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No. 1

An ornithological evaluation of Tayside Region, Scotland, with special reference to the location of future commercial afforestation

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Cultural landscapes of upland Tayside Region, Scotland, support a breeding bird assemblage of considerable nature conservation importance. Commercial large-scale afforestation of these birds' habitats is having a particularly damaging impact on a number of species. These adverse effects have meant that, in recent decades, characteristic species have undergone population declines and contractions in range.

In order that the long-term viability of Tayside Region's upland breeding bird assemblage can be ensured, a strategic evaluation of birds adversely affected by commercial afforestation has been completed. This identifies important areas for open ground birds.

Recommendations for both the future location and type of forestry are suggested, if traditional ranges and numbers of bird populations of conservation concern are to be maintained.

Dr C.A. Galbraith
Head, Vertebrate Ecology & Conservation Branch

Summary

(i) Open ground natural and semi-natural biotopes in Tayside Region support a breeding bird assemblage of considerable nature conservation importance. Commercial, large-scale, afforestation of this open ground is having a particularly damaging impact on a number of these birds.

(ii) Scottish Development Department Circular No. 13/1990 calls for Scottish Regional Councils to prepare Regional Indicative Forestry Strategies as part of the Structure Plan process. These strategies outline the potential opportunities and constraints for new planting.

(iii) The Joint Nature Conservation Committee, as part of its national ornithological research, has been undertaking strategic evaluations of the bird interest associated with open ground. These evaluations enable account to be taken of the open ground bird interest in the overall planning of the countryside, including afforestation, through the production of Regional Indicative Forestry Strategies.

(iv) The ornithological importance of open ground biotopes vulnerable to predicted future afforestation is evaluated. This uses an ornithological index derived for the purpose, ranking individual 10 km squares into one of three categories of high, medium and low ornithological interest. Within Tayside Region these categories are represented as follows:

a) Forty three 10 km squares (42%) - high ornithological interest

b) Thirty five 10 km squares (34%) - medium ornithological interest

c) Twenty four 10 km squares (24%) - low ornithological interest

(v) Recommendations for both future location and type of forestry within each interest category are suggested, if traditional ranges and populations of birds of conservation concern are to be maintained.

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Part 1. Introduction.

1.1 Regional Indicative Forestry Strategies (RIFS): implications for conservation of the wider countryside.

Dramatic changes in rural land-use in recent years highlight the need for the various sectoral strands of policy to be combined into an integrated land-use strategy. This is particularly true of afforestation, which is an increasingly important land-use interest. From an ornithological perspective, land-use strategies are especially important if the continued deterioration of bird habitats in the wider countryside is to be prevented.

A move forward came in 1987, when the Convention of Scottish Local Authorities (COSLA) recommended that each Scottish Regional Council should prepare, as part of the structure plan process, a Regional Indicative Forestry Strategy (COSLA 1987). This report clearly identified Regional planning authorities as the appropriate bodies to generate these statements.

The recommendations of COSLA (COSLA 1987) were subsequently enshrined in Scottish Development Department Circular No. 13/1990 - Indicative Forestry Strategies. This Circular defined the main objectives of RIFSs as:

"to present a broad assessment, at a Regional level and on an outline basis, of the opportunities for new planting...[taking].. account of environmental and other factors".

Preparation of a RIFS for Tayside by the Regional Council has defined a need for a full assessment of the nature conservation interest of the Region. The purpose of this report is to evaluate the ornithological interest of open ground throughout Tayside as part of the overall nature conservation assessment. The ornithological importance of open ground is described in terms of the abundance, distribution and nature conservation value of birds present in each 10 km National Grid square. The Region has been stratified to show variations in the importance of the open ground bird assemblage each 10 km square supports, and the degree of sensitivity of that assemblage to future forestry development.

If the strategic planning of new afforestation does not take account of the requirements of open ground birds some forestry will inevitably continue to be planted on areas of high bird interest. Thus RIFSs have an important role to play in bird conservation, directing future land-use in the wider countryside.

Within Tayside the maintenance of viable populations of many open ground birds of high nature conservation interest depends on the extent and location of future afforestation.

1.2 Nature conservation and the wider countryside: a rationale

This contribution to the preparation of a RIFS for Tayside is based on the principle that the strategy should help to:

i) maintain or enhance the species diversity of bird assemblages characteristic of natural and semi-natural open ground habitats

ii) maintain, within the limits of normal fluctuations, populations and breeding densities of all open ground birds, and

iii) maintain the biogeographical range of open ground birds, particularly those species for which the United Kingdom has both a national and international responsibility.

The strategy can be judged to have been successful if future afforestation does not jeopardise viability and distribution of the bird assemblage characteristic of Tayside. Fundamental in achieving this is a presumption against planting on natural and semi-natural vegetation which provides high quality bird habitat. Establishment of plantations of exotic species should be within forest design standards, agreed by both JNCC and the Forestry Authority. The creation of such artificial habitats to within agreed standards will minimise the adverse effects on nature conservation.

Our approach to the ornithological assessment of the Region is influenced by EC Directive 79/409 on the Conservation of Wild Birds (as amended), and hereafter called the Birds Directive. This Directive requires Member States to designate Special Protection Areas (SPAs) to conserve those vulnerable species listed under Annex 1 (Article 4.1) and all regularly occurring migratory species (Article 4.2).

Member States are also required to take measures to prevent damage to, or the deterioration of, the habitats of both Annex 1 and regularly occurring migratory species outwith these designated areas in the wider countryside (Article 4.4).

Thus, the maintenance and protection of the habitats of both Annex 1 and regularly occurring migratory species in the wider countryside clearly falls within the Directive's scope. Conservation of birds in the wider countryside is vital for the protection of far-ranging and dispersed species, e.g. golden eagle and merlin, whose complex ecological niches mean that site-based conservation measures alone would be inadequate.

Many of the species considered in this evaluation are listed as requiring special protection measures in accordance with the Birds Directive. Eight of the species used are listed under Annex 1 (red-throated diver *Gavia stellata*, black-throated diver *G. arctica*, hen harrier *Circus cyaneus*, golden eagle *Aquila chrysaetos*, merlin *Falco columbarius*, peregrine *F. peregrinus*, golden plover *Pluvialis apricaria* and short-eared owl *Asio flammeus*). Regularly occurring migratory species are similarly well represented (wigeon *Anas penelope*, lapwing *Vanellus vanellus*, dunlin *Calidris alpina*, snipe *Gallinago gallinago*, curlew *Numenius arquata*, redshank *Tringa totanus*, greenshank *T. nebularia*, common sandpiper *Actitus hypoleucus*, and twite *Carduelis flavirostris*).

1.3 Open ground birds and commercial forestry: the conflict

Open ground biotopes throughout Scotland, including bogs, moors, mountains and rough grazings, support a unique open ground breeding bird assemblage of international nature conservation importance (Thompson *et al.* 1988). In this report the definition of open ground birds includes not only species incapable of breeding in dense mature forest but also some which are adapted to forest edge or open woodland.

