destinations, these pressures have resulted in serious degradation of the local environment, which reduces their attraction to both animals and people. Consequently, there is concern about the impacts of increased tourist activity on the environment and biodiversity, and about whether sustainable tourism can be achieved.

The expansion of tourism into pristine areas may disturb wildlife, increase the energetic costs of individuals and nest losses, change wildlife behaviour, and lead to the avoidance of otherwise suitable habitats (Burger & Gochfeld 1998, Miller *et al.* 1998, Miller & Hobbs 2000, Taylor & Knight 2003, Gonzales *et al.* 2006). Downhill ski resorts are particularly controversial (Holden 1999) because the negative effects of their infrastructure and associated human activities on adjacent natural areas are often more severe than the impacts of more general tourist activities further away from ski resorts (Pickering *et al*. 2003). In addition, the combined effects of infrastructure, roads, power lines, trails and cabins might decrease and fragment habitats otherwise suitable for wildlife species. Further, increasing snowmobile traffic will significantly expand the area where humans are in contact with wildlife (Reimers *et al.* 2003). In addition, nature-based tourism and recreational use are often concentrated in pristine environments like national parks.

One way to study how tourist destinations may displace wildlife (see Taylor & Knight 2003) is to use disturbance-sensitive species as models. Human activity may be a sufficient disturbance to cause declines in large-sized birds of prey such as the Golden Eagle *Aquila chrysaetos* (L.) (Abuladze & Shergalin 2002, Kochert & Steenhof 2002, Millar 2002, Pedrini & Sergio 2002, Watson & Whitfield 2002, Whitfield *et al*. 2006). Disturbance near nesting sites might lead to breeding failure or prevent eagles from hunting over part of their feeding range (Watson 1997). In Finnish Lapland, a peak in the number of tourists at tourist destinations occurs in March–April (Regional Council of Lapland 2003), the time just before and during egg-laying of Golden Eagles when they are sensitive to human disturbance.

Watson and Whitfield (2002) proposed three criteria to assess favourable conditions for Golden Eagles: number of occupied territories, breeding performance and proportion of suitable habitat which is occupied. In this study, we examine whether tourist destinations influence territory occupancy and breeding success of the Golden Eagle in northern Finland. We hypothesized that tourist destinations might have a negative effect on territory occupancy and breeding success, and that the territory occupancy and success of eagles would decline over the years according to the corresponding increase in numbers of tourists. In addition, we hypothesized that breeding performance of eagles should differ between different-sized tourist destinations.

2. Material and methods

2.1. Study area

The study area (ca. 41,546 km²) is in the northern boreal zone, except for the most southern part in the midboreal zone (Ahti *et al*. 1968), and Scots Pine (*Pinus sylvestris*, L.) forest and open mires dominate the landscape. We gathered data about the amount of regenerating clearcuts and the total forest area subjected to cutting in Lapland from the Finnish Statistical Yearbook of Forestry 1990–2004. According to the linear regression analyses, regenerating clear cuts ($R^2 = 0.61$, $F_{1,13} = 20.18$, $P = 0.001$) and total harvested forest area ($R^2 = 0.77$, $F_{1,13} = 43.30$, $P < 0.001$) increased significantly in northern Finland during the study years 1990–2004.

The average length of the growing season (days with an average temperature of +5°C or higher) is about 120–140 days in the southern and about 100–120 days in the northern parts of the study area. Snow covers the ground about 6–7 months. We gathered weather data from the So-

Table 1. The basic features of the tourist destinations.

Destination	Number of beds	Number of registered overnights in April	Area (ha)	Length of ski tracks (km)	Length of snow-mobile routes (km)
Large-sized destinations:					
Levi	16,000	33,014	393	230	750
Ruka	16,000	36,712	230	216	500
Ylläs	16,000	40,242	570	320	300
Saariselkä	11,000	33,772	280	240	1,000
Ounasvaara	–	–	2,900	100	530
Medium-sized destinations:					
Syöte	5,000	–	140	120	197
Luosto	3,500	14,363	175	95	250
Pyhä	3,500	14,363	248	70	250
Sallatunturi	2,500	9,947	200	110	160
Small-sized destinations:					
Olos	2,000	–	115	200	45
Suomu	1,500	–	110	40	150
Pallas	130	–	35	160	150

dankylä station located in the middle of the study area (Finnish Meteorological Institute). According to linear regression analyses weather conditions have not changed significantly during the study years ($P > 0.05$).

