

INFORMATION NOTE

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SUMMARY

Golden eagles prefer open country with old, widely-spaced trees and linked large open areas. The density of breeding eagles is generally low in forested landscapes but productivity can be relatively high in old forests where medium-sized prey is more abundant. The main effect on eagles of increased native woodlands in Scotland is related to prey abundance. Live prey will decline in proportion to the amount of area covered by new native woodlands and the supply of carrion will be virtually eliminated. Until a landscape-scale network of 'mature' native woodland is established, which has areas of large, widely-spaced trees and some open ground, current guidance on where to establish commercial conifer forests is broadly applicable to new native woodland when considering its impact on eagles and their prey. Because new native woodlands are likely to be small in relation to eagle home range sizes, they should be managed within the context of surrounding forests and open ground. Forests and woodlands can extend the breeding range of golden eagles by providing suitable nesting places in areas where these are absent, but of course these new nest sites in trees will only develop after many years. Incorporating suitable design features into new woodlands may moderate their impact. In the best case, declines in breeding density as a result of more woodland cover will be partially offset by an increase in productivity — and perhaps an extension of the breeding range. However, without landscape-level management of woodlands, as well as complementary management of large herbivores within the forest and on adjacent open ground, the benefits in terms of increased productivity will not be realised.



INTRODUCTION

This Information Note reviews available information and estimates the likely impacts of native woodland expansion on golden eagles in Scotland. It also provides guidance about how any adverse effects might be ameliorated.

Golden eagles are an open country species, but will sometimes live in partially forested (broadleaved or coniferous) landscapes that include areas of old, widely spaced trees that often incorporate or are adjacent to large open areas. Prior to the clearance of native forests in the UK it is likely that more eagles nested in trees, and that many home ranges included areas of native forest. Golden eagles and their habitats are now protected under Schedule 1 of the Wildlife and Countryside Act (1981), Annex I of the EU Bird Directive and Annex II of the Berne Convention.

Historically, golden eagles bred throughout much of upland Britain, but their range has contracted due to persecution, habitat changes and disturbance. Today, the UK breeding range is mainly in the Scottish Highlands and overall the population is probably stable at about 425 pairs (Green, 1996). The main threats include overgrazing and changes in land-use which can influence the abundance,

The golden eagle *Aquila chrysaetos*.



distribution and availability of prey. Persecution is still a problem in some areas where it limits range expansion. Locally, disturbance can also be a problem.

Forests can affect eagle distribution and breeding success by providing nest sites and influencing prey availability. Although increases in the area of forest within eagle home ranges have been linked to reduced nesting success in Scotland (Watson *et al.*, 1987), forest cover within productive eagle territories in other countries is greater than in Scotland, and in some places the amount of forest cover is not significantly related to breeding success (Pedrini and Sergio, 2001).

Forestry is an important land-use in Scotland. Most planting during the 20th century was with exotic species with commercial value, but over the past 10 years significant areas of new native woodland have been created and also restored from exotic plantations. *The UK Forestry Standard* (Forestry Commission, 2004) underpins forest practices and the *Scottish forestry strategy* (Forestry Commission, 2000) provides the framework for forestry in Scotland in the future. The Strategy recognises that the concept of forest habitat networks (Peterken *et al.*, 1995) provides an ecological basis for planning woodland expansion. Enlarging and reconnecting existing woodlands can counter the adverse effects of woodland fragmentation, including impacts on potential eagle prey (See Petty, 2000).

Although the impact of new native woodland on eagles is the focus of this Note, increased areas of native woodlands will affect other important wild animal and plant species. Establishment and management of native woodlands to benefit eagles will therefore need to be set within the context of other conservation goals and commercial considerations.

NATIVE WOODLANDS AS PLACES TO NEST

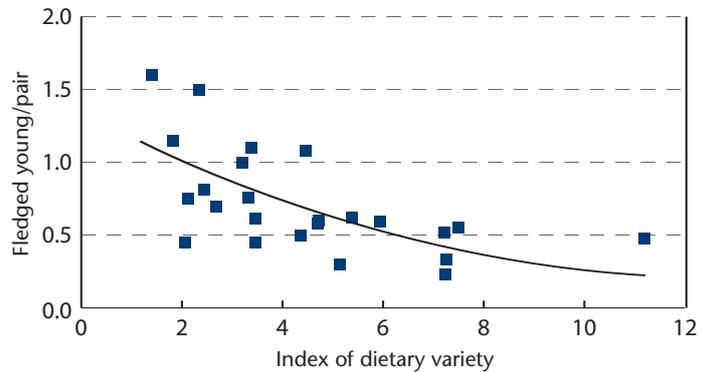
Only 4% of breeding eagles in Scotland nest in trees, mostly in the eastern Highlands where fewer crags are available than in the west and where extensive areas of old native pinewoods occur. Native woodlands could extend the breeding range of golden eagles by providing suitable nesting places in areas where these are lacking, such as the peatlands of Caithness and Sutherland and the Border hills (Watson and Whitfield, 2002). However, such stands need to be in suitable locations and contain large (>40 cm dbh) old trees (80–400 years) with substantial branches (Watson, 1997).