In recent years one of the most serious conservation issues in Britain, and especially Scotland, has been the replacement of open ground habitats with large-scale commercial afforestation (Galbraith & Bates 1991). In terms of extent, forestry has become the principal agent in Britain of the replacement of semi-natural habitats (NCC 1986). Afforestation of open ground habitats, such as moorland, results in an extensive and fundamental change in land-use. This results, generally, in a completely new habitat that is unsuitable for the existing open ground bird assemblage (Ratcliffe 1991). It would be an exaggeration, however, to suggest that all afforestation is necessarily harmful to all birds. Appendix I lists those open ground birds which are potentially threatened by forestry in Scotland.

Appendix III summarises the status and ecology of species with the potential of being adversely affected by present commercial afforestation. Species of high nature conservation importance are discussed in terms of the mechanisms which affect their populations as a consequence of afforestation. The intention of these species' overviews is to provide both background information and rationale for the recommendations included in Part 2.

To understand just why commercial afforestation can have such a damaging ecological impact it is necessary to look at the silvicultural system practised and location of forestry in Britain. The latter shows a distinct geographical trend, being concentrated in the western and northern uplands of Britain, where land prices are generally low, soils are poor, theclimate is wet and agriculture is less profitable. These areas often have extensive expanses of natural and semi-natural open ground habitats and a correspondingly important bird assemblage.

Throughout Britain the forestry practices involved in establishing stands of commercial timber are similar, although the intensity of site preparation depends on local conditions. In the initial stages of plantation development, the area to be planted is fenced to exclude sheep, deer and goats, and then deep ploughed with a continuous-furrow plough. In upland areas, by far the most common tree planted by British foresters is sitka spruce *Picea sitchensis*, a North American conifer species. To qualify for full establishment grant, the minimum stocking density of 2250 conifers per hectare must be fulfilled.

Following planting in the upturned ridges, fertilisers and herbicides are often applied. As the young trees grow to form the thicket-stage (at 10-15 years), the canopy of the plantation closes, resulting in loss of the ground vegetation associated with open ground habitats (e.g. dwarf shrub heath communities). The plantation is then left, apart from thinning which occurs (if at all) between 15-25 years after planting. The dense plantation is clear-felled 30-50 years after establishment. Restocking of clear-fell areas usually takes place within three years of felling, when the management regime is repeated.

The afforestation of open ground produces a profound ecological transformation, involving an accelerated succession from open ground to closed-plantation (NCC 1986). Timber Growers United Kingdom (1985) summarised the effects of forestry on open ground as resulting in: "immediate changes in the general ecology of the area.... existing habitat will largely disappear and new species will be attracted".

This change in habitat results in the replacement of high interest bird assemblages with ones of much lesser nature conservation interest. Predatory and scavenging birds, upland waders, grouse and several small passerine species are all adversely affected by afforestation of the uplands (Thompson *et al.* 1988). Species with dispersed populations (e.g. golden eagle and merlin) depend on large areas of moorland and hill for feeding and breeding (Watson *et al.* 1987; Newton *et al.* 1978). In order to sustain viable populations of these wide-ranging species, protection of large areas must be afforded through sympathetic land-use policies. This should be supplemented by site-based conservation measures (Ratcliffe 1977).

Direct effects of afforestation involve the loss of feeding and breeding areas (Stroud *et al.* 1987). Species particularly affected by habitat loss include the upland waders, especially golden plover and dunlin, which are displaced almostimmediately following planting (Parr 1990). Where feeding grounds (including areas important for carrion and live prey) are reduced, non-breeding and territory desertion results for a number of predatory and scavenging birds (Marquiss *et al.* 1978; Watson *et al.* 1987; Watson in prep.).

In Tayside both far-ranging predatory and scavenging species like hen harrier and raven *Corvus corax* are potentially at risk from a further increase in afforestation.

Indirect effects of afforestation occur due to wider-scale influences such as acidification of waterbodies (Harriman & Morrison 1982; Stoner & Gee 1985) and edge-effects of plantations on bird populations breeding in adjacent open ground (Stroud 1987). New plantations hold larger populations of foxes and crow species than that supported by open ground, leading to increased predation and reduced breeding success for many open ground birds adjacent to plantations (Barnes 1984; Parr 1989, 1990). The displacement of birds from these areas and the subsequently poor recruitment into them confirms that moorland adjacent to plantations may be avoided (Parr 1989).

Fragmentation of sheepwalk or grouse moor by afforestation can disrupt existing land-use practices (e.g. moor burning) in the remaining unplanted areas. Cessation of moorland management results in vegetation changes which tend not to favour those birds preferring a short sward, e.g. golden plover (Ratcliffe 1976), but may favour those birds such as hen harrier which prefer a less uniform vegetation (Watson 1977). Thus, negative impacts of afforestation are not confined only to the area planted.

As a consequence of afforestation, the open ground bird assemblage is successively replaced by species characteristic of scrub and woodland ecosystems (NCC 1986). The nature conservation importance of this replacement bird assemblage is generally far less than the open ground assemblage which it replaces. Qualification of these adverse effects requires detailed ecological study (e.g. Marquiss *et al.* 1978; Marquiss *et al.* 1985; Moss *et al.* 1979; Newton *et al.* 1982; O'Flynn 1983; Parr 1990; Roberts & Bowman 1986; Thompson *et al.* 1988; Watson 1979; Watson *et al.* 1987). Only for some species are the adverse effects of afforestation and associated forestry practices well understood, while much further research is required for others.

Part 2 Ornithological evaluation of open ground biotopes

2.1 Introduction

As a result of changes in land-use and the adverse consequences of these on wildlife, there is an increasing need to evaluate the nature conservation importance of those species and their habitats which may be deleteriously affected. Such evaluations allow environmental planners to formulate appropriate land-use and minimise environmental impact.

From an ornithological perspective, the negative implications of open ground afforestation can be reduced by ensuring that plantations are suitably located, i.e. on areas with intrinsically lower bird interest. This requires consideration of the location of afforestation in the early stages of planning. A strategic approach can identify areas where land-use changes would be least damaging, and where a

presumption in favour of forest development would not affect areas of high bird interest.

2.2 Methods

The evaluation is based on an assessment of breeding birds which are adversely affected by afforestation throughout Tayside. Species used in this evaluation were drawn from a list of those which have either been shown to be adversely affected, or which due to their ecological requirement for open ground have a potential to be deleteriously affected by afforestation (see Appendix I).

Only sub-montane open ground birds have been included in this list. Montane species such as dotterel *Charadrius morinellus* and ptarmigan *Lagopus mutus* have been excluded since they require areas of land outwith the altitudinal range of afforestation.

Thus the species used include all eight listed under Annex 1 of the Birds Directive (red-throated diver, black-throated diver, hen harrier, golden eagle, merlin, peregrine, golden plover and short-eared owl), and nine regularly occurring vulnerable and dispersed migratory species (wigeon, lapwing, dunlin, snipe, curlew, redshank, greenshank, common sandpiper and twite). Three additional species, raven, red grouse *Lagopus lagopus* and ring ouzel *Turdus torquatus*, are also included because their populations are of particular concern in respect to the adverse effects of afforestation.