Population density in Lapland is on average ca. 1.9 inhabitants/km² (Statistics Finland 1999) and tourism has been one of the fastest growing industries here, beginning in the 1980s. In the 1990s, tourism focussed on developing several regional “tourist centres” (Regional Council of Lapland 2003). Information about the tourist destinations (Table 1) was gathered from the literature (Suunnittelukeskus Oy 2004) and from Statistics Finland. The number of registered guest-nights in various types of accommodation has increased from 1993 to 2004 by about 2.7% per year ($R^2 = 0.68$, $F_{1,10} = 21.60$, $P = 0.001$). The area of tourist destinations (km²), including urban areas, cottage areas and downhill skiing areas, was measured from topographic maps (1:50,000) using GIS tools. The total length (km) of snowmobile routes and cross-country ski routes around tourist destinations was gathered from the ski centres, government databases and from the literature (Suunnittelukeskus Oy 2004). We assessed the various criteria and grouped the study sites as large, medium and small (Table 1).

Fig. 1. Study sites (tourist destinations) in northern Finland. Square = large-sized, triangle = medium-sized and dot = small-sized tourist destinations.

We gathered information from all 12 tourist destinations in northern Finland (Fig. 1, Table 1) and from all known Golden Eagle territories surrounding these destinations within a radius of 40 km. A radius of 40 km was sufficient to get adequate sample sizes for a species with large territories. In Lapland, Golden Eagle territory size varies between 160–326 km^2 (Ollila 1995, Ollila unpublished) and the mean average minimum distance between territories is about 12.4 km in the Rovaniemi area, northern Finland (Leppäjärvi 1996). The number of eagle territories within a 40 km radius of each study tourist destination varied between 10 and 24.

The tourist destinations included in this study are ski resorts with many kinds of outdoor and indoor activities. The busiest times are in winter but nature-based summer-time tourism is increasing and spreading into uninhabited and also protected areas further away from urban structures. For instance, Levi and Ylläs destinations have grown into small vacation towns in these relatively peripheral areas. The average population density in the tourist destinations is ca. 20 inhabitants/km² (Statistics Finland 1999).

2.2. Study species

Golden Eagles are of conservation concern in Europe and are among the species listed in Annex I of the EU Wild Birds Directive. Human disturbances, changes in the age structure of forests and illegal killing have been identified as potential threats in Finland (Rassi *et al*. 2001) and elsewhere in Europe (Tucker & Heath 1994, BirdLife International 2004). The total number of Golden Eagle pairs in Finland is nowadays about 450, of which about 80% breed in Lapland (Ollila, unpublished).

In Finnish Lapland, most Golden Eagle nests are in old pines on hillsides (Leppäjärvi 1996). Eagles may alternate between several nest sites on a breeding territory, but usually they have one or two favourite nest sites (Tjernberg 1983) presumably with the most favourable characteristics (Bergo 1984). An alternative nest may be a result of an anti-parasite strategy, but it can also be an adaptation to human disturbance (Brown 1969, Bergo 1984). The breeding season in Finland starts at the end of February and lasts until July. The main egg-laying period is at the end of March and at the beginning of April (Helo 1981).

The main prey of eagles in Lapland are mountain hare (*Lepus timidus*), accounting for 33% of prey material, followed by Capercaillie (*Tetrao urogallus*), Black Grouse (*Tetrao tetrix*) and Willow Grouse (*Lagopus lagopus*) accounting for 16%, 11% and 8% of prey individuals, respectively (Sulkava *et al*. 1999). A few (6–12%) items may be reindeer (*Rangifer tarandus tarandus*) calves. We gathered data about the yearly changes of the main prey species of the Golden Eagle. Abundances of the main prey species in Lapland were extracted from the Finnish Game and Fisheries Research Institute database (unpublished data). This nation-wide monitoring scheme provides August density estimates of Grouse and Mountain Hare in mid-winter (see Lindén *et al.* 1996 for details of the method). According to linear regression analyses prey abundances have not changed significantly during the study years ($P > 0.05$ for all cases).

2.3. Golden Eagle data and statistical methods

2.3.1. Golden Eagle data

The data from the Golden Eagle nests were gathered around 12 tourist destinations within a radius of 40 km. Because the breeding success of the Golden Eagle varies annually according to food supply (Watson 1997) and a single year study could be misleading, we used 2,151 territory records covering the years 1990–2004 (Table 2). In Finland more than 93% of the known territories have been checked annually by skilled volunteer observers (Ollila 2000). The number of territories used in this study was 138 and the total number of nests was 360. The mean number of nests per territory was 2.6, and ranged from one to seven. As there are more data than breeding eagles, there might be some problems related to pseudoreplication. One way to avoid this kind of problem is to mark all individual eagles in northern Finland, but this is practically impossible to do. We have tried to overcome this problem by using territory as a random variable in our analyses.

Most nest checks are done between 15 June and 15 July. Similar to Anthony and Isaacs (1989),

Table 2. The number of cases of empty territories, territories with parent(s) in the territory or nest(s) decorated, territories where breeding had begun, but nesting was unsuccessful, and territories with successful breeding in different tourist destinations. Data from 1990 to 2004.

