

A CONSERVATION FRAMEWORK FOR THE GOLDEN EAGLE (*AQUILA CHRYSAETOS*) IN SCOTLAND

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ABSTRACT.—The current population of around 420 breeding pairs of Golden Eagles (*Aquila chrysaetos*) in Scotland has been relatively stable for the past two decades. A century ago, both the breeding population and breeding range were probably much less than now, although a century before that the range was much more extensive than it is even today. Current factors constraining the Golden Eagle in Scotland include illegal killing, disturbance at nests, loss of hunting range by conversion of open hills to closed forests, and loss of wild food sources such as grouse and hares as a result of overgrazing of upland vegetation by large herbivores such as sheep and deer. Anticipated future constraints include the development of wind farms and the expansion of native woodlands. Current conservation legislation provides for the establishment of “protected areas” for valued habitats and species, and further legislation makes it an offense to kill Golden Eagles or knowingly to cause disturbance at nest sites. International commitments such as the European Union Wild Birds Directive have placed additional conservation obligations on the government of the United Kingdom that will probably not be met solely by reliance on protected areas and species protection measures. Effective conservation of widely-distributed birds such as the Golden Eagle requires measures to address constraints in the wider environment. In this paper, we subdivide the current and historical range of Golden Eagles into a number of zones founded on the Natural Heritage Zones approach being developed by Scottish Natural Heritage. This zonal approach provides a geographical framework for identifying key constraints on the population and provides an objective basis for the identification of targeted conservation policies.

KEY WORDS: *Golden eagle; Aquila chrysaetos; conservation; framework; constraints; zones.*

Un trabajo marco para la conservación del águila real (*Aquila chrysaetos*) en Escocia

RESÚMEN.—La actual población de cerca de 420 parejas reproductivas de águilas reales (*Aquila chrysaetos*) en Escocia, han estado relativamente estables durante las dos décadas pasadas. Un siglo atrás, tanto la población reproductiva como el rango de apareamiento fueron probablemente mucho menores que ahora, aunque un siglo atrás ese rango era mucho mas extensivo de lo que es aun hoy. Los actuales factores que restringen al águila real en Escocia incluyen la caza ilegal, la perturbación de los nidos, la perdida del ámbito de caza por transformación de las colinas abiertas en bosques cerrados, y la perdida de recursos de comida silvestre como los urogallos y las liebres como resultado de sobre pastoreo de la vegetación de la meseta por grandes herbívoros tales como ovejas y venados. Las restricciones proyectadas al futuro incluyen el desarrollo de granjas de energía eólica y la expansión de las arboledas nativas. La legislación actual en cuanto a conservación facilita el establecimiento de “áreas protegidas” para hábitats y especies valiosas, y adicionalmente la legislación castiga como delito el matar águilas reales o causar conscientemente perturbación a los sitios nido. Los comités internacionales tales como la Directiva de la Unión Europea para Aves Silvestres han colocado obligaciones adicionales en cuanto a conservación sobre el gobierno del Reino Unido que probablemente no se responsabilizaría exclusivamente por la seguridad en las áreas protegidas sino también de las medidas de protección para las especies. La conservación efectiva de aves ampliamente distribuidas como el águila real requieren de medidas que dirijan el problema de las restricciones a un medio ambiente mas amplio. En este articulo, subdividimos el rango histórico y el actual de la águilas reales dentro de un numero de áreas encontradas sobre las Zonas de Patrimonio Natural aproximación que esta siendo desarrollada por el Patrimonio Natural Escocés. Este enfoque zonal provee un marco geográfico para identificar las restricciones claves

sobre la población y provee una base objetiva para la identificación de políticas de conservación puntuales.