The distribution and abundance of vulnerable birds are assessed for each 10 km square using an ornithological index developed for the purpose. The choice of the 10 km square unitis based on both biological and species protection criteria. Their use means that precise locations for sensitive species need not be given, whilst also representing a reasonable spatial scale in relation to the ecological requirements of many open ground birds. For example, birds with far-ranging and widely dispersed populations such as raven and golden eagle depend on extensive areas of moorland and hill in the order of 2,000 hectares (20 km^2) per pair and 7,500 hectares (75 km^2) per pair respectively (Ratcliffe 1962; Watson in prep.). The maintenance of viable populations of such species is therefore dependent on the adoption of conservation measures at an appropriately large scale.

Information on the number of breeding pairs of each species was collected for each 10 km square using data held by the JNCC, local experts, Royal Society for the Protection of Birds, Scottish Ornithological Club, Raptor Study Groups and from the *Atlas of Breeding Birds in Britain and Ireland* (Sharrock 1976).

The ornithological interest for each 10 km square was then evaluated using the following conservation index (OI):

$$OI = \sum_{s=1}^{M} [1000(Ks / Ns)]$$

where K_S= maximum number of pairs of a species per 10 km square

N_S= most recent estimate of the British population of a species.

M = number of species found in square.

For each species, the index assesses the importance of a particular 10 km square based on the proportion of that species' British population. For example, a 10 km square containing eight pairs of hen harrier is valued as being four times more important than a square with only two pairs. By treating all species as being of equal value, a conservation index can be made by combining the values for all species within the 10 km square. The index therefore assigns an individual score to each square such that the range in values generated allows comparisons to be made between squares, and hence objective judgements to be made concerning the location of future afforestation.

In order to represent the relative importance of each 10 km square in a format which could be readily used in the RIFS, each square score was further classified into one of three ornithological interest categories: high, medium and low. This classification reduces the likelihood of trivial examinations of the differences between numerical values.

The corresponding threshold scores for this division are as follows:

Category	Score per 10 km square
High interest	>67
Medium interest	10 - 66.9
Low interest	<9.9

Derivation of the thresholds between index categories for Tayside is based on standard cutoff levels as used in ornithological evaluations for all other Scottish Regions (Bates & Galbraith 1993). This allows for a national overview in the formation of afforestation policy. Index scores were initially ranked and then divided where natural divisions allow an adequate core number of vulnerable open ground birds to be defined as sensitive to future afforestation. Although subjective, this relates to the conservation principles outlined in Section 1.2.

It is intended that the categories of ornithological interest derived should equate broadly with the categories of sensitivity used in the RIFS (see SDD Circular No. 13/1990), i.e. high ornithological interest equates with sensitive, medium ornithological interest equates with potential and low interest equates with preferred areas.

2.3 Results: the ornithological importance of open ground biotopes in Tayside Region.

Tayside Region's open ground birds are characterised by a number of species of high nature conservation importance. When these occur in association they form an assemblage of considerable nature conservation importance.

Initial analysis of ornithological data shows Tayside's open ground biotopes to hold both nationally and internationally important populations. The importance of these populations is established primarily on the proportions of British and EC populations which they represent. In particular numbers of black-throated diver, hen harrier, golden eagle, merlin and peregrine each comprise substantial proportions of those species EC breeding populations (see Table 2.1). For example, Tayside supports an estimated 90 pairs of merlin, representing 13% of the total EC population.

Table 2.1. The national and international importance of vulnerable and dispersed open ground birds in Tayside Region.

Species	No pairs in Tayside	% of population in Britain	% of population in EC
Red-throated Diver *	4	0.3	0.3
Black-throated Diver *	8	5.0	5.0
Hen Harrier	85	19.0	2.0
Golden Eagle	45	10.0	5.0
Merlin	90	15.0	13.0
Peregrine	125	14.0	-
Raven	30	0.7	-

* denotes species at limit of southern biogeographical range, and therefore of special ecological importance.

Other species populations, however, are significant because they represent important elements of a species zoogeographical range. An example is red-throated diver, whose regional population although nationally insignificant, in terms of absolute numbers (with < 1% of the total British population), is

important, representing the extremity of this species' southern geographical limit in the EC. Such populations are important for a number of reasons, including monitoring of biological effects of global warming on wildlife.

Appendix II summarises the nature conservation status of species breeding on Tayside's open ground biotopes, using criteria in *Red Data Birds in Britain* (Batten *et al.* 1990). Protection of these species' habitats throughout the Region is therefore of particular importance, in recognition of their nature conservation importance.

Map 2.1 illustrates the results of this evaluation, with Tayside stratified into areas of high, medium and low ornithological interest. Each of the three interest categories are now discussed, with details of their geographical distribution, extent and nature conservation importance. Recommendations for the extent and type of future afforestation are suggested which would minimise the severe impacts on birds.

High Ornithological Interest Areas:

Of the one hundred and two 10 km squares either wholly or partly in Tayside Region, forty-three (c.42%) are of high ornithological value. These are concentrated to the north of the Highland Boundary Fault - forming an east-west band across the Region. This interest category also occurs to a lesser degree in association with other upland areas south of this fault, such as in the Ochil and Sidlaw Hills (Map 2.1).

Appendix IV lists all those 10 km squares classified as being of high ornithological interest.