Destination	Empty territories	Parent(s) present or nest decorated	Breeding started, unsuccessful	Breeding begun, successful	Total n
Levi	65	93	21	60	239
Ruka	11	29	5	41	86
Ylläs	57	83	23	64	227
Saariselkä	48	46	5	37	136
Syöte	80	68	25	58	231
Luosto	33	61	18	77	189
Pyhätunturi	25	49	12	73	159
Sallatunturi	7	40	9	67	123
Olos	63	64	19	52	198
Suomu	31	56	15	68	170
Ounasvaara	42	54	6	62	164
Pallas	69	84	17	59	229

we classified eagle nests/territories into four groups: empty nests/territories (nest checking category 0), parent(s) in the territory or decoration of nest (category 1), failed nesting; i.e. egg(s) or nestling(s) was/were destroyed (category 2), and successful nesting (category 3). The single-visit checking system used in Finland might cause some error for nest categorising but more intensive monitoring was not possible with volunteers and large areas.

We measured the distance from the mid-point of a tourist destination to each Golden Eagle territory within a radius of 40 km by GIS. The largest hotel, usually located in the centre of the tourist destination, was used as a mid-point. The distance was measured to the nest with the "highest" category rank. For instance, if there were several decorated nests in a territory, but also a nest with nestling(s), the distance was measured from the latter and this nest determined the breeding status of that territory in that particular year. If there was only an unsuccessful nest in a territory, the distance was measured to that unsuccessful nest. If there were only empty or decorated nests in a territory, we used the arithmetic mean of distances of these nests from a tourist destination.

2.3.2. Statisticl methods

We used mixed model analysis to assess the effects of tourist destinations on Golden Eagle territory occupancy and breeding success. Before analyses, we standardized each variable with its SD [$x_i = (x_i - \bar{x}) / SD$]. As the same territory was followed during several years, territory was used as a random effect in the analyses. Year, distance from the destination, area (km^2), length of ski and snowmobile routes and destinations were treated as fixed effects. Tourist destination was used as a factorial variable, other as linear variables.

In analyses of territory occupancy, we assigned the value '0' to unoccupied territories (empty nests/territories; i.e. nest checking category 0) and '1' to occupied ones (nest checking categories 1–3). In the analysis of breeding success, unsuccessful territories received the score '0' (breeding started but failed; i.e. nest checking category 2) and successful territories the score '1' (nest checking category 3). Because the number of beds, the number of registered guest-nights and the area of tourist destinations correlated strongly with each other (Pearson $r = 0.80$–0.96; $P < 0.01$), we only included the area variable (km^2) in the analyses. Area did not correlate with the length of snowmobile routes ($r = 0.27$, $P = 0.395$) and skiing routes ($r = -0.097$, $P = 0.765$), and the length of snowmobile and skiing routes did not correlate with each other ($r = 0.43$, $P = 0.160$). The variables included in the models were year, tourist destination, territory distance from a tourist destination, area of destination, and the length of snowmobile and skiing routes.

Table 3. Type III tests of fixed effects and estimates of fixed effects in mixed model analyses of the territory occupancy of the Golden Eagle.

Variable	Estimate	S.E.	df	t	P	F	P
Intercept	2.65	0.612	1, 33.99			15.89	<0.001
Year	–0.03	0.011	1, 1429.19			7.87	0.005
Destination			8, 1022.39			5.70	<0.001
Distance from the destination	–0.003	0.01	1,421.25	–0.27	0.787		
Area (km²)	–0.30	0.11	1,346.80	–2.71	0.007		
Snowmobile routes	–0.10	0.03	1,412.41	–3.97	<0.001		
Skiing routes	–0.19	0.06	1,277.63	–3.14	0.002		

Nonparametric tests were used in comparing territory occupancy and breeding success between small, medium and large tourist destinations. We used a nonparametric Tukey-type posterior test for pairwise comparisons (Zar 1984). All statistical analyses were conducted using SPSS 12.0 for Windows (SPPS Inc. 1989–2003). Unless otherwise stated, the values reported are mean ± SD.

3. Results

In the pooled data across all years and locations, about 25% of Golden Eagle territories were empty, in 34% of cases parent(s) were in a territory or a nest was decorated, in 8% of cases breeding had started, but was unsuccessful, and in 33% of cases breeding was successful (Table 2). When considering only the territories where breeding had begun (n = 893), 20% of the breeding attempts were unsuccessful and 80% were successful. The nearest occupied nest was located at a mean distance of 9.9 km (range 3.8–22.9 km, n = 12) and the nearest successful nest at a mean distance of 10.3 km (range 4.5–22.9 km, n = 12) from a tourist destination.

