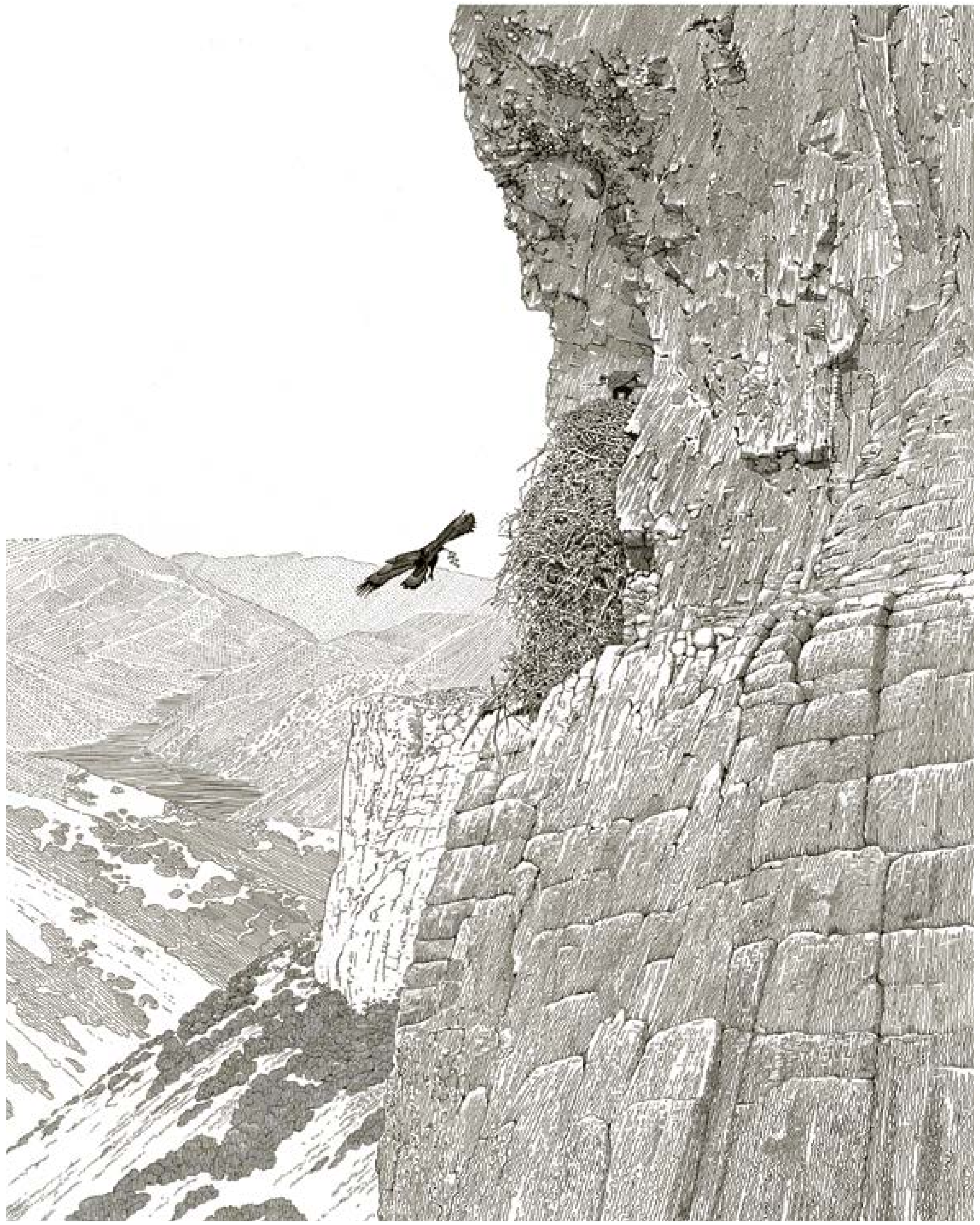
Section IV: Scandinavia and Finland



An adult with a branch arrives at its cliff nest on a towering wall. "Finishing Touches," James W. Lish, ink on scraperboard.

Title page (right): *Golden Eagle on perch, Sandvikåsen, Norway. Photo: Dag Brynjelsen.*

An Introduction to the Golden Eagle in Scandinavia

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Ever since the 1960s, when I first became a birder, I have been particularly fascinated by the Golden Eagle (*Aquila chrysaetos*). I have always felt that it radiates strength and pride, and I am not the only one. Throughout the world, it has been used as a symbol of strength, courage, power, and honour. For example, Native American tribes show their respect for the eagle by using feathered head-dresses, and rulers throughout the centuries have used eagles as a symbol of power.

In the late 1960s, I realized that the Golden Eagle regularly spent their winters in the area where I live (i.e., the agricultural district surrounding Uppsala, central Sweden). The bird fauna around Uppsala is scanty in the winter, and hence the sighting of a Golden Eagle was naturally the climax of the day. It also occurred to me that each individual eagle could be recognized by differences in the plumage.

Thus, for me the sighting of a new individual was akin to the sighting of a new species! Because the Golden Eagles of northern Europe moult more slowly than those of, for example, the Mediterranean, I could also determine the age of each individual up to adult plumage (age of 6 years), if with somewhat lower accuracy after the 4th plumage. This, in turn, gave me knowledge of the geographic range of individual eagles in winter, and of their hunting success. Where I live, their main prey are European hare (*Lepus europaeus*) and Common Pheasant (*Phasianus colchicus*), but many other species are, of course, also on the menu. A study of 85 hunting attempts revealed that young eagles (up to 3 years old) were considerably less successful than older eagles. The youngsters had a success rate of 10% compared to ca 30% for older eagles.

During the 1970s and 1980s, a comprehensive feeding program, aiming at save the White-tailed Sea-eagle (*Haliaeetus albicilla*), was carried out in Sweden. This eagle had been driven to the verge of extinction by extensive use of DDT and PCBs during the 1950s and 1960s, and the plan was to detoxify the eagles by feeding them unpolluted food. Also in my home area carrion was laid out, but it was only frequented by Golden Eagles, never by White-tailed Sea-eagles. Today the situation is completely reversed. Sea-eagles can be observed more or less daily year-round, whereas the Golden Eagle still occurs, but in low numbers, and only in winter.

In the mid-1970s, I began to work on my Ph.D. thesis at SLU, Uppsala. The objective of my study was to elucidate the ecology of the Golden Eagle within its then Swedish range comprising the northern half of Sweden and a few pairs on the island of Gotland in the Baltic Sea, southeastern part of the country. Very little was known about the ecology of the species across Sweden, and the population was estimated at no more than 100 pairs.

Six years of field work revealed that the population was considerably larger than expected. I estimated it at ca 400 pairs, which was probably also an underestimate. More structured inventories covering the entire country were initiated in the late 1990s, and from 2010 on, the number of inhabited territories every year has been almost 500, which means that 600 pairs is a reasonable estimate when undetected pairs are taken into account. The Norwegian population is estimated at 1200 pairs, and the Finnish population amounts to at least 450 pairs.

From 1989 on, Golden Eagle pairs have begun to establish territories in mainland southern Sweden. At present ca 25 pairs are known to breed there, and a few pairs are established in Denmark as well. The population on Gotland has grown rapidly since the 1970s. Today about 60 pairs breed there, and the population density (1 pair/50 km^2) is among the highest in the world. In addition, approximately 50 pairs of White-tailed Sea-eagle breed on the same island.

The average annual reproduction in Sweden amounts to ca 0.5 fledglings per occupied territory. In Norway and Finland the figures are 0.40 and 0.56, respectively. Breeding success does, however, vary widely between years and regions, mainly depending upon prey abundance and weather conditions during February–April (i.e., shortly before and throughout the incubation season). On average, 400 out of the 500 known, established pairs initiate breeding each year, and on average ca 40% of them (ca 160) succeed in producing fledglings. The aforementioned variation in breeding success can be exemplified by statistics from the period 2010–2016. The lowest number of successful breeding pairs per year within that period was 81 and the maximum number was 235. A slightly alarming trend is that the average number of fledglings per established pair has decreased steadily for many years in northern Sweden (and in Norway). The negative impact of this on the national population is, however, reduced by the establishment of breeding pairs in southern Sweden.

Golden Eagle nests are mainly associated with mountains and cliffs, but my study in northern Sweden revealed that at least 50% of the pairs did, in fact, nest in trees. Cliff-nests dominate in the alpine region, but Golden Eagles also nest in woodland areas. Tree-nesting predominates in Finland, and cliff-nesting in Norway. In northern Sweden, at least 95% of the nesting trees are pines. Typically these are sturdy and aged, at least 200 years old. In my study, the average age of 97 healthy nesting trees was 311 years. On Gotland, the average tree age is distinctly lower (145 years), but, because trees grow faster in southern Sweden, the average diameter is similar. All nests in southern Sweden are located in trees.

The Golden Eagle is a generalist in terms of prey. Hence, the diet varies widely depending on where the eagle occurs. In my study in northern Sweden, I identified 57 prey species. More than half of them (66%) were birds, but in terms of biomass, birds and mammals were of equal importance. In northern Sweden, the dominant prey species were Western Capercaillie (*Tetrao urogallus*), Black Grouse (*Lyrurus tetrix*), Rock Ptarmigan (*Lagopus muta*), Willow Grouse (*Lagopus lagopus*), and alpine hare (*Lepus timidus*). In reindeer (*Rangifer tarandus*) breeding areas, reindeer calves also constitute an important food source, especially in May when the calves are born. Approximately 100,000 reindeer calves are born every year in northern Sweden, and it is estimated that around 1,000 of them are eaten by Golden Eagles. The natural mortality among reindeer calves may, however, be as high as 20–30% in certain years, and the majority of calves consumed by Golden Eagles have died from exposure, etc.

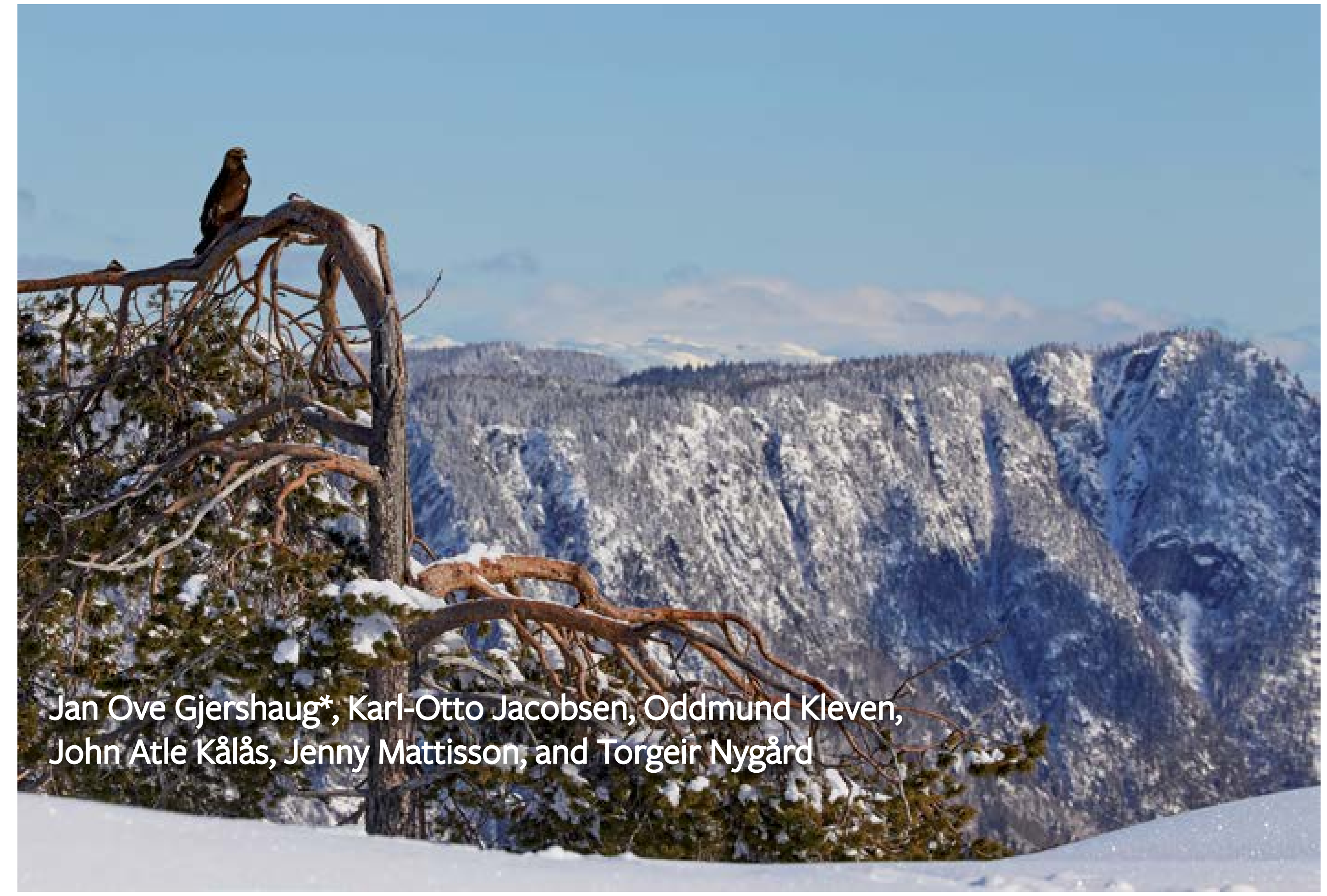
In addition to the reduced reproduction rate in northern Sweden mentioned above, several other factors also have an adverse effect on the Golden Eagle population. Predators are often persecuted, and the Golden Eagle is no exception. In certain parts of northern Sweden, especially in the alpine region, the persecution is quite extensive, and many former territories are now unoccupied. Collisions with vehicles, especially trains, is another important factor. On average, 25–30 Golden Eagles, many of which are adults, are killed by trains every year in northern Sweden. The reason for this is that in winter, reindeer are drawn to railways where it is easy to walk as the snow has been cleared. There, the reindeer are hit by trains, and their carcasses attract eagles which, in turn, are also hit.