THE IMPORTANCE OF PREY

Golden eagles eat carrion (mainly dead sheep and deer) and kill mammals and birds of a suitable size. Although their diet is varied, in any locality live prey comprises the most abundant species of a profitable size. When a prey species is abundant it forms a high proportion of eagle diet (e.g. red grouse in the eastern Highlands), but when food is scarce eagles switch to a variety of alternative foods. In general, the most successful breeding eagle pairs are those with a diet composed of a few principal prey species (Figure 1). The abundance of alternative prey determines how well eagles breed when preferred prey are scarce.

Figure 1

Relationship between golden eagle breeding success and number of prey species in diet (dietary variety) from 24 studies in nine countries (from Watson, 1997).



Food supply and diet are closely linked to eagle breeding density and success, in that the highest breeding densities of eagles occur where carrion is abundant, and the most productive pairs are in areas with high live prey densities (Watson, 1997). Thus, the western Highlands are characterised by high breeding densities but poor breeding success, while the eastern Highlands have lower densities but higher breeding success.

Live prey can be divided into *preferred*, *alternative* and *occasional* prey. Probable changes in prey abundance, as a result of converting open hill ground to new native woodland, are summarised in Table 1. Red grouse is the most important avian prey of eagles. They mostly eat heather shoots and it is the quality of heather moorland that determines their density. In some localities, ptarmigan, crows and seabirds can also be important prey. The two most important mammalian species for eagles are rabbit and mountain hare. Rabbits prefer short, dry grassland, particularly where it is grazed by domestic stock. Some of the highest mountain hare densities in Scotland occur on heather moorland managed for red grouse. Heather is the main winter food of mountain hares, with grasses becoming more important in other seasons. Young deer are also taken (mostly up to one month of age) as live prey. Although young deer are only available to eagles for a short period, it is at a time when nestlings are large and they provide an important source of food for at least some pairs. Carcasses of sheep and deer provide a source of food for eagles throughout the year, particularly in winter, and at other times when live prey is scarce.

Historically, the diet of golden eagles in Britain was probably similar to the diet of eagles in Scandinavia. Today, the main differences in eagle diet between Scotland and Fennoscandia is the virtual absence of woodland grouse (capercaillie and

Table 1

Possible changes (by region) in abundance of the most important prey of golden eagles as a result of converting open hill ground into new native woodland.

Prey	East Highlands		West Highlands		Hebrides	
	Category ¹	Change ²	Category ¹	Change ²	Category ¹	Change ²
Rabbit	O	–	A	–	P	–
Mountain hare	P	–	A	●	A	●
Red fox	O	+	O	+	O ³	+
Deer (calves/kids)	A	+	A	+	A	+
Sheep carrion	O	–	P	–	P	–
Deer carrion	A	–	P	–	O	–
Seabirds	N	●	O	●	P	●
Wildfowl	O	●	O	●	O	●
Red grouse	P	–	P	●	O	●
Ptarmigan	P	●	O/A	●	O ³	●
Black grouse	O	+	O	+	O ³	+
Pheasant	O	+	O	+	O ³	+
Waders	N		O	–	O	–
Pigeons	N		O	+	N	
Corvids	O	+	A	+	O	+

¹ P = preferred prey; A = alternative prey; O = occasional prey; N = not recorded or rarely recorded as prey.

² – = decrease in abundance; + = increase in abundance, ● = no change in abundance.

³ Absent from some Hebridean islands where golden eagles are present.

black grouse), a lower proportion of hares and rabbits and a higher proportion of sheep and deer carrion in Scotland. These differences reflect the overall ecological impoverishment of upland Scotland which is linked to a number of factors, such as the clearance of native forests, overgrazing and the conversion of extensive areas of forest into grouse moors. Implicit in this statement is that expansion of native woodlands linked at the landscape scale with the reduction in numbers of herbivores could provide habitat for a healthy eagle population in Scotland.