3.1. Territory occupancy

According to the mixed model analysis, Golden Eagle territory occupancy decreased over time (Table 3). Territory occupancy differed between tourist destinations (Table 3) and between small-, medium- and large-sized tourist destinations (χ^2 =8.3, d.f. = 2, P = 0.05). According to pairwise comparisons (P < 0.05), territory occupancy was lower in the large-sized tourist destinations (71.9%) than in medium-sized tourist destinations (82.8%; P < 0.05). In the small-sized destinations, eagles occupied 74.2% of the territories.

There were also differences in the occupancy rate of territories between tourist destinations (Ta-

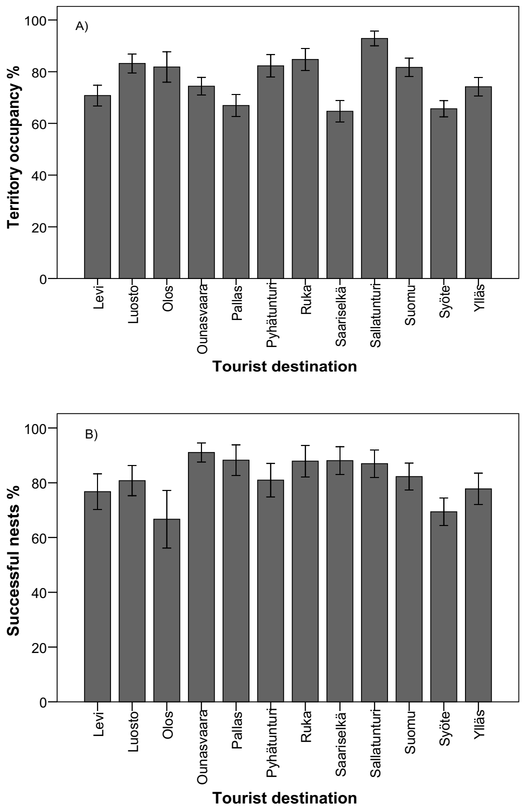

Fig. 2. Occupied nests (%; Fig. 2a) and successful nests (%; Fig 2b) at tourist destinations in northern Finland (Lapland). The mean ± SE is presented.

Table 4. Type III tests of fixed effects and estimates of fixed effects in mixed model analyses of the breeding success of the Golden Eagle.

Variable	Estimate	S.E.	df	t	P	F	P
Intercept	2.17	0.85	1, 3.93			6.31	0.067
Year	0.04	0.16	1, 566.51			4.95	0.027
Destination			8, 214.17			2.06	0.041
Distance from the destination	–0.003	0.02	558.47	–0.17	0.869		
Area (km²)	–0.15	0.14	412.02	–1.09	0.276		
Snowmobile routes	–0.000	0.03	404.42	–0.01	0.994		
Skiing routes	–0.10	0.08	353.97	–1.37	0.170		

ble 3). The mean territory occupancy level was 74.6%. Territory occupancy was lower than the average (>10% lower than the mean) in Saariselkä and higher than the average (>10% higher than the mean) in Sallatunturi and Ruka (Fig. 2a).

Further, the area of the destination (km^2), and the length of snowmobile and skiing routes in the surroundings of a destination negatively affected Golden Eagle territory occupancy (Table 3). The distance from the destination did not affect territory occupancy.

3.2. Breeding success

According to the mixed model analysis, breeding success increased over time (Table 4). There were also differences in Golden Eagle breeding success between tourist destinations (Table 3). The mean of the successful nests of those nests where breeding was started was 81.2%. Breeding success was lower than average (>10% lower than the mean) in Olos and Syöte and higher than average (>10% higher than the mean) in Ounasvaara (Fig. 2b). However, Golden Eagle breeding success did not differ between large-, medium- and small-sized tourist destinations (χ^2 =1.3, d.f. = 2, P = 0.51).

The distance from the destination, area of the tourist destination (in km^2), the length of snowmobile and skiing routes did not affect Golden Eagle breeding success (Table 4).

4. Discussion

Apart from annual variation, we find that the type of tourist destination explained variation in territory occupancy and breeding success of the Golden Eagle. Territory occupancy level was low around large-sized tourist destinations with over 30,000 registered overnights in April. In addition, Golden Eagle territory occupancy was lower around tourist destinations with a high number of skiing and snowmobile routes, although breeding success was not affected. Apart from differences in tourism intensity, natural variation in habitat structure and quality may differ across tourist destinations, and such differences may affect territory occupancy. For example, occupancy was relatively high near some large destinations such as Ruka (near Oulanka National Park and the Russian border), but we did not have data to model specific habitat attributes or preferences across tourist destinations.