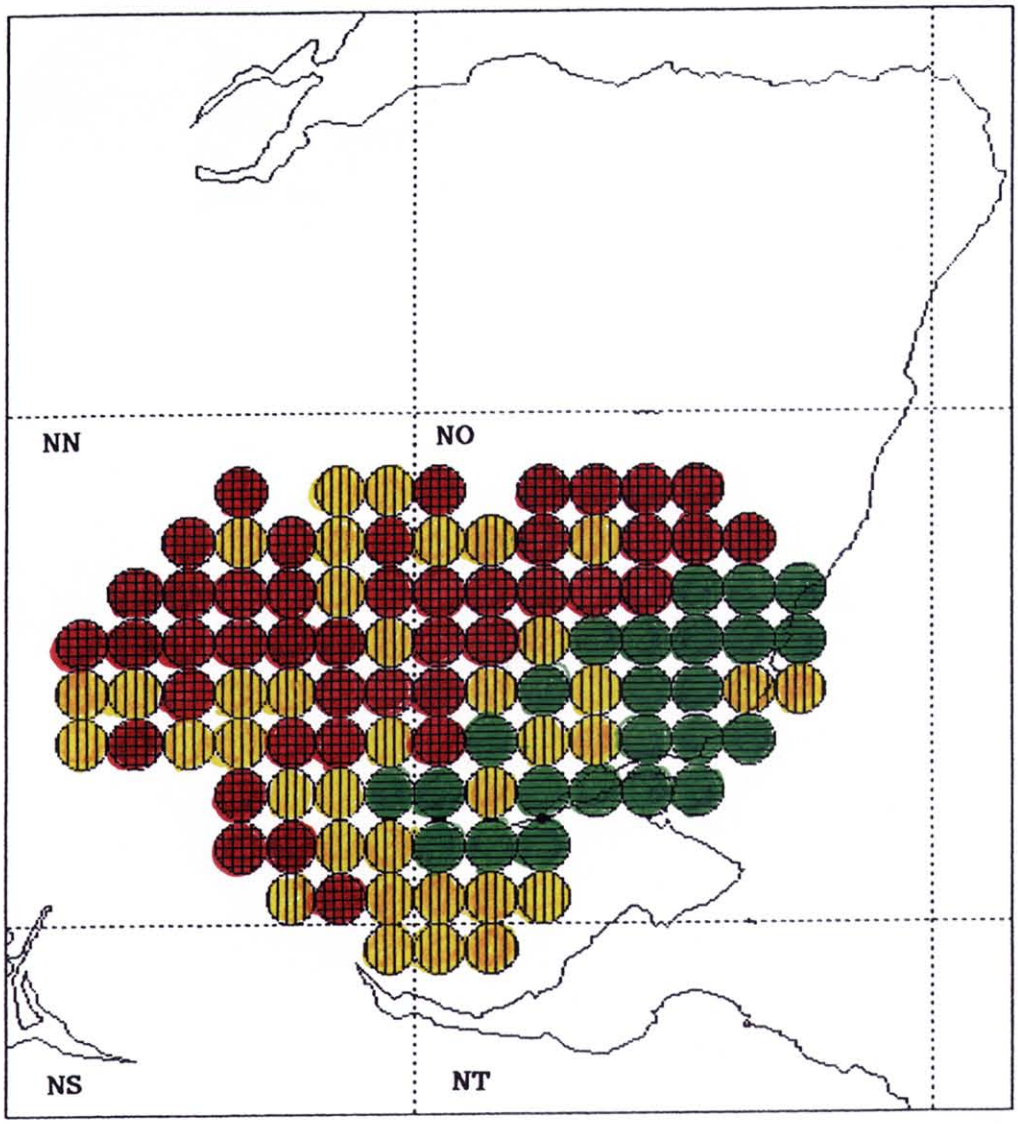
The high interest areas contain the core populations of the vulnerable birds used in the analysis (Table 2.2). Species composition varies as a consequence of geographical location and variations in environmental characteristics throughout the Region, for example the distribution of merlin reflects the occurrence of dwarf-shrub heath.

Table 2.2 Distribution of species in relation to the ornithological interest categories.

Species	Interest Category	No. Pairs*	%
Red-throated diver	High	5	71
	Medium	2	29
	Low	-	0
Black-throated diver	High	12	100
	Medium	-	0
	Low-	0	
Hen harrier	High	91	97
	Medium	3	3
	Low-	0	
Golden eagle	High	37	75
	Medium	12	25
	Low	-	0
Merlin	High	89	86
	Medium	15	14
	Low	-	0
Peregrine	High	10466	
	Medium	54	34
	Low	-	0
Raven	High	30	70
	Medium	13	30
	Low	-	0

* Regional populations (Table 2.3) may be exaggerated as the number of pairs include boundary 10

Map 2.1 Results of ornithological evaluation for Tayside Region



High interest

Medium interest

Low interest

km squares which fall partly outside the Region.

From Table 2.2 it can be seen that by far the largest proportion of populations occur within areas of high ornithological interest. This is important if the recommendations for future afforestation outlined below are to be successful in protecting the present populations and ranges of these important open

Sensitivity to afforestation:

Commercial afforestation of principally exotic conifer species represents an inimical land-use to the ornithological interest present (see 1.3). Such commercial afforestation would erode suitable habitat for those species dependent on open ground. **A presumption against further commercial forest development is recommended in areas of high ornithological interest.** Consequently these areas should be classified, within Tayside Region's RIFS, as sensitive to future afforestation.

Exceptions to this, and in circumstances in which there would be an enhancement in nature conservation interest includes:

i) the expansion of semi-natural woodland by natural regeneration (or in very specific circumstances, the planting of native broadleaves) and,

ii) the expansion of the Caledonian pine wood - as grant-aided under the Forestry Commission's Native Pinewood Grant.

Such an expansion in semi-natural woodland would increase overall species diversity, providing the increase is limited in extent (MacDonald & Thompson 1990). The precise proportion and mix of open ground to scrub-woodland cannot as yet be defined.

Consolidation of these high interest areas, in terms of appropriate land-use policy, is vital if the maintenance of the open ground bird interest is to be ensured.

Medium Ornithological Interest Areas:

The evaluation identified thirty-five 10 km squares (c.34%) within the medium ornithological interest category. Medium interest areas are found throughout the Region but with the majority being concentrated south of the Highland Boundary Fault (Map 2.1).

Appendix IV lists all those 10 km squares classified as being of medium ornithological interest.

The medium interest areas contain important populations of vulnerable species (Table 2.2). This reflects occurrence of open ground biotopes of high nature conservation value, for example, dwarf-shrub heath. However, biotopes of lesser ornithological importance (such as intensively farmed land) are represented to an even greater degree.

Sensitivity to afforestation:

The areas of medium interest may reasonably accommodate some commercial forestry, albeit on a small scale. Forestry in these areas should be concentrated on biotopes of limited nature conservation interest, and away from any raptor home ranges - including hen harrier, golden eagle, merlin and peregrine - whose prey consists predominantly of open ground species.

Biotopes consisting of natural or semi-natural vegetation types are generally more important in nature conservation terms than artificial biotopes. For this reason new commercial planting is generally acceptable only on existing intensive agricultural lands, such as intensified grasslands and arable.Exceptions to this, and in circumstances in which there would be a net gain in the nature conservation interest have been outlined in the previous section.

All new planting and restocking - whether this consists of pure conifer, pure broadleaves or mixtures - should be designed (as an absolute minimum standard) according to prescribed standards. Current standards are outlined in **Forest nature conservation guidelines** (Forestry Commission 1990).

Low Ornithological Interest Areas:

A total of twenty-four 10 km squares (c.24%) of Tayside is of low ornithological value. Low ornithological interest areas are found entirely to the south of the Highland Boundary Fault in the east,

south-east and southern edge of the Region (Map 2.1). They are generally associated with the lowlands, where the predominant land-use is intensive agriculture.

Appendix IV lists all those 10 km squares classified as being of low ornithological interest.

Tayside Region's low interest areas generally contain no breeding vulnerable birds, although some were present in small numbers in some of the squares, especially waders such as lapwing, snipe, curlew and redshank. Such areas tend to be relatively small sites, but are often of regional importance. They require delineation at a local level, as a strategic approach such as this will tend not to recognise these areas.