NEW NATIVE WOODLANDS AND EAGLE PREY

The main effect on eagles of increasing the area of native woodlands is related to prey abundance. Food availability for eagles will decline once domestic stock are removed and deer grazing is reduced to the level where trees can be established (<5 deer km⁻²), largely as the result of a decline in the abundance of carrion. The loss of carrion is not entirely negative because it may lead to a decline in fox and crow numbers and thereby lessen the impact of these predators on the breeding success of grouse. Importantly, no new prey species for eagles will be attracted to new native woodland; instead it will be the relative abundance of existing foods that will change.

The effect of new native woodlands on live prey is likely to vary geographically. During the woodland establishment phase, provided dwarf shrubs are present, red grouse will initially outnumber black grouse, but that position may be reversed once the vegetation recovers from overgrazing. During the thicket stage, open areas within forests will be the only habitat left for grouse and hares. Native woodlands have a greater potential to maintain black grouse numbers through time because they often include more open space, and the shading effect of trees on ground vegetation within tree stands is less severe than with spruce. The effect on rabbits and hares will be negative, although hares may benefit from reduced grazing pressure by larger herbivores – particularly during the woodland establishment phase. Some avian prey of eagles occur in habitats that are less likely to be affected by the establishment of new native woodland, including ptarmigan, wildfowl, and seabirds.

How eagles use woodland of a suitable structure for hunting depends on a number of factors, including terrain features, weather conditions, and prey density and distribution. In very simplistic terms, the carrying capacity for live prey is likely to decline in proportion to the area of new native woodland. Thus, in a given new native woodland, under current Scottish Forestry Grant Scheme (SFGS) conditions the decline will be up to 80% once canopy closure occurs if 20% of the area is left unplanted.

This suggests that the impact of new native woodlands on potential food biomass may be similar to that of commercial conifer forests, although there may be some subtle differences that make native woodlands more attractive to eagle prey than conifer plantations. When managed at the scale of an eagle territory or larger, more than 20% of the area may remain open and be more useable by eagles. However, in the absence of hard evidence on a scale effect, a cautious approach should be taken; current guidance on where to establish commercial conifer forests for eagles should be considered broadly applicable to new native woodlands and used to assess the impact (McGrady *et al.*, 1997). Advice on reducing disturbance is given in Box 1, and is applicable to activity in new native and commercial spruce forests (See also, Andersen *et al.*, 1990).

Box 1

Steps to reduce disturbance at eagle nests (see also McGrady *et al.*, 1997 and Petty, 1998).

- Establish disturbance-free zones (900–1000 m radius) around active nests February–July inclusive.
- Avoid activity near the nest February–July, inclusive. Eagles are most sensitive to disturbance during nest building, at hatching and during the early nestling stage.
- Do not route new forest roads within 1000 m of eagle nests.
- Ensure that any nest visits to collect scientific data are undertaken by trained persons with appropriate licences.

DESIGNING NEW NATIVE WOODLANDS TO BENEFIT EAGLES

Individual proposals to establish new woodlands are likely to be much smaller than individual eagle home ranges. ‘Core areas’ are most important to breeding eagles and, in general, planting within these should be avoided (McGrady *et al.*, 1997). Reaching a suitable balance of different land uses within an eagle’s home range will only be achieved when plans to establish new native woodlands are considered in the context of the surrounding landscape. The value of new woodlands as foraging habitats for eagles depends largely on how open areas are incorporated into woodland design.

Because golden eagle home ranges are large, management aimed at conserving them could make substantial contributions to meeting targets for other species and habitats of conservation concern, including black grouse, blanket bogs and upland heathland.

Most eagle prey are herbivores that largely feed on ground vegetation that is most luxuriant in open areas. Thus, appropriate management of open areas to enhance prey abundance will have the greatest positive impact on eagles (Box 2). Forest types that are beneficial to eagles have high densities of medium-sized prey (0.5–2 kg body mass).

New native woodlands are dynamic habitats where successional changes influence prey abundance and the ability of eagles to use them. The main potential prey species: red grouse, black grouse, and mountain hares, are more abundant in open areas or in the early establishment phase of woodland than after canopy closure. However, all may be scarce or absent in woodlands established on grass moors where there is little potential for dwarf shrub development. Black grouse probably stand to benefit most from new native woodland expansion, providing these include extensive open areas with a high dwarf shrub component.

Open areas need to be large to meet both the requirements of hunting eagles and their prey. Open areas should be larger than 20 ha and over 300 m wide. These should be linked to other open habitats so that collectively they comprise a much larger area. Forest-based predators may well reduce numbers of potential eagle prey in smaller isolated area, making them unprofitable foraging areas for eagles.