Territory occupancy decreased around the tourist destinations during 1990–2004. At the same time, tourism (number of guest nights in accommodation establishments) has increased in northern Finland. Nevertheless, also other factors might cause the decreasing trend in Golden Eagle numbers. The decrease may be explained by a decrease in prey abundance, unfavourable climate conditions or changes in landscape structure irrespective of the impacts of tourism. However, abundances of the main prey species (Mountain hare, Capercaillie, Black Grouse, Willow Grouse) did not decrease during 1990–2004 in the study area (unpublished data from Finnish Game and Fisheries Research Institute). In addition, the Golden Eagle can modify its diet according to the availability of prey species (Sulkava *et al.* 1999, see similar results for the Bonnelli's Eagle, *Hieraaetus fasciatus*; Ontiveros & Pleguezuelos 2000). Therefore, there is no reason to suspect that changes in the abundance of the main prey species have caused the decrease in the Golden Eagle territory occupancy level in our case.

As an early breeding species, the Golden Eagle is sensitive to unfavourable weather especially during incubation. Bad weather can impair breeding output, for example, in an American study 71% of the nests containing chicks failed after a 3-day blizzard in late April (Watson 1997). However, the weather conditions of February–May have not changed significantly during 1990–2004 in northern Finland (unpublished data from Finnish Meteorological Institute). Therefore, weather conditions could not fully explain the declining trend in the territory occupancy around tourist destinations in northern Finland. However, long-term between-year comparisons do not necessarily take into account the possible important role of local, short-term bad weather conditions on Golden Eagle nesting success.

In our forest-dominated study area, nest-site availability is not a limiting factor for the species. However, with its large territory size, the Golden Eagle might be sensitive to changes in landscape structure caused by forestry or other human-related activities (Watson & Whitfield 2002, Whitfield *et al*. 2006). The amount of regenerating clear cuts and total harvested forest area increased significantly in northern Finland during 1990–2004 (Finnish Statistics Yearbook of Forestry 1990–2004). Obviously, forestry might partly explain the decreasing trend in territory occupancy. In Scotland, temporal differences in breeding productivity were negatively related to the extent of forest cover at the landscape scale, but individual territories did not show any relationship with forest cover (Whitfield *et al.* 2007). In our study area, also the number of tourists has increased during 1990–2004, creating more demand for infrastructure and recreational areas and making the region unsuitable for eagles. We suppose that landscape level changes caused by tourism and forestry have both affected Golden Eagle territory occupancy.

Although snowmobile routes were associated with a decrease in territory occupancy, they did not appear to decrease the breeding success of eagles. Disturbances caused by snowmobiles might force eagles to select nest sites outside of the snowmobile routes, and therefore, the number of snowmobile routes would not show impacts on the breeding success of eagles. However, snowmobiles may disturb laying eagles leading to lower territory occupancy when nest are checked in June–July, but snowmobiles may have little influence on breeding success, which depends on conditions in the spring when snowmobiling has ceased. In some areas, the accessibility of nest sites by people may affect Golden Eagle breeding success (Allavena 1985, Watson & Dennis 1992). Finnish authorities have tried to take eagle nests into account when designing snowmobile and skiing routes by locating them as far as possible from known Golden Eagle nests. However, there are no strict legal or administrative guidelines for how close such routes may be built. However, a 500–1,000 m buffer zone has been left around Golden Eagle nests in Finland.

The distance from the tourist destination was not a significant variable explaining the territory occupancy or breeding success of the Golden Eagle according to the mixed model analyses. However, this could be only a statistical artefact. In fact, the nearest territories were located about 10 km from destinations that were a few hundred hectares in size and had 10,000–40,000 visitors during March–April. Our results indicate that the possible effects of tourism extend much further than has been detected in Norway where Bergo (1984) pointed out that some nests were closer than 500 m to permanent human settlements, cabins and roads. In Finland, snowmobiles have become very popular during the past 10 years and may cause unintentional disturbance in the vicinity of tourist locales, especially since the traffic is most intense during March–April, the critical nesting period of the Golden Eagle. In Norway, the incidence of failure among Golden Eagles was greater when the Easter holidays coincided with the egg-laying period; this was probably due to the disturbance caused by skiing tourists (Fremming 1980).

Other studies of eagles have also documented that human activity causes population declines (Abuladze & Shergalin 2002, Kochert & Steenhof 2002, Millar 2002, Pedrini & Sergio 2002) and even 85% of nest losses in the Golden Eagle (Boeker & Ray 1971). Disturbances near the nesting site might lead to failure in breeding or prevent eagles from hunting over part of their feeding range (Watson 1997). Females may be forced to leave the nest for too long (Tjernberg 1983), increasing predation risk or disrupting feeding patterns (review by Knight & Skagen 1988, Richardson & Miller 1997). In the Bald Eagle (*Haliaeetus leucocephalus*, Anthony and Isaacs (1989), results suggest that human activities may affect the selection of alternate nest sites within breeding territories. Recently used nests were further away from recreational facilities and paved, gravel, and logging roads than old nests. Holmes *et al*. (1993) measured the mean flushing distance of wintering Golden Eagles to a vehicle as 82 m but pedestrians might cause greater alarm as Spanish Imperial Eagles reacted sharply to people within 450 m of the nest (Gonzales *et al*. 2006).