Sensitivity to afforestation:

Areas of low ornithological interest may reasonably expect to be the location of future afforestation within the Region. **A presumption in favour of future forest development is recommended in areas of low ornithological interest.** It is generally recognised that suitably designed afforestation of intensive agricultural land, such as arable, results in a net gain in the ornithological interest. Consequently these areas should be classified, within Tayside Region's RIFS, as preferred for future afforestation.

Much land in this category is intensively farmed, being characterised by rich fertile soils and a comparatively mild climate. These conditions provide a wider range of options for afforestation than is available in the less productive uplands. Moreover, the encouragement of lowland planting by Government has never been stronger, with incentives in the form of grant-aid, including a `better land supplement' and support for a variety of silvicultural practices (see Forestry Authorities Woodland Grant Scheme). These include agroforestry, traditional coppice and high forest management.

However, it is of great importance to note that although the ornithological interest of these areas may be low according to this analysis, they may contain habitats of value for nature conservation, some of which have already been designated as Sites of Special Scientific Interest (SSSIs). These sites may be of nature conservation interest other than for their open ground breeding bird interest, hence they would not be detected in the present analysis. Sites, moreover, may also be of seasonal or short-term interest in holding significant numbers of overwintering birds such as geese and swans. It is important that these areas are given protection within the format of the RIFS, i.e. categorised as sensitive.

Part 3. Conclusions

General conclusions

This evaluation has suggested a method of evaluating the existing open ground bird interest of Tayside in order to help minimise the adverse impact of future afforestation. Both the national and international importance of the bird assemblage found here obliges the Forestry Commission (through the provision of grant-aid for planting) and the Regional Council (in the production of a RIFS) to take account of this interest.

Future afforestation should be directed away from those areas which have been shown to be of high ornithological value. Afforestation, however, could be accommodated in those areas categorised as being of low conservation interest for breeding birds. Indeed, appropriate afforestation within these areas has the potential to increase their ornithological interest.

Birds and the wider countryside

Apart from establishing a basis for ensuring the maintenance of the range and numbers of birds associated with open ground throughout Tayside, provision of land-use policy relating to the location of future afforestation should also result in benefits to the conservation of the wider countryside.

The benefits of using birds to formulate land-use policies for nature conservation were outlined by Grice and Galbraith (1992). Of these, the most relevant here are:

i) the ornithological interest relies on and reflects the quality of the countryside in general. This ability of bird species and assemblages to act as indicators of the health of the habitats in which they live arises out of different species' ecological requirements, and

ii) the management (in this context, the consideration of the location of future afforestation) of the rural landscape for birds will also benefit populations of other taxonomic groups for which wider countryside

data is not presently available.

In conclusion, it is clear that the British Government's responsibility to protect vulnerable and regularly occurring migratory birds, including their habitats, as defined by EC Directive 79/409 on the conservation of wild birds, can only be fulfilled through sympathetic land-uses and management practices in the wider countryside. This in turn can only be beneficial to the conservation of the wider countryside as a whole.

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Appendix I: Open ground birds potentially adversely affected by forestry in Scotland

a) Breeding Species:

Red-throated Diver *Gavia stellata*
Black-throated Diver *Gavia arctica*
Slavonian Grebe *Podiceps auritus*
Whooper Swan *Cygnus cygnus*
Wigeon *Anas penelope*
Teal *Anas crecca*
Eider *Somateria mollissima*
Common Scoter *Melanitta nigra*
Red-breasted Merganser *Mergus serrator*
Goosander *Mergus merganser*
Hen Harrier *Circus cyaneus*
Golden Eagle *Aquila chrysaetos*
Osprey *Pandion haliaetus*
Merlin *Falco columbarius*
Peregrine *Falco peregrinus*
Red Grouse *Lagopus lagopus*
Black Grouse *Tetrao tetrix*
Corncrake *Crex crex*
Oystercatcher *Haematopus ostralegus*
Golden Plover *Pluvialis apricaria*
Lapwing *Vanellus vanellus*
Temminck's Stint *Calidris temminckii*
Dunlin *Calidris alpina*
Snipe *Gallinago gallinago*
Whimbrel *Numenius phaeopus*
Curlew *Numenius arquata*
Redshank *Tringa totanus*
Greenshank *Tringa nebularia*
Wood Sandpiper *Tringa glareola*
Common Sandpiper *Actitis hypoleucos*
Red-necked Phalarope *Phalaropus lobatus*
Arctic Skua *Stercorarius parasiticus*
Great Skua *Stercorarius skua*
Black-headed Gull *Larus ridibundus*
Common Gull *Larus canus*
Lesser Black-backed Gull *Larus fuscus*

Herring Gull *Larus argentatus*

Great Black-backed Gull *Larus marinus*

Common Tern *Sterna hirundo*

Short-eared Owl *Asio flammeus*

Skylark *Alauda arvensis*

Meadow Pipit *Anthus pratensis*

Grey Wagtail *Motacilla cinerea*

Dipper *Cinclus cinclus*

Whinchat *Saxicola rubetra*

Stonechat *Saxicola torquata*

Wheatear *Oenanthe oenanthe*

Ring Ouzel *Turdus torquatus*

Chough *Pyrrhocorax pyrrhocorax*

Raven *Corax corax*

Twite *Cardeulis flavirostis*

b) Wintering species:

Bewick's Swan *Cygnus columbianus*

Whooper Swan *Cygnus cygnus*

Bean Goose *Anser fabilis*

Pink-footed Goose *Anser brachyrhynchus*

White-fronted Goose *Anser albifrons*

Greylag Goose *Anser anser*

Barnacle Goose *Branta leucopsis*

Golden Plover *Pluvialis apricaria*

Lapwing *Vanellus vanellus*

Appendix II: Ornithological importance of Tayside Region's open ground habitats

Species	Criterion				
	A	B	C	D	E
Red-throated Diver	*				
Black-throated Diver	*	*			
Wigeon	*			*	
Hen Harrier				*	
Golden Eagle	*				
Merlin					*
Peregrine	*				
Red Grouse	*				
Black Grouse				*	
Golden Plover	*				
Greenshank					*
Short-eared Owl $					
Raven $					
Twite	*				

A International significance of population (>20% of EC breeding population).

B Scarcity as British breeders (<300 breeding pairs in Britain).

C Declining breeding numbers (>50% decline in population over last 25 years).

D Restricted distribution in vulnerable sites/habitats (>50% population confined to <11 sites).

E Species of special concern (discretionary category - usually included due to lack of data).

$ Candidate Red Data species.

(Adapted from Batten *et al.* 1990)

Appendix III: Species accounts: effects of forestry on vulnerable species

Appendix I lists all those birds either potentially or currently being adversely affected by afforestation throughout Scotland. From this master-list of generally open ground birds a number are discussed here, in terms of the ecological consequences of such land-use change.

Species which have been selected for inclusion are of primary nature conservation importance. Their selection is based on criteria given in Appendix II, which has been adapted from that used in *Red Data Birds in Britain* (Batten *et al.* 1990).