Lead poisoning is another cause of death, which has turned out to be more serious than we thought. The reason is that the eagles utilize the entrails of elk (*Alces alces*) and roe deer (*Capreolus capreolus*) killed with lead bullets. Each year, approximately 90,000 elk and 110,000 roe deer are killed by hunters, which means that lead poisoned eagle food abounds in the Swedish forests during the hunting season.

Finally, collisions with electric wires and, increasingly, with windmills are other common death causes.

Despite all this, I would like to end on a positive note. My personal belief is that the future of the Nordic Golden Eagle population is bright. Another good thing is that all eagle lovers now have access to an equally attractive and comprehensive book describing the distribution and ecology of the Golden Eagle throughout its Holarctic range!

The Golden Eagle in Norway



Jan Ove Gjershaug*, Karl-Otto Jacobsen, Oddmund Kleven, John Atle Kålås, Jenny Mattisson, and Torgeir Nygård

Photo: Markus Varesuo.

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The Golden Eagle (*Aquila chrysaetos*) population in Norway is currently considered viable and stable around 1000 pairs, and the species is listed as Least Concern (LC) on the Norwegian Red List for Species (Henriksen and Hillmo 2015). A state bounty for killed Golden Eagles was paid from 1845–1924 resulting in an estimate of 114,000 eagles (Golden Eagles and White-tailed Sea-eagles *Haliaeetus albicilla*) being killed in Norway from 1846–1968 (Statistics Norway 1978). Because of low numbers, the Golden Eagle was protected in 1968 and has since then recovered to a stable population.

Monitoring of breeding success for Golden Eagles started in Norway in 1991 as part of the monitoring program for terrestrial ecosystems (TOV) initiated by the Norwegian Environmental Agency. The objective was initially to monitor flora and fauna in subalpine and alpine ecosystems to investigate impacts of long-range air pollution (Løbersli 1989). The objective was later broadened to include effects of climate change and responses to anthropogenic changes (Framstad 2020).

This monitoring of Golden Eagles follows strict pre-defined protocols and methods to document both positive (breeding attempts) and negative findings (non-breeding; Gjershaug et al. 2018). The monitoring in TOV was initially carried out in 5 areas with 10–13 territories each. From 1997 the monitoring was extended to 6 areas. In 2013 the monitoring of Golden Eagles became a part of the Norwegian Large Predator Monitoring Program (www.Rovdata.no) and was then increased to 12 areas with 15 territories in each to improve geographic coverage (Fig. 1). This intensive monitoring provides an estimate of breeding success defined as the mean number of fledglings for all monitored territories in each area, which provides knowledge about spatial and temporal trends in breeding success.

DISTRIBUTION AND HABITAT

Distribution of the breeding population of Golden Eagles covers most of Norway except the most southeastern part and along the southern coast (Fig. 2). Most of the territories are situated near mountain areas (Fig. 3), but the species are also found in open coastal areas or open heaths (Fig. 4). Territories can also be found in relative flat forested landscapes close to clear cuts and bogs (Fig. 5). The Golden Eagle needs open areas for hunting, which eliminates it from dense forest areas. For information about habitats around nest localities see last section.

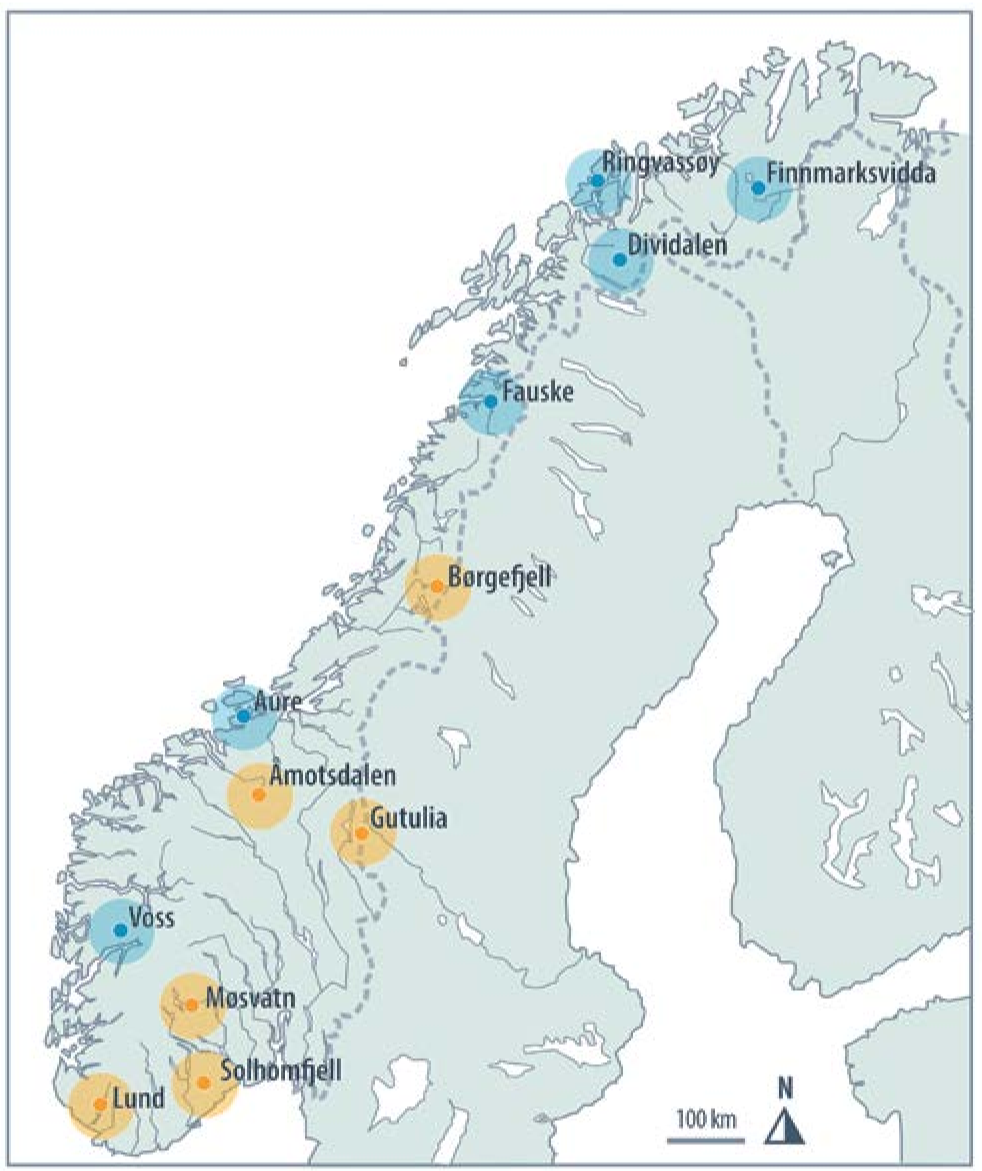

Figure 1. *The intensive monitoring areas of Golden Eagles in Norway. The 6 TOV areas in red have been monitored since 1991 (except Gutulia which was started in 1997) and those in blue have been monitored since 2013 (except Aure which was started in 2015).*

Figure 2. *Distribution of the Golden Eagle in Norway. Known territories with a buffer (grey areas) of 10 km (from Dahl et al. 2015).*

Ilustration: *Robert Katona.*

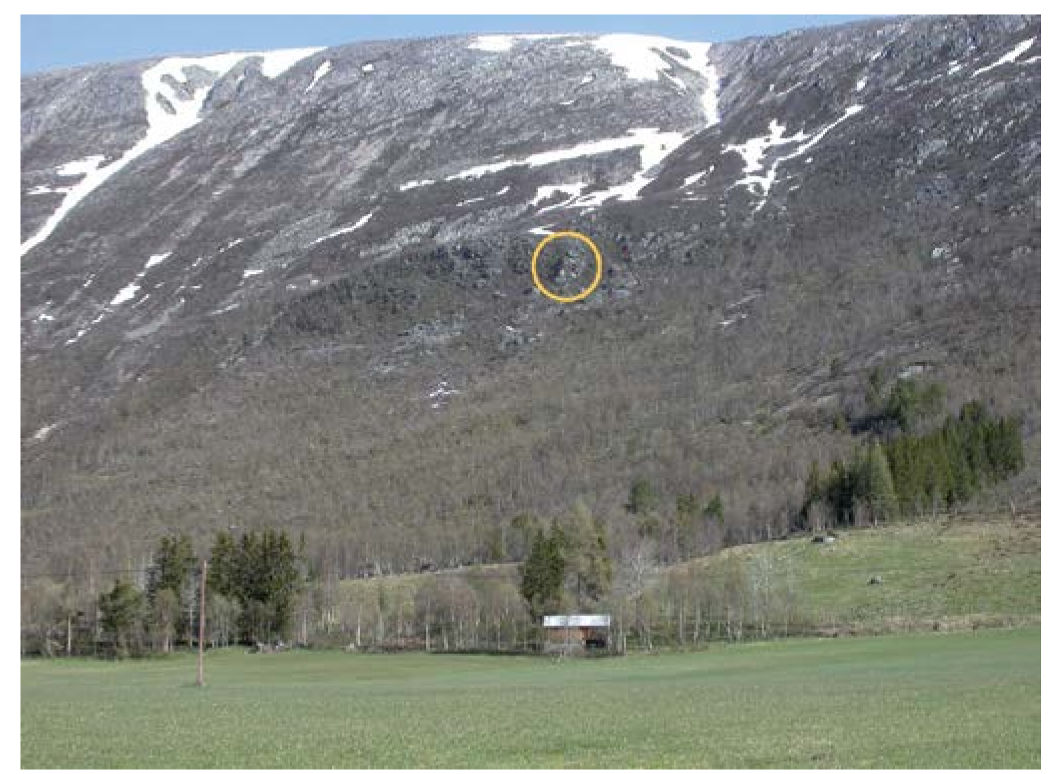

Figure 3. *Nesting site in central Norway in a small cliff at tree line. Photo: Jan Ove Gjershaug.*

Figure 4. *Two coastal nesting sites 1 km apart in central Norway. Photo: Ingar Støyle Bringsvor.*