[Traducción de César Márquez y Victor Vanegas]

Until the middle of the 18th century, the range of the Golden Eagle (*Aquila chrysaetos*) in Britain and Ireland extended beyond its Scottish heartland into northern England as far south as Derbyshire, into the mountains of north Wales, and into much of western Ireland from Donegal to Kerry (Holloway 1996). The 19th and early 20th centuries were periods of intense persecution of birds of prey in Britain, and coincided with a rise in the use of upland areas for sport shooting, especially for Red Grouse (*Lagopus lagopus*). Because they were perceived as competitors with man for game species, and also because predators like eagles were considered threats to domestic stock such as sheep, large numbers of birds of prey were shot, trapped, or poisoned during this time (Brown 1976). This led to substantial range reductions for most raptors and to the ultimate extinction of several species from the native avifauna such as the White-tailed Eagle (*Haliaeetus albicilla*) (see Love 1983).

Today, the Golden Eagle population in Scotland is relatively stable, having undergone a gradual recovery since it was first given full statutory protection under the Protection of Birds Act in 1954 (Watson 1997). Its nadir was probably reached in the decade prior to World War II and the population may then have been as low as 150–200 pairs, entirely confined to the more remote parts of the Highlands and islands of Scotland. The first comprehensive survey of the breeding population in Britain was carried out in 1982 and repeated in 1992. The results of these two surveys were very similar with 424 and 422 territories occupied by pairs of eagles and 87 and 69 territories containing single birds in 1982 and 1992, respectively (Dennis et al. 1984, Green 1996). In both years, only one or two pairs were found in England, and the remainder were in Scotland (Fig. 1).

This paper assesses current constraints on the Golden Eagle population in Scotland and lists the existing measures for the protection and conservation of the bird. It goes on to explore a more strategic approach to the conservation of the species in the light of the international commitments of the government of the United Kingdom for the protection of rare and endangered species, notably

the European Union Directive on the Conservation of Wild Birds (79/409/EEC) (see Tucker and Heath 1994 for details).

CURRENT CONSTRAINTS

Contemporary constraints fall into two broad categories: those that have direct and immediate effects such as persecution and disturbance at nesting sites, and those that operate indirectly and more subtly such as changes in land use and management.

Persecution and Disturbance. Even after 45 yr of statutory protection, many Golden Eagles are still killed illegally each year in Britain and the commonest method of deliberate persecution is poisoning, although shooting and trapping still occur (Watson 1997). During the period 1979–89, a minimum of 13 Golden Eagles were shot or trapped and an additional 27 individuals were killed by poisoning (RSPB and NCC 1991). Because Golden Eagles readily feed on carrion, they are especially vulnerable to carcasses laced with poison. These baits, the use of which is illegal in Britain, are usually laid in places that are visited by predatory and scavenging birds or mammals. While the principal target is usually the red fox (*Vulpes vulpes*), poisoned baits are indiscriminate and annually account for many deaths of birds of prey including Common Buzzards (*Buteo buteo*), Red Kites (*Milvus milvus*), and Golden Eagles.

Within the range of the Golden Eagle in Scotland, the use of poisoned baits is most frequent along the eastern and southern fringe of the Highlands and in the Southern Uplands, typically in areas that are managed for Red Grouse. In these localities, poisoning is a major factor inhibiting the establishment of breeding territories, reducing breeding success, and preventing expansion of the breeding population. Where poisoning is endemic, adult birds are typically absent and ranges are consistently vacant or occupied only periodically by subadults that rarely survive long enough to breed. In the worst-affected areas, these poisoning black spots act as critical mortality sinks for Golden Eagles.

During the breeding season, Golden Eagles are vulnerable to the effects of both deliberate and un-