According to our results, the territory occupancy has decreased, whereas breeding success of eagles has increased around tourist destinations during the study years. If territory occupancy is being considered as an indirect measure of territory quality (Sergio & Newton 2003), we could argue that the area around tourist destinations, especially the largest ones, is poor quality for eagles, i.e. it could be an ecological trap or a sink zone. However, the fact that breeding success increased around tourist destinations during the study years does not support that hypothesis, unless breeding success is being negatively related to the density of breeders, and intra-specific competition is playing some role. If this is true, eagles that remain around tourist destinations would take advantage from low density and competition for food, breeding successfully in an area that cannot otherwise sustain high densities because of poor quality. In Scotland, territories with poorer breeding productivity were more vulnerable to abandonment than territories with better breeding productivity (Whitfield *et al*. 2007). There are also other possible explanations for the improved breeding success. Changes in food may lead to fewer occupied territories, which again might lead to larger feeding areas for remaining eagles, and thus for higher success.

As in all descriptive analyses, we can never be sure if all relevant explanatory variables have been included in the analyses. It would be interesting to consider the possible effects of prey abundance, climatic factors, harvesting and tourism-related factors in the same analysis, but unfortunately there were no suitable territory level data available for e.g. prey and climatic factors.

The total number of registered overnight stays in Finnish Lapland has increased steadily and is still increasing about 2.5% yearly (Regional Council of Lapland 2003). It may be that the increased disturbance impairs Golden Eagle breeding success and/or causes currently suitable nest sites to be unsuitable in the future. Good route planning can help in locating snowmobile and ski routes so that they do not come too close to Golden Eagle nests. A GIS-assisted view combined with a designated buffer zone distance could be one possible tool for reducing the potential disturbance caused by tourism to Golden Eagles. With this in mind, land managers and planners need site-specific information on the horizontal proximity of a nest to a potential disturbance, the type and duration of disturbance, data about the territory occupancy and nesting success of eagles, and more accurate information about the numbers of visitors and their activities in and around the tourist destination. At present, statistics are available only for registered accommodation facilities, and they may cover less than 10% of all accommodation facilities (Regional Council of Lapland 2003). It is also important to note that although a single direct disturbance may not have significant impacts, repeated disturbances of one type or different types of disturbances together may affect the Golden Eagle.

5. Conclusions

Our results indicate that the mean Golden Eagle territory occupancy rate has decreased around tourist destinations during the study years and the territory occupancy rate was low around large-sized tourist destinations. Tourist destinations may alter landscape structure so that wildlife have less or degraded habitat to live. In addition, human disturbance around tourist destinations may negatively affect e.g. territory occupancy of disturbance-sensitive species like the Golden Eagle. The negative trend will probably continue if the tourism-related habitat changes and human activity such as snowmobile driving increases. According to our results, the negative impact of a tourist destination can reach a distance of 10 km away from the tourist destination. We conclude that the Golden Eagle, as a disturbance-sensitive species, might be a good indicator for the early impacts of tourism on nature especially when monitoring the influences of recreational activities. Landscape managers should pay special attention to planning snowmobile routes situated in the surroundings of destination areas where the Golden Eagle breeds. Effective conservation of the Golden Eagle requires addressing constraints in the wider environment and multiple factors affecting both the territory occupancy and breeding success (Whitfield *et al.* 2007).

Acknowledgements. We thank the Finnish Forest and Park Services for providing the nest data and we appreciate the assistance of the many volunteers, who collected the data in the field. We are also grateful to Jon Brommer, Philip Whitfield, Paola Laiolo and an anonymous reviewer for many helpful comments on the manuscript. The EU LIFE Environment Program has supported the study financially.

Maakotkan reviirin asuttaminen ja pesimämenestys pohjoissuomalaisten matkailukeskusten ympäristöissä

Vilkastuneesta matkailurakentamisesta ja virkistyskäytöstä voi aiheutua häiriöitä alueen eliöstölle. Tutkimuksessa tarkasteltiin matkailukeskusten potentiaalisia vaikutuksia maakotkan reviirin asuttamiseen ja pesimämenestykseen Pohjois-Suomessa. Kahdestatoista pohjoissuomalaisesta matkailukeskuksesta koottiin tieto kaikista maakotkan tunnetuista reviireistä 40 kilometrin säteellä. Vuosilta 1990–2004 kertyi 2 151 reviirihavaintoa yhteensä 138 reviiriltä. Maakotkan pesäpuita reviireillä oli kaikkiaan 360. Lähin maakotkan reviiri sijaitsi keskimäärin 9,9 kilometrin etäisyydellä matkailukeskuksen ytimestä. Lähin onnistunut pesintä tapahtui keskimäärin 10,3 kilometrin etäisyydellä matkailukeskuksen ytimestä. Sekä maakotkan reviirin asuttaminen että pesimämenestys vaihteli tutkimusvuosien ja matkailukeskusten välillä.