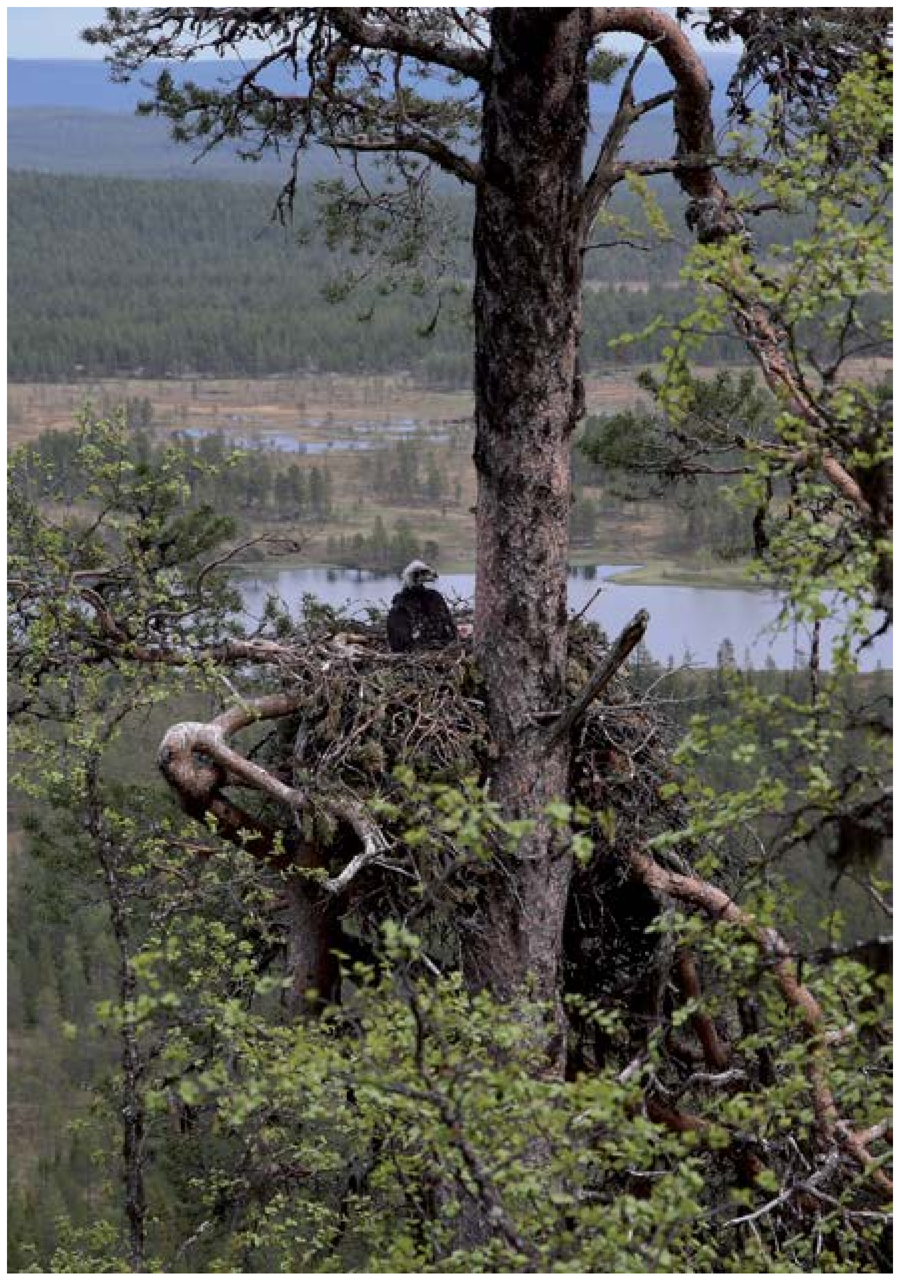

Figure 5. *Nesting site in open pine forest with bogs in south-eastern Norway. Photo: Carl L. Knoff.*

POPULATION SIZE AND TRENDS

The Golden Eagle population in Norway was reduced to a low level until its protection in 1968. An indication of this decrease was that many old nesting-sites were empty and had not been used for many years. In 1971 the Golden Eagle population in Norway was estimated to be ca 250 pairs (Haftorn 1971), but due to poor coverage this was most likely an underestimate. In 1972/73 shortly after the protection of the species, a new population estimate of 344–523 pairs was made based on questionnaires sent to all municipal game officials (Hagen 1976). In 1991 the population was estimated at 700–1000 pairs (Gjershaug 1994). Eleven years later, in 2002, the population was estimated at 773–1072 pairs (Gjershaug and Nygård 2003). The most recent estimates, both in 2015, were 1207–1537 pairs (Shimmings and Øien 2015) and 652–1139 pairs (Dahl et al. 2015). The estimate of Shimmings and Øien (2015) was based on a number of literature sources and personal communications while Dahl et al. (2015) used a site-occupancy model based on territories registered in a national wide database called Rovbase as part of an extensive national monitoring of eagles.

That the Golden Eagle population has increased after protection in 1968 was indicated by the reestablishment of pairs at localities that had been empty for years. However, the population has probably not increased as much as the population estimates indicate. The observed increase is more likely a result of higher survey effort. The Norwegian Golden Eagle population is today regarded as viable and stable.

POPULATION DENSITY AND HOME RANGE SIZE

The estimated distance between nearest neighboring territory centers (NND) varies from 10–20 km (mean 16 km) in Hordaland, western Norway (Bergo 1984a) to 5–28 km (mean 14.7 km) in Møre & Romsdal, central Norway (Gjershaug 1981). In western Finnmark, the average NND between 51 territories was 12 km (Nygård et al. 2016).

Calculation of population density, according to Kochert (1972), yielded 1 pair/200 km² in Hordaland (Bergo 1984a), 1 pair/170 km² in Møre & Romsdal (Gjershaug 1981), 1 pair/170 km² in Aust-Agder (Pfaff 1993), and 1 pair/100 km² in Dovrefjell. In the Dovrefjell area, the NND was only 4 km (Gjershaug 1994). The shortest distance between 2 nests used simultaneously in Finnmark was 3.7 km (Kleven and Jacobsen unpubl. data). On 4 neighboring islands on the coast of Møre & Romsdal there are 9 breeding pairs, which gives a population density of ca 1 pair/50 km² land area, the highest density registered in Norway (Alv Ottar Folkestad pers. comm.).

The home range sizes of 3 well-studied pairs were calculated to be min. 32 km², min. 50 km, and 100 km² (Bergo 1984a). In Vest-Agder and Rogaland, the home ranges were estimated to be 80–100 km² (Tysse 2005, Tysse et al. 1999).

BREEDING

Nest Sites. Golden Eagles build nests either on ledges in cliffs or on branches in large trees, most often pine trees (*Pinus* sp.; Fig. 5). In the counties Hordaland and Møre & Romsdal in western Norway, 98% and 100% of the nests were in cliffs (Gjershaug 1981, Bergo 1984a). In Rondane further east, 88% of the nests were in cliffs, while the rest were in trees (Fremming 1982). Golden Eagle nests are often situated in quite small cliffs in a hill or valley side (Fig. 3), but sometimes in quite large cliffs (Fig. 6) or down in canyons (Fig. 7). The nest is usually protected by an overhang in the cliff. When the nests are built in trees, they are usually in large pine trees with strong horizontal branches (Fig. 5), but lacking such trees Golden Eagles build nests in spruce (*Picea* sp.) and birch (*Betula* sp.).

In Møre & Romsdal in western Norway the distance from nests to the nearest open mountain area varied from 0–1500 m (mean 480 m; n = 50). All nests, except 2, were situated between 200–500 m below the tree line (Gjershaug 1981). It is energetically favorable to bring the prey downwards to the nest instead of upwards. Another benefit of such placement of the nests in cliffs is that it is usually more protected against bad weather than high up on exposed large cliffs or in a tree.

The Golden Eagle is usually regarded as a wilderness bird, nesting in remote places far from people (Hagen 1952), but sometimes the nests are situated quite close to human settlements (Fig. 4, 8). In Møre & Romsdal, the distance from nests to permanent human settlements varied from 300 m–10 km (mean 1700 m; Gjershaug 1981). In Hordaland all nests were found >500 m from permanent settlements (Bergo 1984b).

In 14 territories in Møre & Romsdal county, the number of alternate nests in a territory varied from 1–9 (mean =

Figure 6. *A nesting site high up on a large cliff in Møre & Romsdal. Photo: Jan Ove Gjershaug.*

Figure 7. *Nest site in a canyon far below the tree line in central Norway. Photo: Jan Ove Gjershaug.*

Figure 8. *A nest site quite close to a human settlement in central Norway. Photo: Jan Ove Gjershaug.*

3.6). The distance between the alternate nests in 13 of these territories varied from 1 m–6.5 km (mean = 584 m; Gjershaug 1981). This was very similar to the situation in Hordaland county were the distance varied from 1 m–3.2 km (mean = 603 m; Bergo 1984b). In Rondane, the distance varied from 1 m–7 km (Fremming 1982).

Based on 3468 nests from 1360 different territories registered in the national database Rovbase (c.f. Dahl et al. 2015, Nilsen et al. 2015), the average number of nests per territory was 2.6 (r = 1-19, SD = 2.0). Of these nests, 78% were placed in cliffs and 8% in trees (the remaining 14% of nests lacked information). Twelve percent of the territories with >1 nest (n = 710 territories) had nests both in cliffs and trees. Based on data from the same database, Nilsen et al. (2015) showed that most nests were located between 260–700 masl (1^{st} –3^{rd} quantile), on relatively steep slopes (33–54%). Nests were distributed in most habitat types (mainly in deciduous forests 40%, open habitats 31%, and coniferous forests 22%), except human dominated landscapes or mires. Most nests were between 1.1–8.6 km away from agricultural land and 5.8–17 km from built-up areas, but the minimum distances were only 18 and 121 m respectively (Nilsen et al. 2015).

South facing slopes seem to be preferred for nesting sites (Fig. 9; n = 1510). The majority (76%) of nests in Hordaland were orientated towards the west or south, whereas 24% of the nests were oriented towards the northerly sector (Bergo 1984b). A similar situation was found in Møre & Romsdal where 81% of the nests were orientated towards west or south. These nests were used significantly more often than nests oriented towards east or north (Gjershaug 1981). One explanation of this could be that northern-orientated cliffs retain snow longer in spring and have lower temperatures during the often climatically severe incubation period. Most nests (67%) were more or less sheltered by overhanging and laterally protruding rocks (Fig. 10). The size of this protruding overhang varied from 0–6 m (mean = 2.2 m; Gjershaug 1981). The greater use of sheltered nests may again be an adaptation to avoid nests covered by snow at the start of the breeding season. There are very often bushes or trees in front of the nesting ledge protecting chicks from overheating. This is especially important at nests facing south and west (Fig. 10–11).

Age at First Breeding. Of 98 Golden Eagle nestlings that were genetically tagged during the period 2004–2018, three have later been detected on breeding territories. These 3 birds were 3, 6, and 10 years old when they were detected for the first time as adults on territory. The 2 younger birds were males, and the 10-year-old bird was a female. While it is uncertain whether the 2 males made a breeding attempt, the female did so, and she has yearly been detected in the same breeding territory since she appeared there in 2016. The distance from her natal site to her breeding territory was 28 km (Kleven and Jacobsen, unpubl. data).

Brood Size. Of 42 Golden Eagle broods in Møre & Romsdal from 1970–1979, 67% had 1 chick and 33% had 2

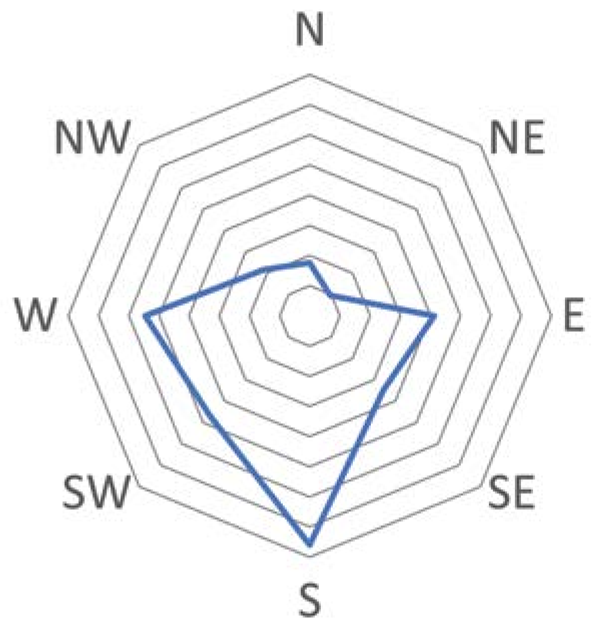

Figure 9. *Orientation of 1510 Golden Eagle nests. Each circle line represents 50 nests.*

chicks. Two broods of 3 chicks were hatched, but only 2 fledged in each of them (Gjershaug 1981). Of 298 successful breeding attempts within the intensive monitoring program in Norway, 244 broods had 1 chick and 54 broods 2 chicks (e.g., Tovmo et al. 2019). A breeding attempt with 3 chicks fledging has only been recorded once in Norway (Fig. 12). Collett (1921) described a brood of 5 chicks from a Norwegian nest in the lemming year 1891. Three of the chicks were near fledging, while the other 2 were partly in downy plumage. Gjershaug (1981) and Ellis and Nygård (2013) interpret this as a case where the Golden Eagle has robbed 2 Rough-legged Buzzard (*Buteo lagopus*) chicks from a nest and taken them alive to its own nest. Similar cases have been described from Sweden (Wesselen 1947), and for White-tailed Sea-eagles bringing live Rough-legged Buzzard chicks to its nest in Norway (Folkestad 1991).

Time of Egg-laying. The estimated date of egg-laying (estimated based on age of chicks) for 40 clutches in Møre & Romsdal in the period 1970–79 varied from March 4 to April 27 (mean March 31; Fig. 13).

Replacement Clutch. We know of only 1 case of a replacement clutch from Norway. In 2017, egg-laying was recorded to have taken place between 12 and 15 March (the nest to the left in Fig. 3). On 20 March the incubation was interrupted, and on 3 April the eagle pair were refurbishing an alternate nest 1.1 km away (the nest to the right in Fig. 4). On 27 June, one 4-week-old chick was observed in the nest. The chick was observed fledging from the nest between 5 and 10 August (Ingvar Støyle Bringsvor pers. comm.).