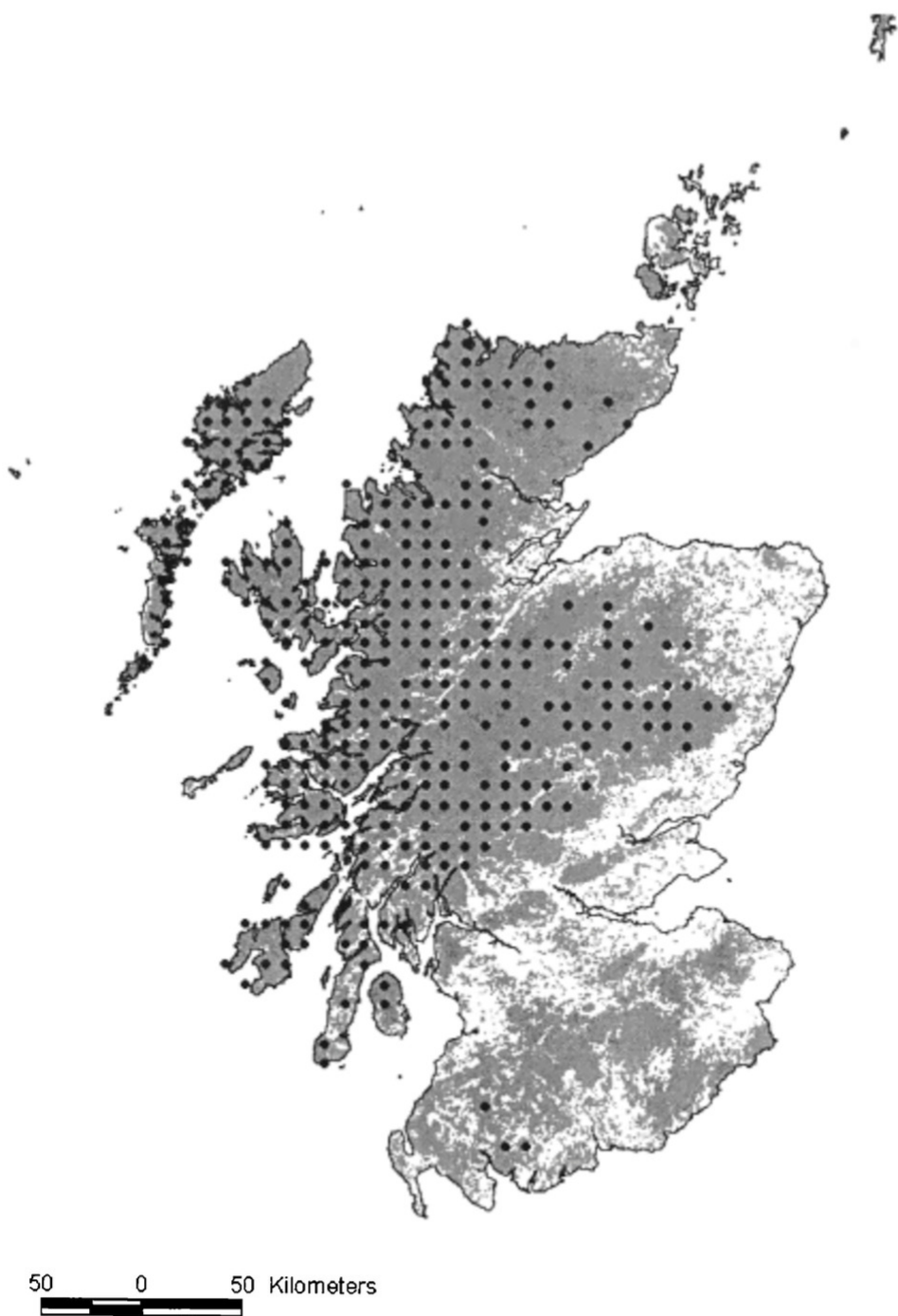


Figure 1. The distribution of the Golden Eagle in Scotland based on breeding attempts in 10 × 10 km squares in 1992. For reasons of confidentiality, records for four 10 × 10 km squares have been omitted.

intentional disturbance at nesting sites. The main consequence of disturbance is to reduce overall breeding performance. Watson and Dennis (1992) assessed the impact of deliberate disturbance on over 300 breeding attempts monitored during the 1982 national survey of Golden Eagles. They concluded that overall production of young may have been reduced by around 18% as a result of delib-

erate disturbance. As in the case of killing of adult eagles, the incidence of deliberate disturbance was most prevalent around the eastern fringe of the current Golden Eagle range.