The following points are made in the species accounts:

Legal status

A statement on the legal status of the species within the present statutory framework is given under the following:

i) Wildlife and Countryside Act, 1981.

ii) EC Directive 79/409 on the Conservation of Wild Birds.

iii) Convention on the Conservation of European Wildlife and Natural habitats - The Bern Convention.

iv) Convention on the Conservation of Migratory Species of Wild Animals - The Bonn Convention.

Stroud *et al.* (1990) outline and discuss the importance of the international wildlife legislation which covers the conservation of wild birds in Britain.

Population status

Information is given to provide a brief historical overview, where available, of the British population and distribution of species through to modern times. Indication is also given of the relative nature conservation importance in an international context.

Ecology

Detailed information is given on the autecological requirements of species in their breeding grounds, and where applicable on their wintering grounds also.

Effects of forestry

Information based on the Ecology section is reviewed and discussed with reference to the adverse impacts of commercial forestry.

1. Red-throated Diver *Gavia stellata*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 2 of the Berne Convention.

Population status

Britain holds almost the entire EC breeding population of red-throated diver, with nesting being confined to Scotland. Outside Britain a few pairs (<10) breed in north-west Ireland but with no breeding occurring in any other EC country (Stroud *et al.* 1990). The British breeding population is, therefore, of international importance.

The main breeding strongholds are located in Shetland, Orkney and the Western Isles but substantial numbers also breed in Highland Region (especially Caithness and Sutherland). Breeding extends south to Tayside and Strathclyde (Argyll and Arran) with sporadic breeding occurring in Dumfries and Galloway, and Grampian Regions (Thom 1986).

After a decrease in the population in the 19th century (Venables & Venables 1955; Parslow 1973) due to persecution, more enlightened attitudes and legal protection have resulted in a considerable increase in population size and expansion in breeding range in the initial half of the 20th century (Sharrock 1976). This upward trend is apparently continuing; however, there has never been a comprehensive survey of the Scottish population. The current population is probably in the region of 1,000 - 1,200 pairs (Batten *et al.* 1990).

Tayside currently holds an estimated 4 pairs of red-throated divers representing c.0.3% of the total British population. This population is important in maintaining the traditional geographical range of red-throated diver, here at part of its southern global limit.

Ecology

Red-throated divers breed on freshwater lochs. In Scotland these are typically associated with open moorland and blanket bogs where oligotrophic (nutrient-poor) water bodies provide the required habitat. The nest is usually located on a small island or on an undisturbed mainland shore.

Red-throated divers breed on waters of all sizes although work in Shetland found that divers prefer small lochans, but lochs of 5 hectares and larger are also utilised (Bundy 1976). Gomersall *et al.* (1984) found that pairs breeding on lochs smaller than 1 hectare were more successful than those nesting on larger lochs. This preference for smaller water bodies has been noted as one of the main ecological differences betweenthis species and the closely related black-throated diver (Sharrock 1976).

Feeding during the summer usually occurs away from the breeding loch with the majority of food obtained at some distance from the nest site, either on the sea or on large freshwater or sea lochs. Rankin (1947) established that food is occasionally taken from breeding waters.

Effects of forestry

Commercial afforestation and associated forestry practices may affect divers either directly or indirectly.

The direct loss of breeding habitat as a consequence of afforestation is a serious threat. The planting up of the edges of breeding lochs may lead to the physical obstruction of take-off from the water surface (Norberg & Norberg 1971), resulting in the desertion of smaller lochs/lochans. Red-throated divers' preference for small water bodies means planting close to the water's edge may well adversely affect this species.

Indirect effects of afforestation on upland freshwater systems are well documented with ecological damage attributed to afforestation and forestry practices (NCC 1986). Although red-throated divers usually feed away from the breeding loch/lochan, mostly at sea, large freshwater lochs are also used.

Divers feed on fish, insects and amphibians and therefore good water quality of the feeding loch is essential for successful breeding performance. Deleterious effects due to changes in chemical composition of waterbodies have been observed; for example, declines in fish stocks resulting in a reduction in prey availability (Erickson 1984). Reproduction failure of small fish (<20 cm) adversely affects the feeding of young and therefore divers breeding productivity.

McNicol *et al.* (1987) demonstrated that the rate of reproduction in the closely related great northern diver *Gavia immer* was significantly lower in acidified water bodies. This is likely to be a result of decreased availability of fish due to physical changes in water quality.

A further indirect effect of forest development arises from the possible relationship with afforestation and an increase in nest predation adjacent to planted areas. Plantations provide refuges for both mammalian and avian predators such as fox and crows. For obvious reasons ground nesting birds are highly susceptible to any increase in predator densities.

2. Black-throated Diver *Gavia artica*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 2 of the Berne Convention.

Population status

Black-throated divers are scarce birds with Scotland holding the entire British and EC breeding population. Britain therefore has a special international responsibility for its protection as a breeding species.

The breeding range is restricted to the northern and western parts of Scotland with strongholds in Highland Region (Sutherland and Wester Ross) (Thom 1986). The present population is estimated at about 150 breeding pairs (Campbell & Talbot 1987). Recent evidence points to a population decline and

retraction of range (Campbell & Mudge 1989). Tayside currently holds an estimated 8 pairs of black-throated divers representing 5% of the total British and EC population. As with the red-throated diver, this regional population is important in maintaining the southern global range.

Ecology

In contrast to the red-throated diver, this species favours freshwater lochs in excess of 30 hectares and which contain low islets suitable for nesting (Bundy 1979).

Feeding during the breeding season normally occurs in shallow water on the breeding or adjacent lochs. The diet consists mainly of fish, though the young are fed also on aquatic insects. Batten *et al.* (1990) suggest that poor chick survival may possibly reflect shortages of suitably sized fish. High water quality in these feeding lochs is essential for successful breeding.

Effects of forestry

The effects of forestry on divers have been described in the species account for red-throated diver. In summary these are associated with changing water quality, which in turn affects food stocks; changing water regimes resulting in flooding of nests; and alteration of habitats around lochs and nest sites resulting in the desertion of previously suitable waterbodies (Batten *et al.* 1990).

Work in north-west Scotland by Mudge *et al.* (1986) showed that poor breeding success was attributed predominantly to predation. Whilst predation occurs in both undisturbed and disturbed conditions, it is likely that afforestation is associated with acorresponding increase in the number of predators (e.g. Langslow 1984; Stroud *et al.* 1987). This is due to both reduced predator control in plantations, compared to grouse moor and sheepwalk; and the fact that plantations provide suitable habitats for predators, as opposed to open-ground. It is therefore reasonable to suggest that breeding lochs abutting plantations are susceptible to increased predation of both eggs and young.

Black-throated divers' preference for large breeding lochs means that flight paths are less likely to be adversely affected by the planting-up of areas adjacent to breeding waterbodies.

3. Wigeon *Anas penelope*

Legal Status

Listed in Schedule 2, part 1 of Wildlife and Countryside Act, 1981; Annex II/1 of EC Directive 79/409 on the Conservation of Wild Birds; Appendix III of the Berne Convention; Appendix II of the Bonn Convention.