Reproduction. The average reproductive rate in the period 1992–2019 for all TOV monitoring areas was 0.41 (95% CI: 0.35-0.46) chicks older than 50 days per territory

Figure 10. *Nest site with a protecting overhang and a bush in Møre & Romsdal. Photo: Jan Ove Gjershaug.*

Figure 11*. A nest with a protecting tree in front in Finnmark. Photo: Karl-Otto Jacobsen.*

Figure 12. *A very rare case of a brood of 3 Golden Eagle chicks ca 50 days old in Møre & Romsdal. Photo: Jan Ove Gjershaug.*

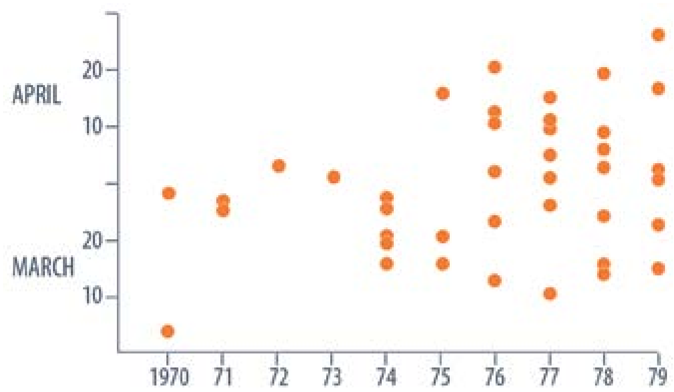

Figure 13. Egg-laying dates in Møre & Romsdal, 1970–1979 (from Gjershaug 1981).

(including territories without breeding attempts) (Fig. 1 in Tovmo et al. 2019).

In 2 of the TOV monitoring areas, Børgefjell and Lund (Fig. 14), both areas show a decreasing production trend, and both have a similar mean reproductive rate (0.50, SD = +- 0.30 and 0.52, SD = +- 0.19) for the period 1992–2019 (Fig. 14). However, the Børgefjell area shows a greater between-year fluctuation, resulting in the negative trend being significant only for Lund (Lund: $R = -0.58$, $P = 0.001$, n = 28; Børgefjell: $R = -0.22$, $P = 0.27$, n = 28).

Børgefjell is located in mountain habitat with cold winters, fluctuating onsets of spring, and unpredictable weather conditions, while Lund is located in southern Norway and includes more lowland forested habitat with a generally milder climate and more stable weather conditions during the breeding period. The areas are also likely to differ in the between-year variation in prey availability, with more pronounced 3–4 year cyclic fluctuations in rodents and small game (ptarmigan *Lagopus* sp. and mountain hare *Lepus timidus*).

There is great variation in reproductive rates among pairs within the same area. Using data from territories with 25–30 years of data for Børgefjell, the best performing territories produced on average 0.75 nestlings/year while the poorest produced on average 0.20 chicks (Fig. 15). Large differences in reproductive rate between territories are typical for many raptor species (Newton 1979) and are probably caused by differences in the quality of the territories or of individual birds (Gjershaug et al. 2018).

In Lund, ca 45% of Golden Eagle territories produced chicks each year, while only about 20% of territories in Åmotsdalen produced chicks each year (Fig. 16). There was a negative correlation between proportion of successful territories and the frequency of 2-chick clutches (Fig. 17). The reason for this may be variation in prey availability. The mountainous Åmotsdalen and Børgefjell areas seem to have greater variation in prey availability between years than areas at lower elevations in the south (Solhomfjell and Lund on Fig. 1). Simply stated, in Børgefjell the eagles do not reproduce very often, but they produce a higher number of chicks when the prey conditions are good.

A significant correlation was found between productivity of Golden Eagles and the density of Willow Ptarmigan (*Lagopus lagopus*) in the previous autumn in Børgefjell in the period 1991–1999 ($R = 0.69$, n = 9, $F = 6.25$, $P = 0.04$). This is in contrast to the results in Finnmark below, where the correlation was best with the ptarmigan density in the same year.

The populations of mountain hare were high in Norway in the 1980s and the total number of hares shot peaked in 1990, but since then the annual bag has declined (Pedersen and Pedersen 2012). However, there are local variations in this trend.

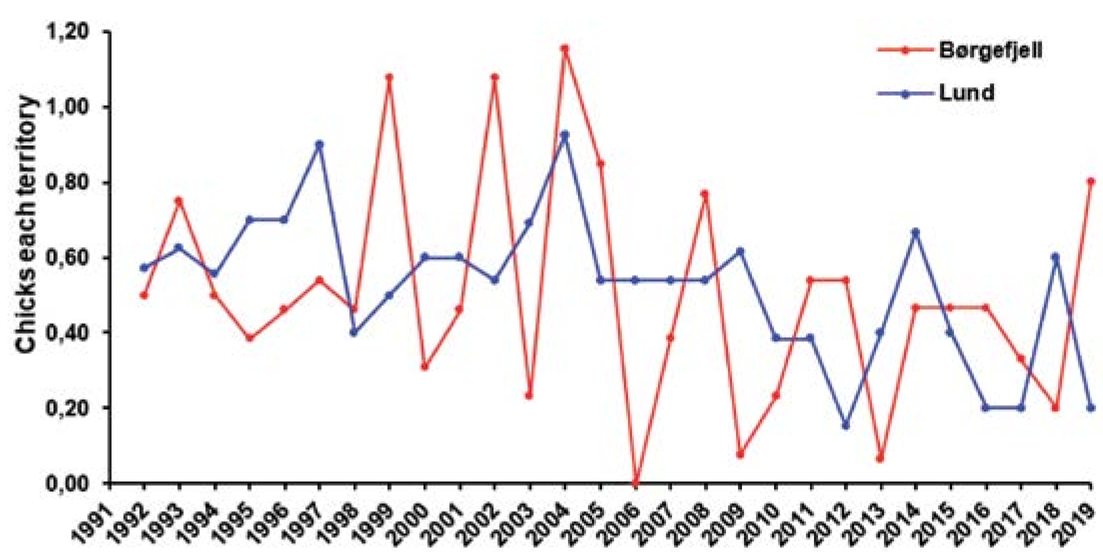

Figure 14. Reproductive rates (number of nestlings >50 days/ territory) for 2 of the TOV intensive study areas, Børgefjell and Lund (see Fig. 1).

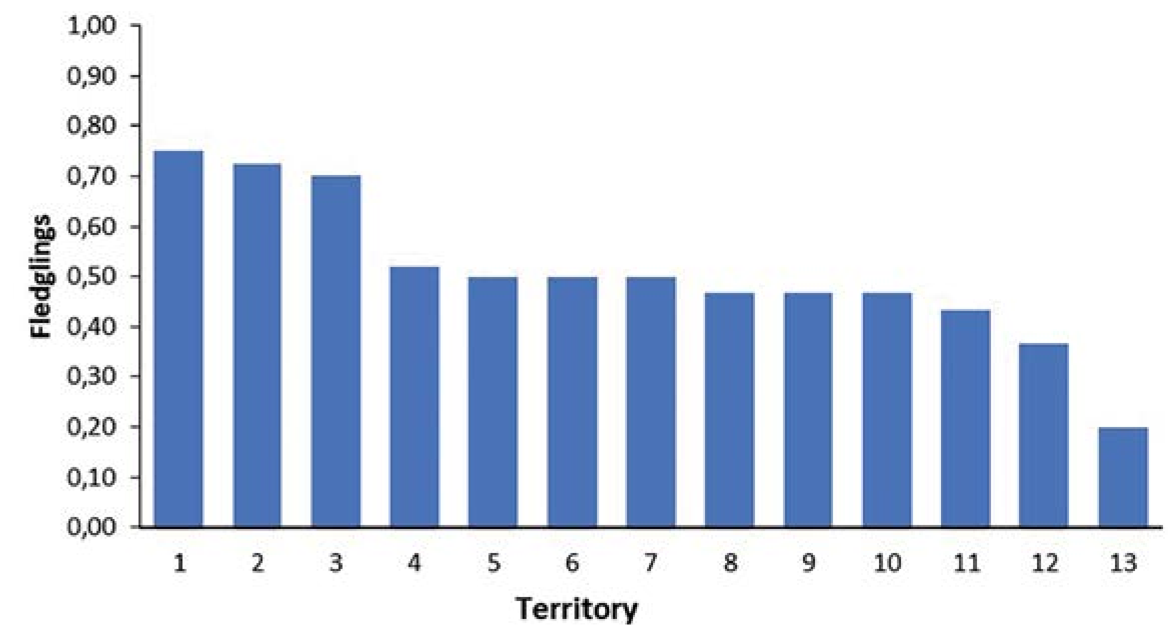

Figure 15. Variation in reproductive rates (average number of chicks reaching 50 days of age) for 13 territories in the Børgefjell study area from 1990–2019. Included are only those territories with 25–30 years of data.

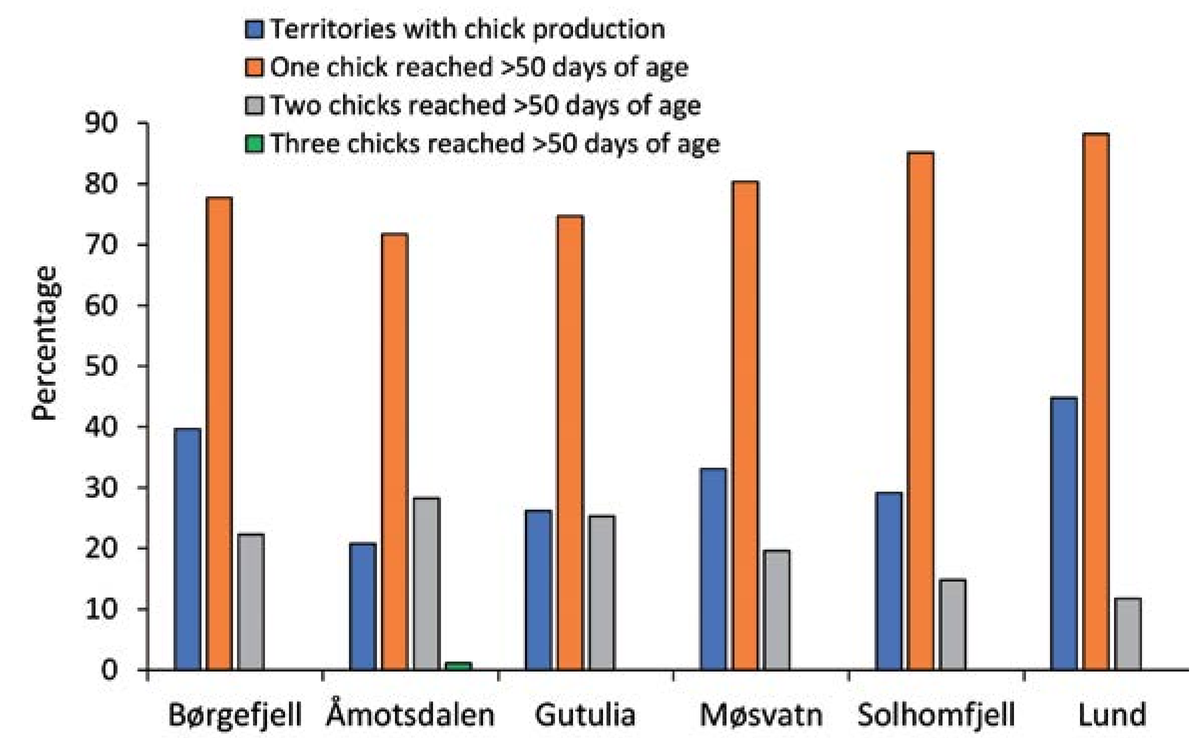

Figure 16. Proportion of territories in the 6 TOV monitoring areas that produced 1, 2, or 3 chicks.

In the interior parts of Finnmark, there was a significant correlation between the productivity (chicks/occupied territory) of Golden Eagles and the density (individuals/km^2) of Willow Ptarmigan in the same year from 2004–2019 (Z = 2,403, P = 0.01). There was no significant correlation with Willow Ptarmigan density in the previous year. Adding the lemming (*Lemmus lemmus*) abundance index in the previous year also gave a significant correlation (Z = 2,701, P = 0.007; Fig. 18). High lemming populations can result in high ptarmigan populations according to the alternative predation hypothesis (Hagen 1952).