Land Use and Management. The principal land uses in upland Scotland where Golden Eagles live are largely extensive and are either managed for grazing of both domestic animals and wild game

species or for forestry (MLURI 1993). In general, land use changes tend to occur relatively slowly and consequently any effects on eagle populations can be difficult to measure, with precise causal links hard to identify. Over the past 50 yr, the main changes in and influences of land use in the Scottish uplands have been large-scale increases in plantation forestry, continued high densities or increases in sheep grazing, and marked increases in the numbers of red deer (*Cervus elaphus*) raised on the remaining open ground. There have been long-term declines in many areas in the numbers of several medium-sized wild herbivores such as Red Grouse and mountain hares (*Lepus timidus*), especially in the west of the eagle range in Scotland. These declines are mainly attributable to the effects of overgrazing by sheep and deer, leading to loss of dwarf shrubs such as heather (*Calluna vulgaris*) on which grouse and hares depend for food and cover, and their replacement by ecologically impoverished grass-dominated vegetation.

Since 1945, huge tracts of open landscapes in the uplands of Britain have been converted to plantation forestry. Within the Golden Eagle range, the greatest extent of plantation forestry has occurred in southwest Scotland and in Argyll in the southwest Highlands. Until quite recently, most forestry in the uplands was with exotic conifers such as Sitka spruce (*Picea sitchensis*) and lodgepole pine (*Pinus contorta*). After about 10 yr, the canopy closes in these plantation forests and they become densely-packed stands of fast growing trees with very little structural or species diversity. For the Golden Eagle, this type of afforestation can lead very quickly to the loss of food in the form of sheep and deer carrion and, in due course, to the removal of virtually all hunting potential once the tree canopy closes (McGrady et al. 1997).

Two studies, one in southwest Scotland and another in Argyll, have demonstrated reduced breeding success by eagles linked to increases in afforestation (Marquiss et al. 1985, Watson 1992). The effects of afforestation on breeding density take longer to show, although there is evidence that, in one of the most heavily afforested landscapes in south Argyll, there has been a loss of 60% of the breeding eagles over the past 30 yr (Watson 1997).

The relationship between Golden Eagles in Scotland and large grazing animals, notably ungulates such as sheep and deer, is complex. On the one hand, eagles depend on carrion in the form of dead sheep and deer, especially for food in winter.

Watson et al. (1992) showed that variation in breeding density of eagles across Scotland could be explained largely by differences in the amount of carrion available. Highest densities of eagles occurred in the west mainland and on the islands where amounts of deer and sheep carrion were greatest. However, the same study showed no such positive correlation between carrion availability and breeding performance. Instead, breeding success was positively correlated with the numbers of medium-sized wild herbivores such as Red Grouse, Rock Ptarmigan (*Lagopus mutus*), mountain hare, and rabbit (*Oryctolagus cuniculus*). So, in places where eagles were not subjected to human persecution, breeding success was highest (around 0.8 young/pair) in the eastern Highlands where grouse and hares were most numerous. On the islands off the west coast where rabbits are especially plentiful, eagles produce around 0.6 young/pair. Breeding success was typically close to the national average of about 0.5 young/pair in a wide band from the southwest Highlands through the central Highlands to the northwest Highlands. In this zone, there were low to moderate numbers of grouse, ptarmigan, and hares reflecting some overgrazing by red deer, with consequent heather loss. Finally, the poorest eagle breeding performance (around 0.3 young/pair) was in the west-central Highlands where grouse and hare numbers were exceptionally low and where there were very few rabbits as alternative prey. In this region, overgrazing by large numbers of red deer and both past and present high sheep numbers, combined with a very wet climate, have resulted in loss of much of the "natural" heather cover, which in turn explains the low grouse and hare numbers.

In conclusion, abundant winter carrion, which occurs where large ungulates are present in high numbers, can lead to exceptional densities of eagles. However, excessive grazing pressure by large ungulates, notably in the wet west of Scotland, can also lead to the serious loss of medium-sized wild herbivores that are critical summer food for eagles if they are to breed successfully.