Open habitats are also dynamic, but the rate of change is less rapid than with woodland. Open areas at medium and low elevations will progress to woodland in the absence of significant grazing. Selecting higher elevation sites for the location of open areas often delays these successional changes. Nevertheless, variable amounts of regeneration are likely to occur. Up to a certain level this can be advantageous for black grouse, but if regeneration is prolific the site will revert to woodland, and its value, as a habitat for eagle prey, will diminish rapidly.

Grouse and hares are dependent on habitat mosaics that provide suitable foraging opportunities. Within these mosaics, black grouse require longer vegetation than red grouse. Some of the best habitats for grouse and hares comprise dwarf shrubs, particularly blaeberry and heather, but also cowberry, crowberry, cross-leaved heath and bell heather. The main constraint to producing vegetation of an acceptable structure and height is

Box 2 Key points for managing open ground within SFGS sites to benefit eagles and their preferred prey, such as grouse and mountain hares (see text for more details and McGrady *et al.*, 1997 and Petty, 1998).

Scale of open ground

- Manage forests and open areas at the landscape scale. Areas need to be large (minimum area of 20 ha and minimum width of 300 m).
- Avoid small, linear-shaped areas.

Location of open ground

- Select upper hill slopes and high-elevation sites; avoid valley bottoms.
- Link open areas within the SFGS with other open areas and adjacent moorland.
- Plan open areas where there is limited potential for regeneration.
- Avoid planting in grassy areas where rabbits occur.
- Maintain open areas with ericaceous vegetation, cotton grass and wet flushes, which are important habitats for grouse and mountain hares.

Management of open ground

- Develop wide ecotones (low tree density with <40% canopy cover when mature) between open areas and woodland.
- Manage deer by culling rather than by fencing as collisions with deer fences are an important cause of mortality in grouse.
- Aim for deer densities below 5 deer per km²; densities above this will have adverse impacts on the food plants of grouse and hares. However, some grazing by deer can contribute to plant diversity and improve habitats for potential eagle prey.
- Some ericaceous vegetation should be encouraged to grow tall (40–50 cm).
- Black grouse eat tree buds and flowers; the most important trees to establish are birch, aspen, rowan, Scots pine and larch.
- Blaeberry, cowberry, crowberry and rowan should be encouraged as their berries provide an important food for grouse in late summer.
- Invertebrate-rich areas are crucial for the survival of grouse chicks, these include damp sites with grass, rushes, bog myrtle and herbs. Such areas can often be created or extended by appropriate drain blocking.

overgrazing by deer, so as far as possible deer densities should be no more than 5 deer per km². However, these lower densities of deer should be balanced to also impede excessive forest regeneration (see above).

After hatching, grouse chicks are highly dependent on invertebrates, which are much richer in protein than the vegetarian diet of adults. Invertebrate-rich sites are often in damp areas where grasses, herbs, bog myrtle and rushes are abundant and where the vegetation is relatively tall. Edges between forest and open areas should be managed to create conditions preferred by black grouse. Wide ecotones (>100 m) with low-density tree planting should be encouraged. In these zones aim for no more than 40% canopy cover when the trees are mature, but this can vary from the inner to outer edge. On the open side of the ecotone encourage the use of low growing *Salix* spp. (e.g. *S. aurita*), juniper and other shrubs when conditions are suitable.

Rabbits prefer grassy, well-drained sites. In those areas where rabbits are an important food source, maintenance of warrens will have benefits for eagles.

Some benefits of new native woodlands for eagles will only become available after many decades (e.g. new nesting places). Box 3 provides advice on creating new nesting sites in trees for eagles.

Box 3

Activities useful in creating new nest sites for golden eagles in forests (see text for more details and Petty, 1998).

- Conserve existing nesting trees and the surrounding forest.
- Avoid planting trees that, when mature, will obstruct flight lines into crag nests.
- Develop existing stands of old trees that could be used as nest sites in the future.
- Consider leaving groups of trees in ravines or on steep, craggy slopes during clearfelling operations, as these trees are often of low economic value or difficult to extract.
- Establish new stands in locations that would be suitable for nesting in the future, but which lack tree-nesting opportunities at present.
- Potential nesting stands should be located at or near the edge of the forest–moorland boundary, in stands >10 ha in size, where the risk of windthrow is low and adjacent to suitable foraging areas.
- Aim to create nesting stands with <100 trees per ha at around 100 years of age; eagles can breed in conifers from around 80 years of age that have an appropriate branch structure.
- Trees that develop large open crowns with substantial branches are preferred by eagles; Scots pine is particularly valuable species.

There has been some success elsewhere in providing nesting platforms for eagles in trees that would be otherwise inappropriate for nesting. However, eagles still prefer to nest in natural sites, and platforms should be seen only as a means of getting eagles to nest in trees some years earlier than expected, rather than as a permanent solution.

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