Lemmings and other small rodents are probably more important prey for Golden Eagles than traditional diet studies indicate based on prey remains in the nest. This was shown by a video monitoring study by Skouen (2012) where small rodents were swallowed whole and thus left no remains

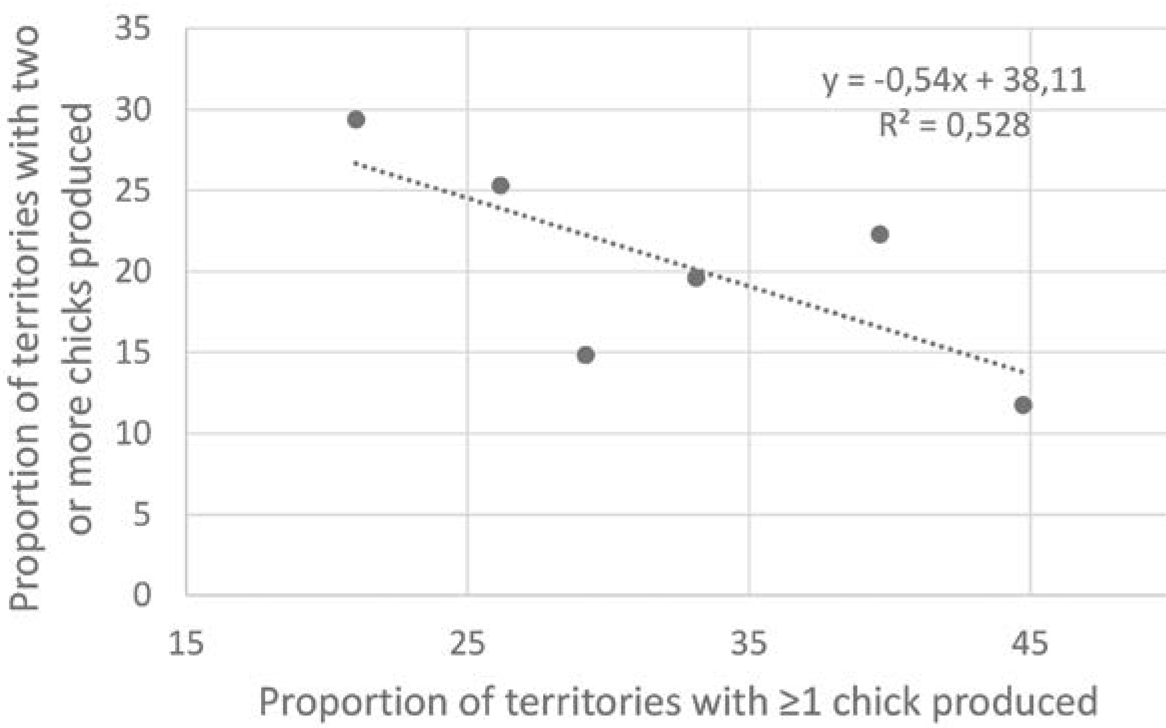

Figure 17. The relationship between frequency of nests with 2 chicks and annual proportion of nest producing chicks.

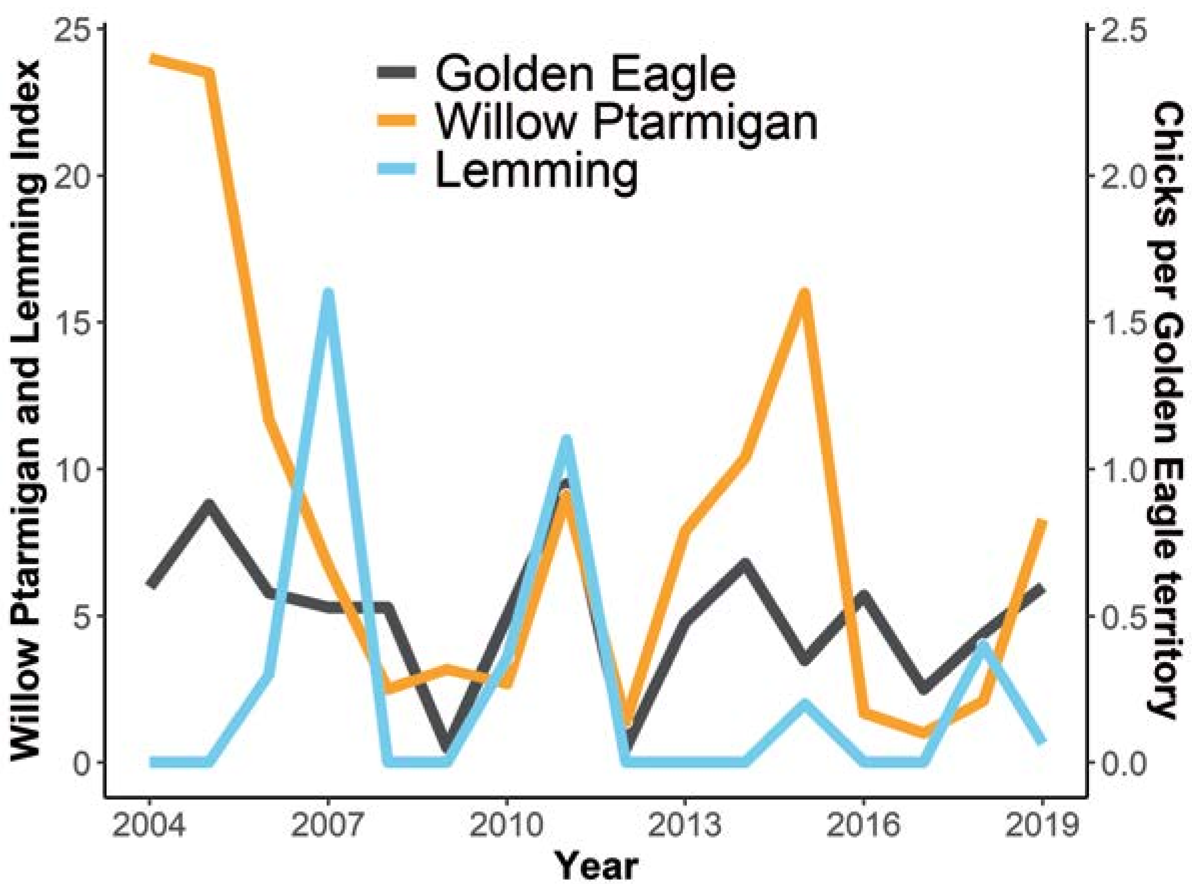

Figure 18. The relationship between Willow Ptarmigan density (individuals/km²), lemming abundance (number/100 trap nights), and mean productivity of Golden Eagles (chicks >40 days old per occupied territory) in the study areas in interior Finnmark, 2004-2019. Ptarmigan data from Nilsen et al. 2020, and lemming data from Soininen et al. 2019.

(except in the pellets). In the peak lemming and small rodent year of 2014 in Oppland county, the Golden Eagle had very high productivity, with 0.75 fledglings per territory. At 4 of these nests, chicks were fed mostly small rodents (probably mostly lemmings) indicated by the absence of prey remnants in the nests. At another nest, 5 prey deliveries were observed in 3.5 hr, indicating effective hunting (Dunker 2015). Lindell (2007) observed a Golden Eagle walking on the ground hunting small rodents in Sweden. In the lemming peak year 1969, many lemming remains were found on a Golden Eagle nest in Sykkylven, Møre & Romsdal (A. O. Folkestad pers. com.).

Breeding success, brood size, and productivity in Golden Eagles in Møre & Romsdal in 1970–1990 is shown in Table 1. The mean productivity in this period was 0.58 young per occupied territory (Gjershaug 1996). There was a significantly higher breeding success and productivity 1 year after a small rodent year compared with other years (X^2 = 4.6, df = 1, P = <0.05). A multiple regression analysis and Spearman rank correlation tests was carried out for weather variables (temperature and precipitation in different periods) but no significant relations were found. Likewise no significant correlation was found between an index of ptarmigan density and productivity of the Golden Eagle (Gjershaug 1996).

Some studies in Fennoscandia have found significant positive correlations between indices of prey density and Golden Eagle productivity. Nyström et al. (2006) found such a relationship between the ptarmigan density index (droppings/km) and percent of Golden Eagle territories with breeding pairs, and Tjernberg (1983) found a significant positive correlation between total hunting bag of mountain hares plus gallinaceous birds versus the proportion of Golden Eagle pairs successfully breeding. Lack of such positive correlations may be caused by inaccurate indices for the prey species, or the effects of peak rodent years as in the study of Tjernberg (1983) and Jacobsen et al. (2016). Adverse spring weather can also be the reason for low breeding success even in years with high densities of prey. There are several cases known where the eagles have interrupted breeding after storms with heavy snowfall in the spring (Gjershaug unpubl. data).

Table 1. Breeding success, brood size, and productivity for Golden Eagles in Møre & Romsdal, 1970–1990 (number of territories in parentheses) (after Gjershaug 1996).

Year	Percent occupied territories with successful breeding	Number of chicks per successful breeding	Number of chicks per occupied territory
1970	100 (4)	1.8 (4)	1.8
1971	50 (2)	1.5 (2)	0.8
1972	33 (6)	1.5 (2)	0.5
1973	33 (3)	2.0 (2)	0.7
1974	39 (13)	1.4 (5)	0.5
1975	25 (12)	1.3 (3)	0.3
1976	50 (12)	1.2 (6)	0.6
1977	58 (12)	1.1 (7)	0.7
1978	50 (14)	1.3 (7)	0.6
1979	83 (6)	1.2 (5)	1.0
1980	75 (4)	1.0 (3)	0.8
1981	75 (4)	1.3 (3)	1.0
1982	80 (5)	1.5 (4)	1.2
1983	50 (4)	1.0 (2)	0.5
1984	20 (5)	1.0 (1)	0.2
1985	56 (9)	1.4 (5)	0.8
1986	43 (7)	1.0 (3)	0.4
1987	0 (6)	0 (0)	0
1988	43 (7)	1.3 (3)	0.6
1989	71 (7)	1.0 (5)	0.7
1990	0 (12)	0 (0)	0
1970-1990	46 (156)	1.28 (71)	0.58

DISPERSAL, MIGRATION, AND WINTERING AREAS

Adult Golden Eagles in Norway are commonly sedentary and stay in their territory throughout the year, whereas young birds disperse. The mean distance from the ringing site (nest) to the recovery site for 50 fledgling Golden Eagles in Norway was 213 km, while for 5 individuals ringed at an older age, the mean distance was 107 km (Bakken et al. 2003).

During 2002–2012, 25 fledgling Golden Eagles were satellite-tagged in Finnmark, northern Norway, 69–70°N. After having dispersed permanently from the natal area by the median day of October 21, the general direction of movement was southerly, mainly south through Sweden. However, some birds visited all neighboring countries including Sweden, Finland, and Russia (Nygård et al. 2016). The general pattern was to move to a more southerly location during autumn, stay in the south for the winter, then return in the opposite direction during spring (Fig. 19) until they reached their natal area. This pattern was repeated in the following years while they were sub-adults. The median maximum distance from the natal site during their first year of life (1 calendar year, 1cy) was ca 300 km but there were large variations. The longest movement recorded was 1500 km; a male that moved from Finnmark (ca 70°N) to the southernmost tip of Sweden (56°N) in its first winter. On the other hand, 1 bird stayed in Finnmark during the first winter without dispersing. Often the spring movement resulted in an "overshoot" (i.e., travel to a position north of the natal site). At the return migration, the median nearest straight distance from the nest where they were hatched (12 bird-years) was 10 km for males, and 88 km for females. The average rate of movement during migration was 15 km/day during autumn and 20–30 km/day during spring. The peak of movement was between 12:00–14:00 H.

Some birds, mainly those hatched in the coastal areas, stayed on the north Norwegian coast for a prolonged period compared to the inland birds. One male used the same wintering area in central Sweden during 5 consecutive winters (Nygård et al. 2016).