FUTURE CONSTRAINTS

Within the range of the Golden Eagle in Scotland, there are a number of changes that could be anticipated over the next decade or two. One is the likely increase in the number of wind farms which are being promoted in order to increase the proportion of energy generation from renewable

sources, and for which the windy west of Scotland offers considerable potential. Another is the anticipated recovery of the White-tailed Eagle population following the successful reintroduction of that species into its previous range on the islands and adjacent mainland of western Scotland (Love 1988). A third, and rather different type of potential constraint, is the change in current forestry practices in upland Scotland. This is now favoring the reestablishment or restoration of woodlands of native species and more natural structure, as opposed to the exotic conifer plantations of the past. Bearing in mind the wider biodiversity benefits from the recovery of Scotland's much depleted native woodland resource, to what extent does this pose a threat to Golden Eagles? Fourthly, there is the steady increase in recreational use of the uplands by the general public and the prospect that this could lead to increased casual disturbance of eagles during the breeding season.

CURRENT CONSERVATION MEASURES

An effective conservation strategy for rare but widely-distributed species such as the Golden Eagle needs to include three elements: species protection, site protection, and conservation of the wider environment.

Species Protection. The Golden Eagle in Britain is listed on Schedule 1 of the Wildlife and Countryside Act (1981). This protection includes special penalties for the killing and intentional disturbance of Golden Eagles during the nesting season. Although all forms of killing and intentional disturbance are illegal under this act, there continues to be substantial disregard for the law. In part, this is because of the comparative difficulty of bringing prosecutions where the burden of proof is high, but also because the deterrent effect of the financial penalties available in the event of a successful prosecution is low.

Site Protection. The current focus on site protection for Golden Eagles in Scotland is a result of the commitment of the government of the United Kingdom to implement the European Union Wild Birds Directive. The Golden Eagle is listed in Annex 1 of the Directive, which requires that species listed in Annex 1 "shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in the area of their distribution" and that "member states (of the European Union) shall classify in particular the most suitable territories in number and

size as special protection areas (SPAs) for the conservation of these species, taking into account their protection requirements in the geographical sea and land area where this directive applies." At the present time, there are five classified and three more proposed SPAs for Golden Eagles in Scotland (Fig. 2), and these contain just over 12% of the Golden Eagle population in the United Kingdom.

Conservation in the Wider Environment. While the level of protection afforded Golden Eagles within these SPAs is high, and should certainly ensure the continued survival of the species in these localities, site protection can only be a contribution to the long-term conservation of such a widely-distributed species. We believe the challenge for conservationists in Scotland is to design a strategic approach to the protection of birds such as Golden Eagles in the wider environment. Such an approach must necessarily compliment existing species and site protection measures. In the following section, we propose a framework for the conservation of Golden Eagles in Scotland that goes substantially beyond the existing site and species conservation arrangements.

A CONSERVATION FRAMEWORK

We propose the following as an overall aim for the effective long-term conservation of Golden Eagles in Scotland: maintenance of the present favorable condition of the population by implementing effective site and species protection measures and adoption and implementation of conservation policies that are targeted at known constraints across the species current range.

Favorable Condition. There are a number of key elements in this goal. First, it requires an agreed definition of what is meant by "favorable condition." We propose that the concept of favorable condition in the case of the Golden Eagle should take into account population size overall, average breeding performance, and the extent of the known historical range that is occupied. We propose that, on the first of these criteria, the Golden Eagle population in Scotland could be judged to be in favorable condition if the number of territories occupied by pairs is maintained at not less than 450–500. On the basis of this target, the current population is not in favorable condition (Table 1). We argue this assessment on the grounds that some 60–80 eagle ranges are currently occupied by single birds, and because the distribution of single occupancy coincides closely with areas of