Population Status

Wigeon is one of several subarctic ducks which appear to have colonised Britain during the cooler climatic phase of the 19th century (Sharrock 1976). Breeding was initially recorded in Sutherland in 1834 (Baxter & Rintoul 1922), with subsequent expansions occurring southwards down central Scotland and into northern England. Parslow (1973) points to the fact that elsewhere breeding birds never became permanently established, and to this day wigeon remain sporadic breeders outside their Scottish and north Pennine strongholds.

The marked increase and expansion of breeding range which occurred in the second half of the 19th century, and which probably continued in southern Scotland until about 1950 (Baxter & Rintoul 1953) seems to have halted (Yarker & Atkinson-Willes 1971; Owen *et al.* 1980). Difficulties with censusing this secretive species mean assessment of the population remains problematical (Thompson & Dougall 1988).

Britain's breeding wigeon population, estimated in the late 1960s at some 300 pairs (Yarker & Atkinson-Willes 1971), and in the early 1970s at 300-500 pairs (Sharrock 1976) remains concentrated in their original Scottish strongholds. Thom (1986) suggests that some 75% of the total British population is to be found at these original sites. Of these, the majority (55%) occur in the Flow Country (Stroud *et al.* 1987; Fox *et al.* 1989a). The present population status in Tayside is unclear.

Ecology

Throughout much of their British range wigeon are associated with moorland where dubh-lochans, tarns, lochs and streams provide ideal breeding sites. This is despite the fact that the largest

concentration of breeding wigeon is found on the islands of Loch Leven in Tayside. Islands are preferred where they exist, for they reduce or eliminate access to nests by mammalian predators.

Effects of Forestry

Extensive afforestation of peatlands in recent decades has resulted in the transformation of open moorland to closed forest. Although wigeon are an important component of the assemblage associated with open moorland/peatland, it is difficult to quantify losses due to the fact that this species is so thinly distributed across most of its favoured areas. Wigeon must, however, be presumed to have been adversely affected by afforestation (e.g. Stroud *et al.* 1987). Further losses as a direct result of the replacement of breeding habitat with plantations will continue to represent a threat.

Wigeon are almost entirely vegetarian, their diet and feeding behaviour resembling that of geese, being grazers of short swards. The importance of grazing areas away from the water-body is unclear. Thompson & Dougall (1978) found two broods in Ettrick Forest about 50 m and 300 m respectively from a loch. The loss of these open areas to plantations could well have an adverse affect on wigeon habitat requirements.

4. Hen Harrier *Circus cyaneus*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 3 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

During early decades of this century breeding hen harrier were confined to Orkney and the Outer Hebrides. This followed a decline in the 19th century as a result of habitat loss and intense persecution by game-keeping interests.

Since the 1930s the population has increased and the breeding range has spread to include much of upland Scotland, parts of northern England and north Wales. The current Scottish breeding population is estimated to be about 520-630 pairs (Bibby & Etheridge, in prep.), representing approximately 9% of the EC breeding total. Tayside currently holds an estimated 85 pairs of hen harrier representing about 19% of the total British population, and 2% of the EC population. This population is therefore important in maintaining both the number and traditional range.

In Tayside 93% of the Region's hen harriers are found on moorland and other open ground biotopes. The viability of populations such as this is entirely dependent on the maintenance of open moorland and to a large degree on the cessation of persecution. Conservation requirements, in terms of planting recommendations for this species, include a reduction in afforestation of open ground (especially heather moorland), and a cessation of infill planting between existing forest blocks.

Watson (1977) gives a detailed historical account of the hen harrier in Britain.

Ecology

Formerly, hen harriers bred throughout Britain in a wide variety of habitats. Presently, however, the breeding distribution is mainly limited to extensive open heather moorland between 200 m and 300 m above sea level (Thom 1986) and plantations with trees in the early stages of growth. Heather-dominated moorland has declined dramatically in many parts of Scotland in recent times, as a result of land-use changes and in particular as a consequence of afforestation (e.g. Ratcliffe 1991).

Hen harriers prey on small birds, grouse, rodents, rabbits and hares - all species typical of open ground biotopes.

Effects of forestry

In recent decades young forestry plantations have been used by hen harriers as nest sites (Watson 1977). Afforestation provides some short-term benefits, but along with agricultural intensification is harmful to this species in the long-term, through loss of open moorland (Watson 1977; Galloway & Meek 1978; O'Flynn 1983). As young plantations mature, these forest habitats will cease to hold breeding hen harriers. Thus, plantations are only recognised as being of value in the initial years of establishment

with populations declining as the forest enters the thicket stage (O'Flynn 1983). There are only few known examples of hen harriers either breeding or attempting to breed in re-stock areas (Petty & Anderson 1986).

Watson (1977) showed that plantation nesting harriers in southern Scotland did much of their hunting over adjacent open moorland. Their diet consisted mostly of small passerines typical of open ground, such as meadow pipit *Anthus pratensis* and skylark *Alauda arvensis*. Watson showed male hen harriers to hunt up to 5 km from nest sites and defend territories up to 3 km in diameter. Large areas of open moorland are therefore essential for a viable hen harrier population.

Even for forest nesting hen harriers the proportion of forest living prey in the diet was low. Paradoxically, Bibby & Etheridge (in prep.) found that productivity of hen harriers nesting in plantations was comparatively higher than those in open ground habitats. This is believed to be due entirely to lower human persecution in plantations compared to persecution associated with grouse moor management.

The viability of hen harrier populations is entirely dependent on the maintenance of open moorland and to a large degree on the cessation of persecution. Conservation requirements, in terms of planting recommendations for this species, include a reduction in afforestation of open ground (especially heather moorland) and a cessation of infill planting between existing forest blocks.

5 Golden eagle *Aquila chrysaetos*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 3 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

Throughout the 19th century, the golden eagle was intensively persecuted by sheep farmers, game keepers and collectors in Britain and Ireland resulting in their extinction in England, Wales and Ireland. In Scotland, the population and range was much reduced and confined largely to more remote mountain areas (Thom 1986).

During the wars of 1914-18 and 1939-45, fewer game keepers and shepherds were on the land; this resulted in an increase in the golden eagle population. Recolonisation occurred in parts of Scotland including areas vacated by the extinction of the white-tailed eagle *Haliaeetus albicilla*. From 1953 to 1960 a pair nested in Co. Antrim, N.Ireland and in 1969, the species returned to breed in northern England.

The most recent population estimate by Dennis *et al.* (1984) revealed some 424 pairs of golden eagle occupying home ranges, with single birds present in a further 87 areas. The majority of these pairs are located in Scotland. The British population is of international importance, representing approximately 50% of the EC population (Stroud *et al.* 1990). Tayside is currently estimated to hold 45 pairs of golden eagle, representing 10% of the total British population and 5% of the EC population. The Region therefore has an international responsibility for the protection of this breeding species, both in terms of absolute numbers and in maintaining the geographical range. This population is also important as a potential source for recolonisation and increase of numbers into other regions.