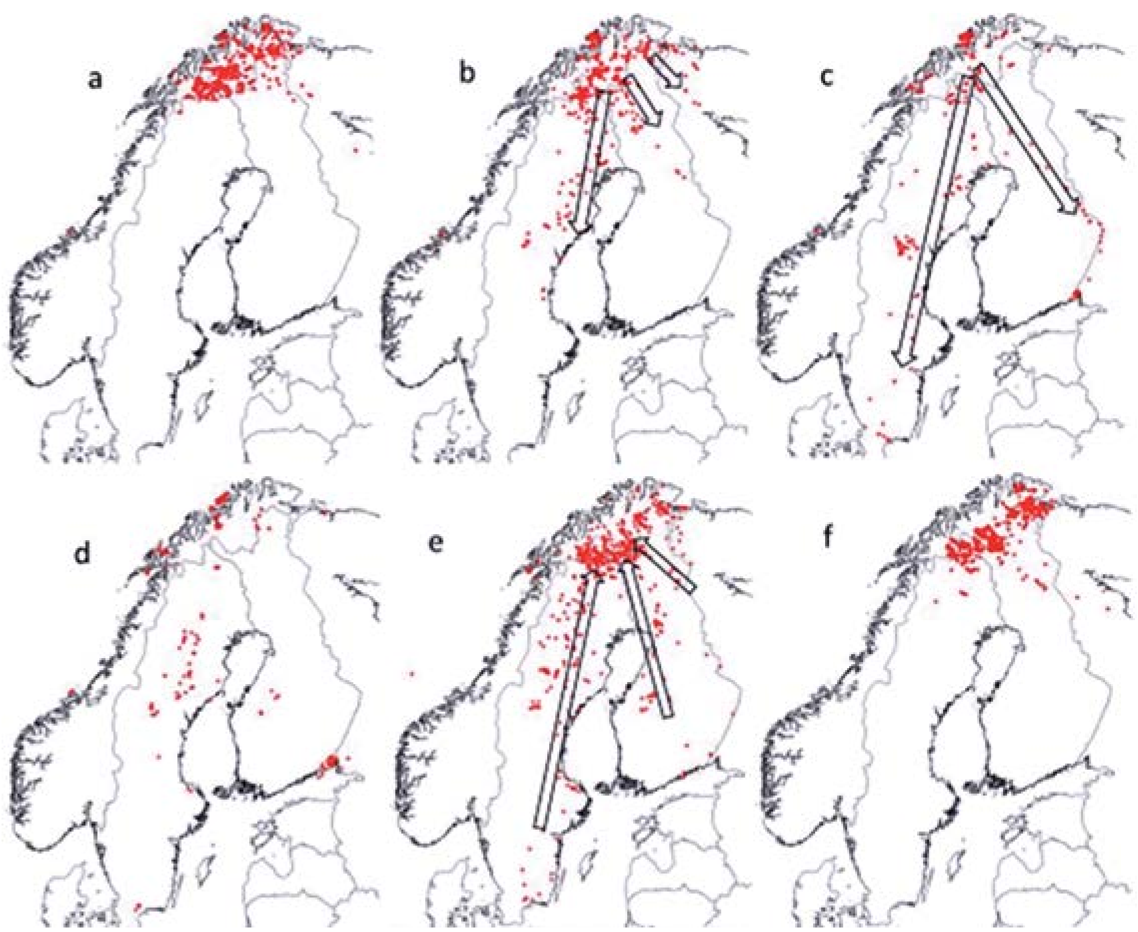

Figure 19. The movement of satellite-tagged juvenile Golden Eagles from Finnmark, northern Norway, 2002–2012. a = July–August, b = September–October, c = November–December, d = January–February, e = March–April, f = May–June. Each dot represents 1 position/bird/day (n = 25 individuals, 1–7cy). The relative lack of positions during winter (c, d) is due to low light conditions resulting in poor charging of the solar-powered transmitters.

Figure 20. Three GPS transmitters from young Golden Eagles found in the field in northern Sweden where human persecution was implicated. The teflon ribbons were cut off with a sharp object. The transmitter to the left was found together with remains of the bird on a municipal sewage-dump. Photo: Torgeir Nygård.

SURVIVAL AND MORTALITY

The fate of 25 satellite-tagged juveniles from Finnmark made it possible to calculate 1cy and 2cy survival. The overall survival rate during 1cy was estimated at 0.58 ± 11 SE, while 0.50 ± 11 SE were estimated to be alive by the end of 2cy (Nygård et al. 2016). Survival of birds hatched at inland nests was higher than for birds hatched in coastal areas. Of 11 birds where cause of death was determined with reasonable certainty, 3 were killed by humans (illegal persecution, Fig. 20), 3 were natural deaths away from the nest (possibly due to starvation), 3 were found close to the nest (possibly due to starvation), 1 was found under a power-line (electrocution, collision?), and 1 probably died as a result of conspecific aggression. In addition, signals from 2 transmitters indicated that the birds were dead, but in remote and inaccessible areas (Russia and Finland). Ten radios quit without any indication of cause (Nygård et al. 2016).

As part of an intensive monitoring program across Norway, adult Golden Eagle survival was closely studied in Finnmarksvidda, northern Norway (see Fig. 1), for 8 years. Individuals were identified through genetic analyses of moulted feathers (adults) and samples (blood or pulled feathers) from nestlings (cf. Gjershaug et al. 2018). Applying capture-mark-recapture methods, adult annual survival was estimated at 0.92 (95% CI = 0.87–0.96; Tovmo et al. 2019). There was no evidence for age- or sex-dependent effects on adult annual survival (Tovmo et al. 2019). These estimates of adult annual survival (0.91–0.98) fall within the range of estimates reported from other populations of the Golden Eagle (Watson 2010).

DIET

The Golden Eagle is both a predator and a scavenger and is considered a food generalist, feeding on a wide range of prey. The prey species of the Golden Eagle vary greatly between areas and years and are influenced by availability. Based on prey remains from nests in Norway, the most common prey species are Rock Ptarmigan (*Lagopus muta*), Willow Ptarmigan, other forest grouse species, mountain hare, rodents, semi-domestic reindeer (*Rangifer tarandus*), and domestic sheep (*Ovis aries*). In 6 studies in different parts of Norway, the proportion of mammals among the prey items varied from 28–56% (Table 2). Mountain hare was the most common mammalian prey (13% to 30%). It is often impossible to determine whether the remains of reindeer and sheep in the nest are killed or scavenged by the eagle, but it is well documented that the eagle can kill these animals, especially small calves and lambs.

The 2 species of ptarmigan are the most common birds taken by the Golden Eagle, with 20–51% of the total prey numbers (Table 2). Ptarmigan biomass was 22% compared with 47% based on numbers (Gjershaug 1981). Mountain hare and ptarmigan together contribute 83% of the prey biomass when sheep and reindeer are excluded. When excluding reindeer and sheep, the biomass of mountain hare, for an area in Møre & Romsdal, was estimated to be 61% compared to 22% based on numbers (Gjershaug 1981).

Analysis of stable isotopes in plucked feathers from 9 Golden Eagle nestlings from different nests in a semi-domestic reindeer grazing area in Finnmark revealed considerable variation in prey consumption between years. Willow Ptarmigan dominated the diet with 68% in 2004 and 75% in 2005, but only 28% in 2006. Mountain hare was 13% in 2004, 15% in 2005, and 51% in 2006, while reindeer remained relatively stable as a food source with 11% in 2004, 8% in 2005, and 7% in 2006 (Halley et al. 2007).

In a study based on video monitoring of prey deliveries at 1 nest in Oppland county during the 10-week nestling period, mountain hare was the most important prey (67%), while thrushes (*Turdus* sp.) and Willow Ptarmigan accounted for 7% and 20% of total delivered biomass respectively. Only 1 small rodent was delivered at the nest (Nygård 2015).

In another study based on video monitoring at a nest in Telemark county in the peak rodent year of 2011, the most important prey type was Willow Ptarmigan, both by numbers (34%) and by biomass (35%). Mountain hare and red fox (*Vulpes vulpes*) made up 7% and 3% respectively by numbers, and 33% and 14% respectively by biomass. Thrushes (24%), *Microtus* voles (11%), and lemmings (9%) were also important numerically as prey. No ungulates were observed delivered at this nest (Skouen 2012).

Based on prey remains in Golden Eagle nests, small rodents normally represent a very small proportion of the remains (Table 2). In a sample of 90 pellets from nests in Møre & Romsdal county, 19% of the pellets contained small rodents. There was a clear relationship between the proportion of small rodents in the pellets and the population index for small rodents (Gjershaug 1981).

Nestling thrushes may be important prey for the Golden Eagle. Nestlings leave few remains even in eagle pellets as they are swallowed whole. Gjershaug (1981) found 2 nests of Fieldfare (*Turdus pilaris*) in Golden Eagle nests with the nestlings still in them and several empty nests of the same species.

Table 2. The diet of the Golden Eagle in different areas in Norway during the breeding season based upon prey numbers.

Species, Latin name	Hagen 1952	Haftorn 1958	Gjershaug 1981	Fremming 1982	Pfaff 1993	Johnsen et al. 2007
	%	%	%	%	%	%
Mountain hare, *Lepus timidus*	29	30	19	15	30	13
Reindeer, *Rangifer tarandus*	5	11	1		2	9
Sheep, *Ovis aries*	8	5	7	9	6	
Roe deer, *Capreolus capreolus*					2	
Carnivores (mammalian)	9	5	2	3	4	3
Small rodents, Cricetidae	2		1	10		2
Other mammals	4			1	1	
Total mammals (%)	**56**	**51**	**30**	**38**	**45**	**27**
Ptarmigan, *Lagopus* spp.	27	27	40	37	20	51
Other gallinaceous birds, Galliformes	13	9	3	13	29	3
Waterfowl, Anatidae	2			1	3	9
Hawks and buzzards, Accipitridae			1		1	1
Falcons, Falconidae	1		3	1	1	1
Owls, Strigidae				1		
Other birds	2	13	13	9	2	8
Total birds (%)	**44**	**49**	**70**	**62**	**55**	**73**
Total prey	**136**	**56**	**162**	**161**	**154**	**469**

There was a marked difference in prey in the 3 areas in Finnmark (Fig. 21). Mountain hare was the main prey at the coastal area with 64% of the prey numbers brought to the nests, while this category was only 13% at interior localities. The density of hares was very high on the coastal islands and much lower in inland areas. Gallinaceous birds (mostly ptarmigan) were the most common prey in the inland areas (54% of prey). Reindeer was the most common prey in valley-and-fjord areas, where there are calving areas (15% of prey; Fig. 22).

Winter diet of Golden Eagles is much less studied, but it is believed that carrion is an important food resource, especially for young eagles (Gjershaug et al. 2019).

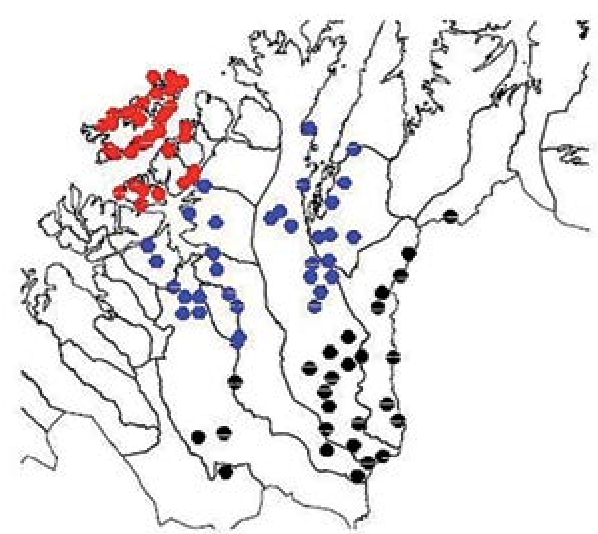

Figure 21. *Distribution of Golden Eagle territories in 3 areas: Interior (black), Fjord/valley (blue), and Coastal (red) (after Jacobsen et al. 2012).*

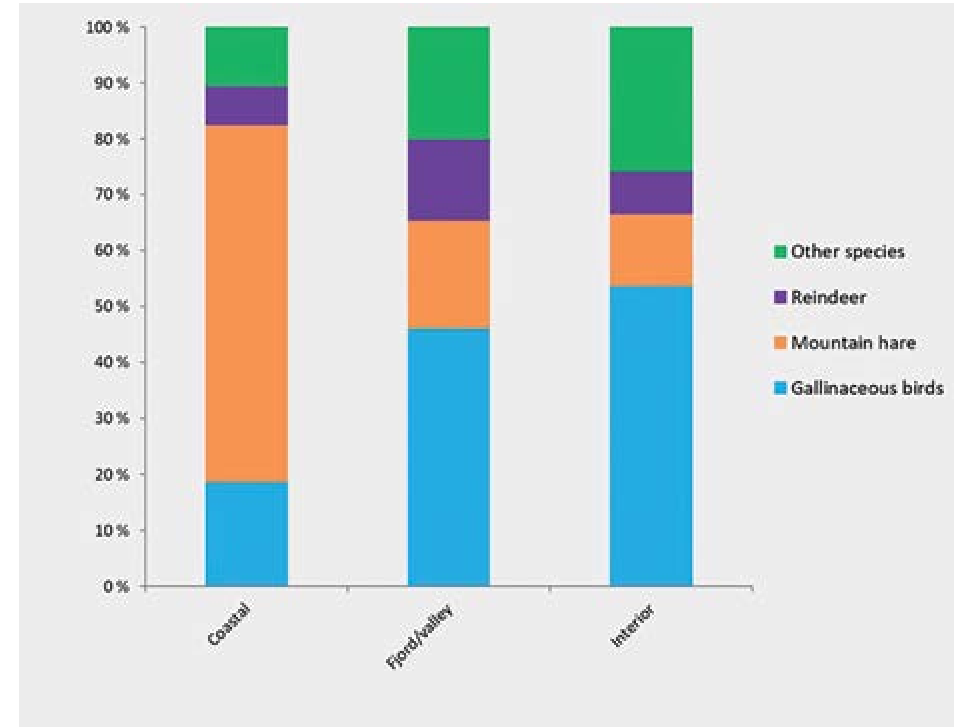

Figure 22. *The relative percentage of 644 prey collected in Golden Eagle nests in the 3 areas in Finnmark (Fig. 21), divided by groups (after Jacobsen et al. 2012).*

GOLDEN EAGLES AND PREDATION ON SHEEP AND REINDEER

The Golden Eagle can be a predator on both sheep and semi-domestic reindeer. Eagles primarily kill lambs and calves (Fig. 23), but they are also capable of killing adult reindeer up to 60–70 kg (Nybakk et al. 1999). Data from examination of reindeer carcasses in Norway reveal that 90% of the reindeer killed by Golden Eagles were calves, and the majority were killed in May during the calving season (Mattisson et al. 2018).