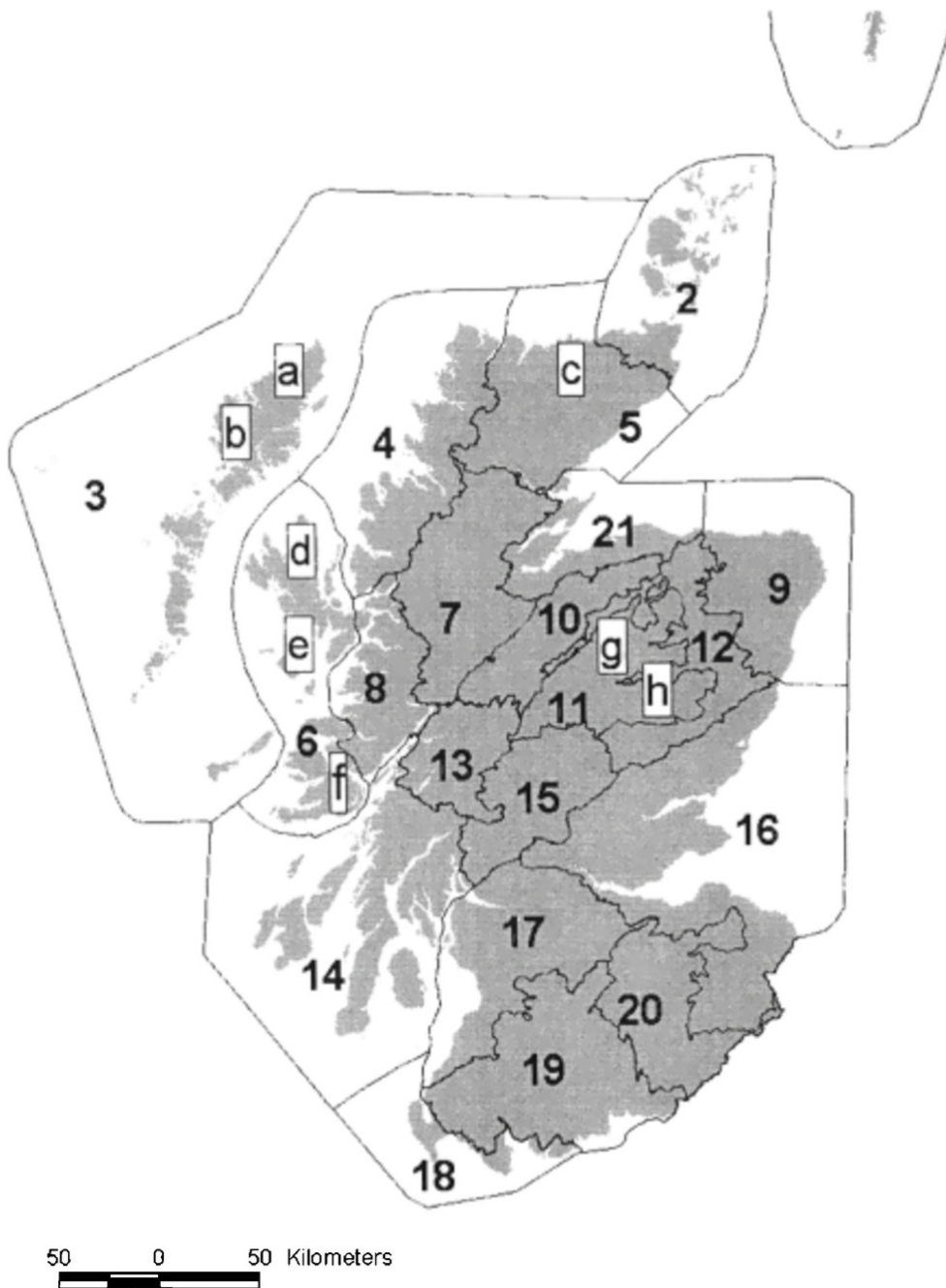


Figure 2. Map of Scotland showing the boundaries of SNH Natural Heritage Zones (2–21, excluding Shetland Zone 1) and the location of proposed and classified Special Protection Areas for the Golden Eagle (a–h: a = Lewis Peatlands, b = North Harris Mountains, c = The Peatlands of Caithness and Sutherland, d = Skye Mountains, e = Rum, f = Mull hills and coast, g = The Cairngorms, and h = Caenlochan).

human persecution (Dennis et al. 1984, Watson 1997).