Maakotkan asuttujen reviirien määrän havaittiin laskeneen tutkimusvuosien aikana, etenkin suurikokoisten matkailukeskusten ympäristöissä. Ihmisten aiheuttaman häirinnän määrän tasoa kuvaavaksi muuttujiksi valittiin hiihtolatujen ja kelkkareittien kilometrimäärä. Reittien suuri määrä vaikutti negatiivisesti maakotkan reviirin asuttamiseen. Pesimämenestykseen näillä ei ollut vaikutusta.

Tutkimusvuosien aikana matkailijoiden ja avohakkuiden määrät sekä hakkuiden kokonaismäärät kasvoivat, kun taas sääolot ja maakotkan saaliseläinten määrät eivät muuttuneet merkittävästi Pohjois-Suomessa. Tutkimustulosten perusteella pääteltiin, että matkailuun liittyvät elinympäristömuutokset sekä aktiviteetit voivat lähitulevaisuudessa aiheuttaa kasvavia paineita häiriöherkille lajeille kuten maakotkalle. Maakotkan suojelutyössä tulisikin huomioida useita eri tekijöitä yhtäaikaisesti ja käsitellä maakotkan menestyvyyteen vaikuttavia tekijöitä laaja-alaisesti.

References

Abuladze, A. & Shergalin, J. 2002: The Golden Eagle in North Caucasia and Transcaucasia. — Journal of Raptor Research 36: 10–17.

Ahti, T., Hämet-Ahti, L. & Jalas, J. 1968: Vegetation zones and their sections in northwestern Europe. — Annales Botanici Fennici 5: 169–211.

Allavena, S. 1985: Preliminary results of research on the Golden Eagle *Aquila chrysaetos* in the central-southern region of the Appennines in Italy. — WWGBP Bulletin 2: 79–81.

Anthony, R.G. & Isaacs, F.B. 1989: Characteristics of Bald Eagle nest sites in Oregon. — Journal of Wildlife Management 53: 148–159.

Bergo, G. 1984: Habitat and nest-site features of Golden Eagle *Aquila chrysaetos* (L.) in Hordaland, West Norway. — Fauna Norvegica. Ser. C, Cinclus 7: 109–113.

BirdLife International, 2004: Birds in Europe. Population Estimates, Trends and Conservation Status. — BirdLife Conservation Series 12. Information Press, Oxford.

Boeker, E.L. & Ray, T.D. 1971: Golden Eagle population studies in the Southwest. — The Condor 73: 463–467.

Brown, L.H., 1969: Status and breeding success of Golden Eagles in north-west Sutherland in 1967. — British Birds 62: 345–363.

Burger, J. & Gochfeld, M. 1998: Effects of ecotourism on bird behaviour at Loxahatchee National Refuge, Florida. — Environmental Conservation 25: 13–21.

European Environment Agency 2003: Europe's environment: the third assessment (Summary). — Office for Official Publications of the European Communities; Luxembourgh.

Fremming, O.R. 1980: Kongeørn i Norge. — Viltraportt 12: 1–63. (In Norwegian).

Gonzales, L.M., Arroyo, B.E., Margalida, A., Sanchez, R. & Oria, J. 2006: Effects of human activities on the behaviour of breeding Spanish Imperial Eagles (*Aquila adalberti*): management implications for the conser-