Reindeer remains in Golden Eagle nests made up 0.6–10.7% of the prey remains by number in 5 Norwegian studies. Sheep (mostly lambs) made up 5.4–8.7% of the diet by number (Table 2).

There have been several studies in Finland and Norway, were reindeer calves have been equipped with mortality sensors. The proportion of reindeer calves killed by Golden Eagles varied between 0–4.4% (Nybakk et al. 1999, Norberg et al. 2005, Norberg et al. 2006, Nieminen et al. 2011). At most, Golden Eagles were responsible for 43% of the total mortality (Nieminen et al. 2011). All these studies show that the calves killed by Golden Eagles were smaller and lighter than the calves that survived, especially in areas with high densities of reindeer. In the Norwegian study from Trøndelag in 1995–1996, it was found that 1.4% of 853 semi-domestic reindeer equipped with radio transmitters were killed by Golden Eagles, 9 calves and 3 adults (Nybakk et al. 1999). The winter of 1995/1996 was rich in snow and had a low availability of other prey species. The late summer weight of reindeer calves was 2.7 kg lower than normal for this area in 1996 (Nybakk et al. 1999).

Figure 23. *Reindeer calf eaten by Golden Eagles. Photo: Jan Ove Gjershaug.*

Warren et al. (2001) found that Golden Eagles killed about 2% of the total number of sheep (mostly lambs) on pastures in some areas in northern Norway (Troms). As Norway has a compensation system for livestock killed by protected large carnivores, including the Golden Eagle, all data on claimed losses are gathered in the central database for predator management (Rovbase, Norwegian Environment

Agency). In the period 2001–2011, the database contained data on 47,741 sheep (45,635 lambs and 2,106 ewes) that were claimed killed by Golden Eagles. Of these only 861 lambs and 56 ewes carcasses were found and documented as being Golden Eagle killed. Most of the predation occurred in June and July (Mabille et al. 2015, Warren et al. 2001). Sheep with small lambs are normally released onto their free-range grazing areas in the mountains in late May and early June.

There are no positive correlations between the frequency of lamb kills, eagle density, and sheep density in Norway (Fig. 24).

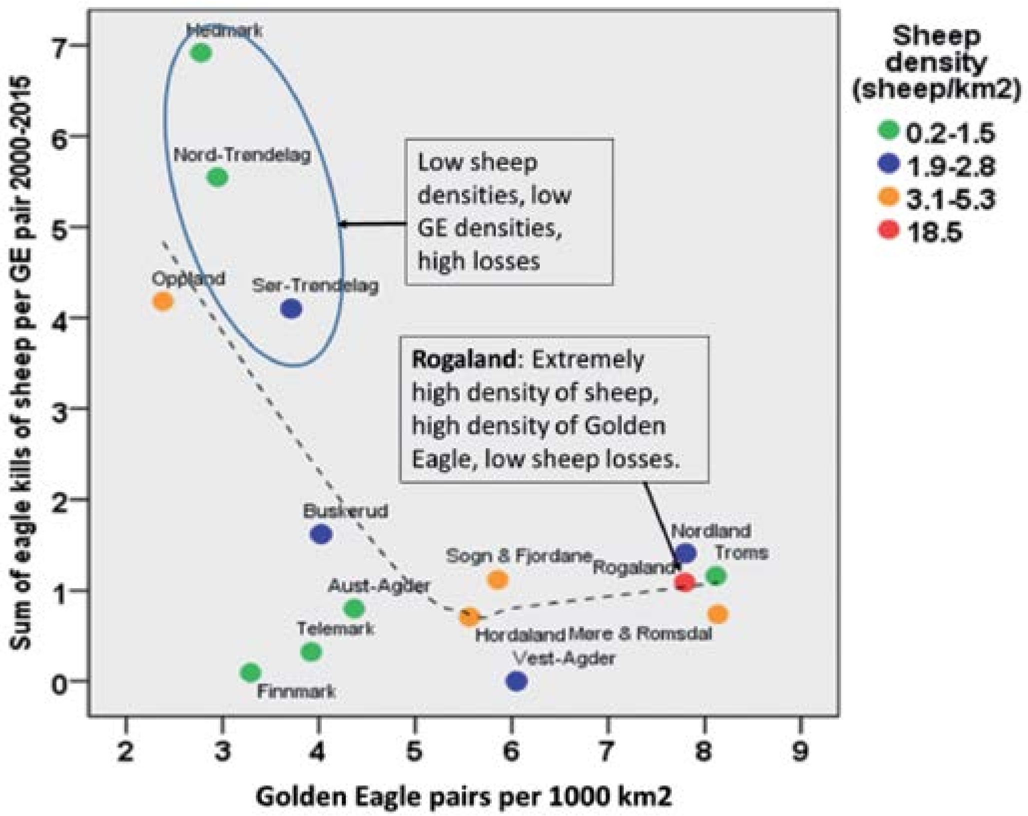

Figure 24. *The relationship between Golden Eagle densities, sheep densities, and sheep losses due to predation by Golden Eagles in different Norwegian counties.*

INTRASPECIFIC COMPETITION

Halley and Gjershaug (1998) found that younger Golden Eagles tend to dominate older conspecifics at carcasses during the winter. In a new study, the data were reanalyzed using all observed conflicts including those between the same birds that were not statistically independent (Gjershaug et al. 2019). Of 82 observations of young Golden Eagles at carcasses, 48 involved conflicts between different young eagles, while the remaining 34 cases did not result in any conflicts. Adult Golden Eagles were involved in antagonistic interactions with younger birds (7 of 35 bouts) less often than young birds with other young birds (48 of 82, $P < 0.001$). Relative hunger of each bird involved in the conflict may influence the results above. Individuals that have been at the carcass for a long time seem to lose some of their motivation to defend it as they become satiated.

The juvenile Golden Eagle is the only *Aquila* eagle that is both dependent upon carcasses and that normally does not tolerate other large raptors at carcasses. At the same time, the juvenile Golden Eagle is also the *Aquila* with the most conspicuous plumage compared to adult plumage. The contrasting dark and white plumage in juvenile and immature Golden Eagles may therefore be a product of natural selection in which young eagles that are best able to advertise their higher motivation to gain or retain access to a carcass receive a competitive advantage.

INTERSPECIFIC COMPETITION

The Golden Eagle occurs sympatrically with the White-tailed Sea-eagle in Norway. There is very little overlap in diet in the breeding season, as the Golden Eagle eats mostly mammals and terrestrial birds, while the White-tailed Sea-eagle eats mostly fish and seabirds. However, where White-tailed Sea-eagles nest in inland areas, there often is overlap in the use of carcasses (Gjershaug unpubl. data). During the winter, carcasses of large mammals are more important for both species. The Golden Eagle is the dominant species at carcasses (Halley and Gjershaug 1998, Gjershaug et al. 2019), but it is sometimes outnumbered by the more social White-tailed Sea-eagle.

The competition for nest sites between the 2 species is low, but sometimes they use nests built by the other species. In areas where both species breed, the Golden Eagle prefers nests in cliffs while the White-tailed Sea-eagle prefers nests in trees. The Golden Eagle prefers to nest higher up in terrain with shorter distances to elevated hunting areas, while the White-tailed Sea-eagle in Norway more often nests closer to the sea, which is their hunting area. Sometimes the 2 species breed successfully when very close to each other; distances of only 200 and 134 m between nests with successful breeding is known. In 1 case, the Golden Eagle pair abandoned their nest site when a White-tailed Sea-eagle pair established themselves ca 200 m from the Golden Eagle nest. The male White-tailed Sea-eagle was very aggressive toward Golden Eagles (Alv Ottar Folkestad pers. comm.).

Once, a White-tailed Sea-eagle killed a Golden Eagle chick at the nest when the parents were away (Ingar Støyle Bringsvor pers. comm.). It is also known that White-tailed Sea-eagles have disturbed incubating Golden Eagles, and in 1 case this was probably the reason for unsuccessful breeding (Alv Ottar Folkestad pers. comm.).

A "natural experiment," the recolonization by Golden Eagles of the Dovrefjell area in central Norway after the protection of eagles in 1968, resulted in the systematic abandonment of Rough-legged Buzzard breeding sites as the number of Golden Eagle pairs increased (Fig. 25). The evidence is only circumstantial; the mechanism could be competition for food, competition for nest sites, or predation by the Golden Eagle. As the diet overlap between the 2 species is small and the competition for nest sites does not seem to be likely, the most likely explanation is the threat by the much larger Golden Eagle; Golden Eagles are known to take Rough-legged Buzzard chicks from their nests (Gjershaug 1981). There was a significantly higher proportion of non-occupied Rough-legged Buzzard nests inside Golden Eagle territories than outside (Gjershaug et al. 2010).

The shortest recorded distances from occupied nests of Golden Eagles to occupied nests of potential competitors in western Norway were 0.5 km for Common Ravens (*Corvus corax*), 5.5 km for Gyrfalcons (*Falco rusticolus*), and 4 km for Rough-legged Buzzards (Bergo 1987).

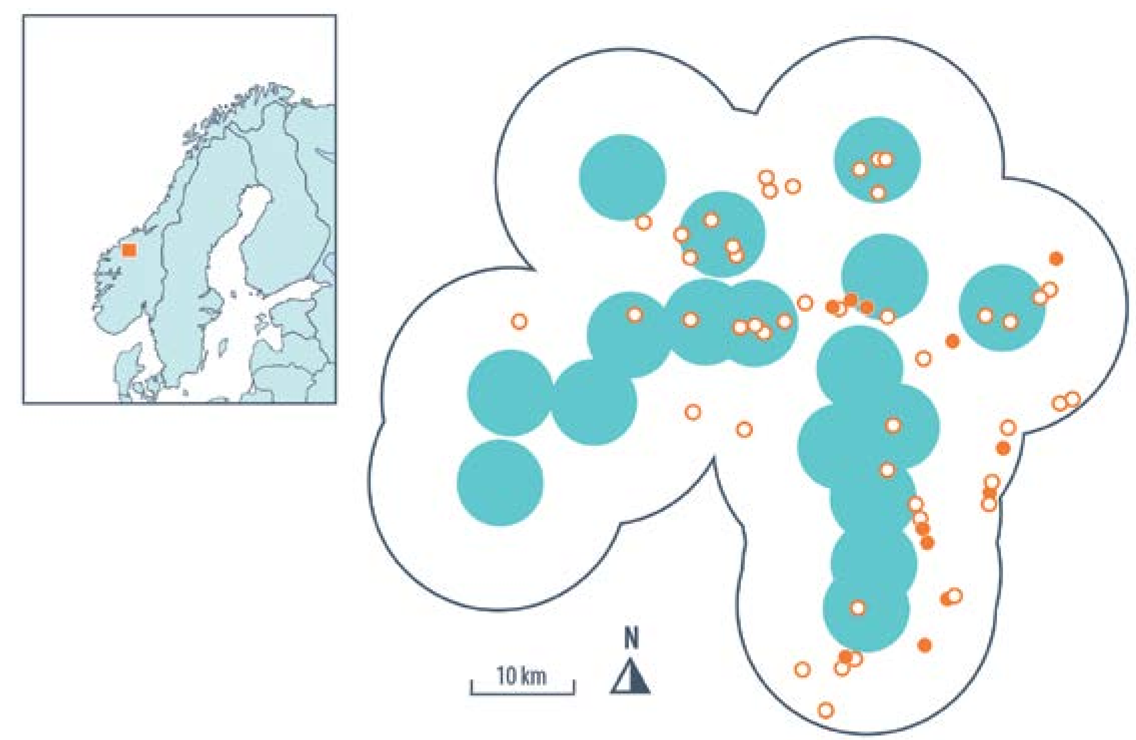

Figure 25. *Distribution of Rough-legged Buzzard nests in relation to nesting areas for Golden Eagles. Open circles: unoccupied Rough-legged Buzzard nests; solid circles: occupied Rough-legged Buzzard nests; blue dots: Golden Eagle territories (after Gjershaug et al. 2010).*

THREATS

Environmental pollution. As a top predator, the Golden Eagle is exposed to environmental pollutants that accumulate in the food chain. The pollutants found in the highest concentrations in Golden Eagle eggs in Norway are mercury (Hg) and organochlorines, such as DDTs, PCBs, and chlordanes (Nygård and Polder 2012). Lead deposited in carcasses and gut piles from big game animals shot with lead ammunition was recently identified as a major health risk for scavengers (Bedrosian et al. 2012, Hampton et al. 2018, Krone 2018). In Sweden, where hunting for large ungulates such as moose (*Alces alces*) is very similar to Norway, 8.3% of 44 dead Golden Eagles examined by the Swedish Veterinary Institute (SVA) showed above lethal levels of lead poisoning (Axelsson 2009). In a study by the Norwegian Veterinary Institute, lead was found in livers of 116 dead Golden Eagles found in Norway from 1973–2014. The lead level in livers of 6.9% of the eagles was classified as lethal (>15 mg/kg; Madslien et al. 2015). Thus, lead is a serious threat to Golden Eagles in Norway.