Identifying a condition target based on breeding performance is more difficult because of substantial between-year and area variation. Nevertheless, we recommend that condition should be judged to be favorable if the breeding success of the popu-

lation overall remains >0.5 young/territorial pair/yr on average over a 5-yr period, and if no substantial part of the population in a particular geographical area is producing on average <0.4 young/territorial pair/yr over a 5-yr period. The first target is currently met (Watson unpubl. data), but the second is not, notably in a substantial area of the

Table 1. Summary of Golden Eagle range occupation, breeding numbers, breeding performance and constraints on favorable condition according to 14 Natural Heritage Zones in Scotland.

NATURAL HERITAGE ZONE ^a	EAGLE OCCUPATION OF SUITABLE HABITAT ^b	EAGLE BREEDING NUMBERS ^c	EAGLE BREEDING PERFORMANCE ^d	CONSTRAINTS
3	82% (44)	51	3?	sheep > persecution
4	69% (39)	37	4	deer > persecution
5	28% (53)	16	3?	persecution > nest site availability
6	100% (43)	70	5	sheep > commercial forestry
7	77% (52)	58	5	deer > persecution
8	80% (30)	40	3	deer > sheep
10	54% (28)	15	6	persecution > deer
11	59% (44)	28	7	persecution > deer
12	50% (16)	9	6?	persecution > commercial forestry > sheep
13	71% (24)	30	2	deer > sheep
14	85% (46)	43	5	commercial forestry > sheep > persecution
15	69% (32)	20	5?	persecution > sheep > deer > commercial forestry
19	10% (30)	3	2	commercial forestry > persecution > sheep
20	0% (31)	0	0	persecution > sheep > nest site availability

^a See Fig. 2.
^b % of 10 × 10 km Ordnance Survey grid squares with >50% upland habitat (Land Cover of Scotland 1988, upland summary classes MLURI 1993) containing breeding Golden Eagle home range centers (*sensu* McGrady et al. 1997) in 1992. Number of upland grid squares in brackets.
^c Number of breeding pairs in 1992.
^d Set relative to 1985 standard due to data availability and it being an apparently average year (Watson 1997) (young/pair/year). 0 = 0–0.09, 1 = 0.10–0.19, 2 = 0.20–0.29, 3 = 0.30–0.39, 4 = 0.40–0.49, 5 = 0.50–0.59, 6 = 0.60–0.69, 7 = 0.70–0.79.

west-central Highlands of mainland Scotland (Table 1, Watson 1997).
At present, approximately 72% of the apparently suitable range of Golden Eagles in Scotland is occupied by breeding birds (Table 1), and the figure for the United Kingdom as a whole may be as low as 60% (Newton 1994). For the range criterion, we recommend that the population should be judged to be in favorable condition when substantially all the apparently suitable habitat is occupied. We accept that this criterion must allow for continued nonoccupancy of some of the historical range. This could arise as a result of substantially natural causes (e.g., the recovery of the White-tailed Eagle population and any associated Golden Eagle range reduction), or where long-term and irreversible habitat change has occurred as a result of human or natural causes. Taking these considerations into account, we believe this condition target is probably not met in several parts of the eastern Highlands and in the Southern Uplands at the present time.
Site and Species Protection. This goal also recognizes the role of “site and species protection

measures” and, by use of the word “effective,” it acknowledges that these measures may require testing and review from time to time. We believe that, in respect of species protection, the current legislation in Britain probably needs to be amended further to deter people who kill and intentionally disturb eagles and other specially protected species. The distribution of classified and proposed SPAs is shown in Fig. 2. Given the inevitable limitations of a site-based approach in addressing the overall conservation of the species, we do not believe there is a strong case for an appreciable increase in the number or extent of these SPAs.
Constraints and Conservation in the Wider Environment. A third important element of the goal is the requirement for conservation policies targeted at constraints affecting eagles in the wider environment across the range. In this context, “conservation policies” should be taken to include the agreed set of advice, prescription, and incentive to be followed during the process of decision-making by government and its agents. We propose that such policies are generally amenable to targeting on a geographical basis across Scotland, giv-

ing the opportunity to adjust the priority attached to a range of prescriptions or incentives, dependent on the anticipated effect on the overall goal of achieving or maintaining favorable condition for the Golden Eagle population.