vation of a threatened species. —Animal Conservation 9: 85–93.
Helo, P. 1981: Kotka: lintujen kuningas. — Omakustanne, Kajaani. (In Finnish).
Holden, A. 1999: High impact tourism: a suitable component of sustainable policy? The case of downhill skiing development at Cairngorm, Scotland. — Journal of Sustainable Tourism 7: 97–107.
Holmes, T.L., Knight, R.L., Stegall, L. & Craig, G.R. 1993: Responses of wintering grassland raptors to human disturbance. — Wildlife Society Bulletin 21: 461–468.
Knight, R.L. & Skagen, S.K. 1988: Effects of recreational disturbance on birds of prey: a review. In Proceedings of the Southwest Raptor Management Symposium and Workshop (ed. Glinksi, R.L.): 355–359. National Wildlife Federation, Washington.
Kochert, M.N. & Steenhof, K. 2002: Golden Eagles in the US and Canada: Status, trends, and conservation challenges. — Journal of Raptor Research 36: 32–40.
Leppäjärvi, M. 1996: Maakotkan (*Aquila chrysaetos* L.) pesimähabitaatin maisemarakenne ja sen merkitys poikastuotannolle. –Masters thesis, University of Oulu, Biological department, Oulu. (In Finnish).
Lindén, H., Helle, E., Helle, P. & Wikman, M. 1996: Wildlife monitoring scheme in Finland: methods and aims for monitoring wildlife populations. — Finnish Game Research 49: 4–11.
Millar, J.G., 2002: The protection of eagles and the Bald Eagle Protection Act. — Journal of Raptor Research 36: 29–31.
Miller, J.R. & Hobbs, T.N. 2000: Recreational trails, human activity, and nest predation in lowland riparian areas. — Landscape and Urban Planning 50: 227–236.
Miller, S.G., Knight, R.L. & Miller, C.K. 1998: Influence of recreational trails on breeding bird communities. — Ecological Applications 8: 162–169.
Ollila, T., 1995: Suomen maakotkat 1990–1994. — Linnut 30: 24–26. (In Finnish).
Ollila, T., 2000: Population trends and breeding success of the Golden Eagle *Aquila chrysaetos* in Finland 1990–1999. — Linnut-vuosikirja 1999, 4–7. (In Finnish with English summary).
Ontiveros, D. & Pleguezuelos, J.M. 2000: Influence of prey densities in the distribution and breeding success of Bonelli's eagle (*Hieraaetus fasciatus*): management implications. — Biological Conservation 93: 19–25.
Pedrini, P. & Sergio, F. 2002: Regional conservation priorities for a large predator: Golden Eagles (*Aquila chrysaetos*) in the Alpine range. — Biological Conservation 103: 163–172.
Pickering, C.M., Harrington, J. & Worboys, G. 2003: Environmental impacts of tourism on the Australian Alps protected areas – Judgments of protected area managers. — Mountain Research and Development 23: 247–254.
Rassi, P., Alanen, A., Kanerva, T. & Mannerkoski, I. (eds.) 2001: The Red List of Finnish Species. Ministry of the Environment & Finnish Environment Institute, Helsinki. (In Finnish with English Summary).
Regional Council of Lapland 2003: Lapland Tourism Strategy 2003–2006. Rovaniemi.
Reimers, E., Eftestol, S. & Colman, J.E. 2003: Behavior responses of wild reindeer to direct provocation by a snowmobile or skier. — Journal of Wildlife Management 67: 747–754.
Richardson, C.T. & Miller, C.K. 1997: Recommendations for protecting raptors from human disturbance: a review. — Wildlife Society Bulletin 25: 634–638.
Sergio, F. & Newton, I. 2003: Occupancy as a measure of territory quality. — Journal of Animal Ecology 72: 857–865.
SPSS Inc., 1989–2003: SPSS 12.0 for Windows.
Statistics Finland 1999: Population density in Finland 1999, 1:1,100,000. A population density map.
Sulkava, S., Huhtala, K., Rajala, P. & Tornberg, R. 1999: Changes in the diet of the Golden Eagle *Aquila chrysaetos* and small game populations in Finland in 1957–96. — Ornis Fennica 76: 1–16.
Suunnittelukeskus Oy 2004: Levi 3 Kehittämissuunnitelman loppuraportti. Lapin Painotuote Oy, Kemijärvi. (In Finnish).
Taylor, A.R. & Knight, R.L. 2003: Wildlife response to recreation and associated visitor perceptions. — Ecological Applications 13: 951–963.
Tjernberg, M., 1983: Habitat and nest site features of Golden Eagle *Aquila chrysaetos* (L.) in Sweden. — Swedish Wildlife Research 12: 131–163.
Tucker, G.M. & Heath, M.F. 1994: Birds in Europe: their conservation status. – Cambridge, U.K.: BirdLife International, BirdLife Conservation Series no. 3. The Burlington Press, Cambridge.
Watson, J., 1997: The Golden Eagle. T & A D Poyser, London.
Watson, J., & Dennis, R.H. 1992: Nest-site selection by Golden Eagles in Scotland. — British Birds 85: 469–481.
Watson, J. & Whitfield, P.D. 2002: A conservation framework for the Golden Eagle (*Aquila chrysaetos*) in Scotland. — Journal of Raptor Research 36 (1 Supplement): 41–49.
Whitfield, D.P., Fielding, A.H., Gregory, M.J., Gordon, A.G., McLeod, R.A. & Haworth, P.F. 2007: Complex effects of habitat loss on Golden Eagle *Aquila chrysaetos*. — Ibis 149: 26–36.
Whitfield, P.D., Fielding, A.H., McLeod, D.R.A., Haworth, P.F. & Watson, J., 2006: A conservation framework for the Golden Eagle in Scotland: Refining condition targets and assessment of constraint influences. — Biological Conservation 130: 465–480.
Zar, J.H. 1984: Biostatistical analysis. — Prentice-Hall, Englewood Cliffs, NJ.