Langford et al. (2013) found potential lethal doses (>100 ng/g) of second-generation anticoagulant rodenticides (SCARs) in 30% of 16 dead Golden Eagles in Norway. It was not possible to conclude the cause of death, but it is likely that SGAR poisoning was responsible for the death of some individuals.

There are indications that the Golden Eagle is more sensitive to organic pollutants than most species of raptors. The coastal sites in western Norway had lower annual reproductive output than inland sites, and the eggs had a higher content of organochlorine compounds. There were relatively strong negative correlations between reproductive output, egg shell thickness, and DDE concentration in eggs. It is proposed that the higher organochlorine levels in the eggs of coastal eagles was caused by marine birds in the diet, as

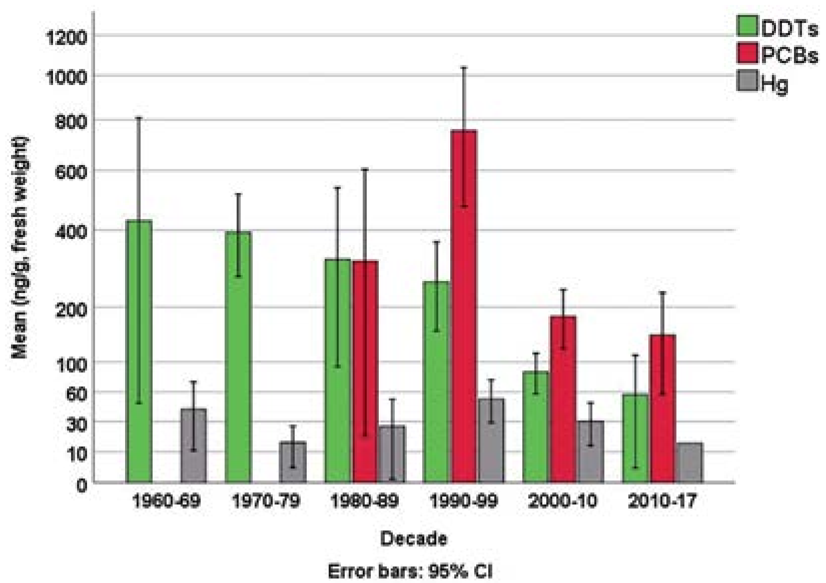

Figure 26. *Levels of DDT, PCBs, and mercury in Golden Eagle eggs in Norway since the 1960s.*

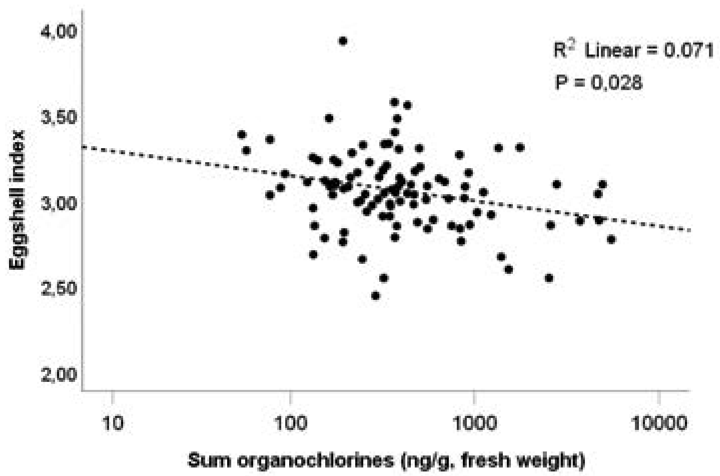

Figure 27. *The relationship between the eggshell index in Golden Eagle eggs from Norway and the combined concentration of all organohalogen pollutants in these eggs.*

opposed to inland eagles which have a prey base consisting almost entirely of terrestrial herbivores such as ptarmigan and mountain hares (Nygård and Gjershaug 2001).

DDT has long been known to cause eggshell thinning in birds of prey (Ratcliffe 1970). DDT was banned as an insecticide for general use in Norway in 1970. Since then, DDT levels have been reduced by ca 80% in eagle eggs (Fig. 26). PCBs were banned in 1980; PCB in eggs peaked in the 1990s and have since declined, but it is still today the pollutant that has the highest concentration. Mercury in eggs has been stable throughout the period. Other pollutants found at low levels in the eggs are HCB, HCHs, chlordanes, Mirex, PBDEs, and PFCs. Polyfluorinated carbon compounds (PFCs) are a new group of flame retardants of environmental concern that are replacing PCBs and PBDEs worldwide. The relation between DDT and the eggshell index (a measure of eggshell quality) was not significant in our sample of eggs, but when all organohalogen pollutants were combined (chlorinated, brominated, and fluorinated), a significant negative relationship was found (Fig. 27). This indicates that organochlorines and other organic pollutants still may play a negative role for the reproduction and health of the Golden Eagle in Norway.

Human Disturbance. The Golden Eagle is sensitive to disturbance during the incubation period. Fremming (1980) found more unsuccessful nesting in years with an early Easter holiday, which could have been caused by ski tourists in the nesting areas around the time of egg laying, a time when the eagles most readily abandon their nests. Also other recreation activities like hiking, ice- and rock-climbing, and paragliding have possibly caused nesting failure in Norway.

Electrocution and Collision. Raptors such as the Golden Eagle are especially vulnerable to collisions with wind turbines and powerlines (Bevanger 2011). Three Golden Eagles have been found killed by turbines at the Smøla windfarm in western Norway from 2006–2019 (unpubl. data). Several Golden Eagles have been found killed by powerlines in Norway, but the extent of the problem is little known (Bevanger and Overskaug 1998).

Of the recorded causes of death of Golden Eagles in Norway from1987–2013, collision with trains was the most important factor with 63 cases (24%; Fig. 28). The number of such death increased during this period (Spearman corr, R = 0.658, p <0.001), but it is unknown if this was caused by more collisions or increased reporting. A probable explanation is the increase of ungulate populations in Norway during this period. Collisions with cars (6%) were less common, with 15 cases (6%). Of other registered death causes, 11 cases (4%) were illegal hunting and 4 cases (1.5%) of selective culling of eagles having killed livestock (by license, or as emergency prevention where there was an imminent danger for eagle attack on livestock). Most of the eagles found dead (65% were without known cause or other causes of death (Statistics Norway 2013), but most of these were probably found as carcasses in such a condition that cause of death could not be determined. In a smaller sample of 35 banded Golden Eagles found dead, 9 had been shot, 4 were killed by powerlines, and 22 of unknown causes (Bakken et al. 2003).

Environmental Crime. Different forms of environmental crime involving Golden Eagles have been documented in Norway (Holme et al. 1994, Steen and Sørli 2008, Knoff and Nøkleby 2009, Statistics Norway 2013). These crimes include illegal hunting, use of poisonous bait, damage of eggs or nests, and intentional disturbance. In addition, it is known that eggs and eagles have been collected illegally in Norway (Hägerroth 2015).

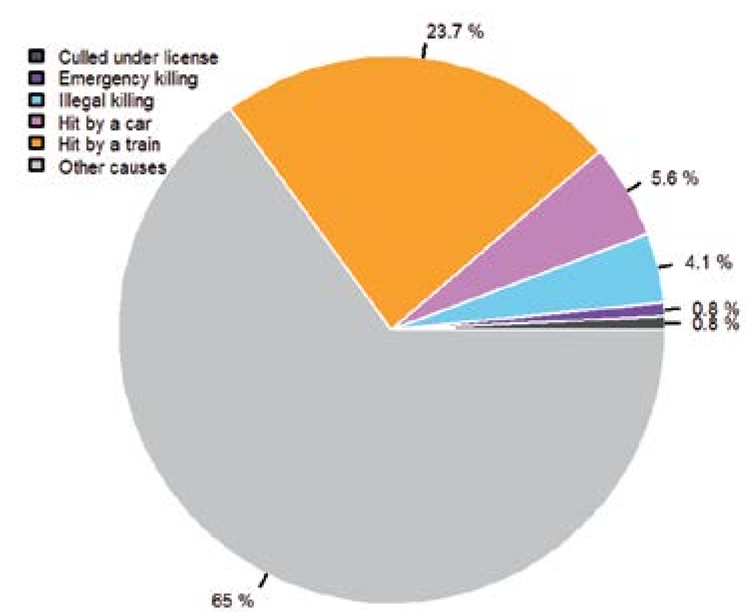

Figure 28. *Recorded causes of death of 266 Golden Eagles in Norway in 1987–2013.*

CONSERVATION AND MANAGEMENT

The Golden Eagle has long been persecuted by humans in Norway because it was regarded as a competitor for game animals and a threat to livestock. A law on eradication of carnivores and the protection of game species was passed in 1845. Until the protection of the Golden Eagle in April 1968, 114,000 eagles (Golden Eagles and White-tailed Sea-eagles) were killed. In 2020, permits to kill Golden Eagles, as a damage control measure, can be issued if high losses of livestock are documented, but it is required by law that only the individual eagle doing the damage can be killed and thus first needs to be identified.

Forestry and Golden Eagles. Most forestry organizations in Norway have adopted the "Programme for the Endorsement of Forest Certification" as standards for good forestry management. This implies that forest activities in areas with nesting birds of prey should strive to maintain the species' habitat. Special rules and restrictions apply when the species is particularly vulnerable to disturbance. This includes, among other species, the Golden Eagle. During the breeding-season, logging cannot take place closer than 400 m to the nest, and outside the breeding season not closer than 100 m. Violators are subject to penalties, loss of certification, and loss of the ability to sell timber. However, such convictions are rare.

Artificial Nests. In some areas, low breeding success of Golden Eagle pairs is caused by human disturbance or lack of suitable nest sites. Sometimes nests have fallen during the breeding season, and, in areas with intensive forestry, trees are seldom old enough to have solid branches suitable for nests. The conservation measure of building artificial nests can both lead the eagles away from places with human disturbance (e.g., roads, cabins, and ski and snowmobile tracks) and give the eagles safe and stable nesting sites in trees and cliffs. Many artificial nests were built in trees in Hedmark from 1993–2002, several of which have been used by Golden Eagles (Fig. 29). The artificial nests are built in trees as a platform with stabilizing limbs of spruce or pine. Nest material is held in place with loops of wire. Finally, the nest is filled with peat and other materials to make it more compact. When finished, such nests are about 1.2 m in diameter. With some experience, 2 men can build a nest in 2–3 hours (Knoff and Nøkleby 2002). We also know of some artificial nests built on cliffs that previously did not have suitable ledges (Fig. 30).

***Figure 29.** Artificial nest for Golden Eagles in a pine tree. Photo: Carl L. Knoff.*

***Figure 30.** Artificial nest for Golden Eagles (same as in Fig. 3). Photo: Jan Ove Gjershaug.*

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Frontispiece: *A Golden Eagle encounter, Utajärvi, Finland, February 2007. Photo: Markus Varesvuo.*

Title page (right): *Golden Eagle plucking a female Capercaillie, Kuusamo, Finland, April 2015. Photo: Markus Varesvuo.*

The Golden Eagle in Finland

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The Golden Eagle (*Aquila chrysaetos)* is a scarce breeding bird in the northern half of Finland, with tens of scattered pairs further south especially in western Finland and close to the Russian border in the east (Fig. 1). The present breeding population is estimated at ca 450 pairs, and it has increased slowly since the 1970s (Ollila and Koskimies 2008, 2009). The Golden Eagle is classified as Vulnerable in Finland because of its small population size (Hyvärinen et al. 2019).

The Golden Eagle was distributed over almost all of Finland up to the late 1800s (von Haartman et al. 1963–1972). Persecution, expansion of agriculture and human habitation, modern forestry, and unintentional disturbance were the main causes of the total disappearance of the breeding population in the south (about 40% of the country) by the mid-1900s (Fig. 2). The population was at its lowest in the 1950s and early 1960s, with probably around 250–300 pairs (Ollila and Koskimies 2008, 2009). The main reasons for the marked population increase are the cessation of persecution since the 1960s and fiscal compensation of reindeer (*Rangifer tarandus tarandus*) losses based on the number of occupied nests and breeding success of the eagles since 1998.