We propose that one starting point for the development of a targeted, and therefore prioritized, policy framework is to use the Natural Heritage Zones approach developed by Scottish Natural Heritage (SNH 1998, Fig. 2, Table 1). The SNH zonal program has identified 21 Natural Heritage Zones that reflect the variation in biological and landscape qualities across Scotland. The bulk of the Golden Eagle population is found within 13 of these zones and, in one other (Zone 20), Golden Eagles were present historically and could occur again in the future.

Table 1 lists the 14 zones, the number of breeding territories currently occupied by Golden Eagles in each zone, an assessment of range occupancy, and an estimate of current average breeding performance. It also lists the main constraints that presently affect Golden Eagle populations within each of the zones. At the present time, this list of constraints should be viewed as indicative, although it is substantially supported by the analysis of threats to Golden Eagles in Scotland given in Watson (1997). We are currently working on quantitative assessments of these constraints, to be published in due course. We do not expect that our analysis will alter appreciably the allocation of constraints to the particular zones. The principal finding of the analysis so far is to affirm that human persecution on eagle populations is a key issue in the east of the range (zones 5, 10, 11, 12, and 20), the influence of high deer numbers is a key factor in the north and west of the range in mainland Scotland (zones 4, 7, 8, and 13) and possibly also in the parts of the east (zones 10, 11, and 15), the influence of commercial forestry is greatest in the southwest (zones 14 and 19) and may also be an issue in parts of the southeast Highlands (zones 12 and 15), and high sheep numbers are a key factor on the islands (zones 3 and 6) in the southwest Highlands (zones 8, 13, 14, and 15), and in the Southern Uplands (zones 19 and 20). The only other constraint that we have identified and which we believe may now be having an appreciable effect on eagles is the availability of nest sites (zones 5 and 20). In these two zones, there is a comparative lack of suitable cliff nesting sites and there

are few large trees such as Scotch pine (*Pinus sylvestris*) which would offer alternative nesting places.

Our analysis is also investigating the geographical distribution of constraints linked to the probable future expansion of wind-farms, expansion of the reintroduced White-tailed Eagle population, increases in the extent of native woodland in the uplands, and the possible effects of increased recreational use of the uplands by people. Although work here is at an early stage, our initial view is that the zonal approach offers a useful way of anticipating and responding constructively to new constraints while taking into account existing constraints and their combined influence on the overall goal of achieving favorable condition for the population as a whole.

CONCLUSION

We propose a strategic framework for the conservation of Golden Eagles in Scotland, founded on site and species protection measures complemented by the use of targeted conservation policies designed to address key constraints on Golden Eagles in different parts of the species current range. Geographical targeting of conservation policies is possible thanks to relatively good biological information on eagle numbers, range and breeding success, good understanding of current constraints affecting eagle populations, and the existence of a geographical or zonal framework that is able to accommodate information on eagle "condition" and land use "constraints."

We believe this strategic approach has merit and commend, in particular, the proposed approach to the conservation of Golden Eagles in the wider countryside. This combines simplicity with robustness. Being relatively straightforward, it has the prospect of being adopted by decision makers. Its robustness is founded on the ability of the strategy to accommodate adjustments to policies or policy priorities in the light of new information on eagle "condition" or new types of land use "constraint."

The next step in the development of the overall strategy will be to articulate policy objectives designed to address the range of constraints, tackling in the first instance issues relating to persecution, deer management, sheep, and forestry. There is the opportunity to address current land management practices that are contributing to lack of favorable condition in the eagle population. We are also exploring the possibility of making predictions on the effects of proposed policy changes on the

various measures of condition, and thereby providing a useful test of the effectiveness of these policies. In addition, we propose to test the usefulness of the framework in helping identify conservation policies and priorities for Golden Eagles in relation to new but readily anticipated constraints such as the development of wind farms and the current expansion of new native woodlands in the uplands.

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