Ecology

Throughout their Scottish range golden eagles hunt over extensive, usually upland areas varying from heather-dominated moorland to relatively barren mountains. This habitat preference corresponds, generally, with the altitudinal range of current commercial afforestation. As a result the population is considered to be in serious threat from further afforestation (Watson *et al.* 1987).

Golden eagles in much of Scotland are substantially dependent on carrion for winter food, which accounts for up to 40-75% of prey items during the period January to April (Watson *et al.* 1987). The main components include sheep in the south-west and red deer *Cervus elephus* in the north-west. An adequate supply of carrion is closely correlated with eagle density.

However, Watson *et al.* (1987) also showed the occurrence of a dietary shift to more live prey in

summer (May to August), thereby establishing that breeding performance is inherently associated with amounts of live prey. Live prey components,including red grouse and Lagomorphs (rabbits and hares), were shown to contribute the bulk of summer prey items. Additional live prey included those characterised by requiring open ground for their survival.

Variation in golden eagle nesting density and breeding performance across its Scottish range has, therefore, been shown to involve an inextricable link with winter and summer prey (Watson *et al.* 1987). This prey is itself dependent on large areas of open ground.

Effects of forestry

In Britain golden eagles occupy large home ranges, in the order of 75 km^2, in which their food supply is randomly distributed (Watson *et al.* 1987). These home ranges traditionally comprise open ground in which eagles prey on species which favour open ground themselves. Forest dwelling animals do not form a substantial part of the diet. This is, presumably, because eagles cannot catch their prey easily amongst trees. This is consistent with the fact that throughout their geographical range golden eagles are birds of open country. Even in breeding areas in coniferous parts of Fennoscandia, the pine/spruce woodland is interspersed with extensive open areas of bogs as well as with higher ground above the natural tree-line.

Any land-use change which substantially alters availability of open ground prey thereby affects eagle carrying capacity. Commercial large-scale afforestation of golden eagle home ranges represents an inimical land-use to the survival of the present eagle population (Marquiss *et al.* 1985; Watson *et al.* 1987; Watson, in prep.). Extensive changes in upland land-use, predominantly as a result of increasing afforestation, have meant a widespread decline in hill sheep farming and grouse moor management. At the same time this has reduced open ground prey and as a result the eagle population has declined (Watson *et al.* 1987).

Work in the Scottish Highlands by Watson *et al.* (1987) concluded that as a result of afforestation, at present rates of planting, the number of golden eagles in the Scottish Highlands could decline by more than 20%.

The adverse effects of afforestation on eagles are complex, being dependent both on the proportion of the home range afforested and the habitat quality (in terms of prey availability) of the remaining open ground. These effects vary in severity, including at worst desertion of the home range to a decline in breeding performance. Marquiss *et al.* (1985) found that breeding success declines as the proportion of eagle home range that is afforested increases. More recently, Watson (in prep.) has confirmed this, but he also showed that a significant lag period of not less than 10 years operates prior to suppressed breeding. It is therefore apparent that, depending onprey availability, golden eagles cannot tolerate large proportions of their home range being afforested.

Conservation of golden eagles requires the maintenance of open moorland and hill ground, and the continuation of traditional land-use practices thereby ensuring the sustainability of the present population.

6 Merlin *Falco columbarius*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 2 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

The British merlin population has declined over a long period, perhaps at an increasing rate since about 1950 (Parslow 1973). As with a number of birds of prey, organochlorine pesticide use, which began in the 1960s, is implicated as a contributing factor (Newton 1973; Newton *et al.* 1982). In more recent times, studies have reported continuing population declines of varying severity (e.g. Newton *et al.* 1981, 1986; Williams 1981; Roberts & Green 1983).

The current British breeding population is estimated to be 550-650 pairs, and is widely but thinly scattered in moorland areas from south-west England to Wales, northern England and Scotland. Tayside currently holds an estimated 90 pairs of merlin representing 15% of the British and about 13% of the

EC population. The only other EC country where merlin breed is in Ireland (with about 100 pairs).

The population status of the merlin has been reviewed and discussed by Bibby & Nattrass (1986).

Ecology

Merlin are typically associated with extensive heather moorland (Newton *et al.* 1978), primarily where grouse shooting and its attendant management continues as a major land use (Bibby & Nattrass 1986).

Typically merlin nest on the ground amongst rank heather, or in trees and on small crags. Their diet consists of a wide range of predominantly open country birds, with meadow pipit making up a considerable part (Bibby 1987).

Effects of forestry

Changes in upland land-use in recent decades has meant the loss of vast areas of heather dominated moorland - merlins' preferred habitat. These losses have primarily been due to increased rates of afforestation. Although in recent decades young forestry plantations have been used as nest sites, Newton *et al.* (1978) showed that where young plantations were used all occupied nests were within 1 km of open ground. Moreover, the diet of plantation nesting merlin has been shown to consist almost entirely of open ground species (Watson 1979). Clearly, any large-scale afforestation would lead to a reduction in numbers of these typically open country prey species and thus in the amount of food available to merlin.

The implications for existing populations within areas which are heavily afforested at present, and where as a consequence expanses of open moorland have been diminishing rapidly, are particularly serious. Maintenance of open moorland is essential for the continued survival of merlin. In order to ensure the viability of the present population in Tayside Region afforestation of merlin's habitats (especially heather moorland) should be avoided.

7 Peregrine *Falco peregrinus*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 1 of the EC Directive (79/409) on the Conservation of Wild Birds; Appendix 2 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

Over the past fifty years peregrines have undergone several retractions in range and population decline. These occurred as a result of persecution and alterations in land-use practices (Ratcliffe 1984).

The British breeding population is currently estimated to be about 1050 pairs and is widely but thinly distributed in coastal and upland areas from south-west England to Wales, northern England and Scotland. Scotland holds the bulk of the total British breeding population. Tayside currently holds an estimated 125 pairs of peregrine representing 14% of the total British population, and is therefore important in maintaining the numbers and geographical range.

Ecology

The distribution of peregrine is largely dependent on the presence of suitable cliffs or crags for nesting, with only occasional departures from this nesting adaptation occurring in Britain and Ireland (Ratcliffe 1980).

Peregrines prey on a wide variety of birds, typically caught on the wing. The species taken as prey reflects their availability generally and includes those typical of open ground biotopes. Prey includes a variety of passerine and wader species (Ratcliffe 1980). In regions in which feral pigeons *Columbia livia* are abundant these often form a major part of their diet. Species of closed-forest are not an important part of peregrines' diet.

Effects of forestry

Ratcliffe (1980) considered that large-scale afforestation of moorland and open hill had not yet affected peregrine numbers or breeding success significantly. He suggested that if current Forestry Commission objectives to plant up to another 1,800,000 hectares of new forest by 2025 were realised, the effect

would have serious deleterious implications. Continued afforestation of open ground, especially in areas where feral pigeons are infrequent, would alter prey availability and hence a possible reduction in the present population could result.

Absence of any valid evidence of tree-nesting by this species in Britain means that afforestation of open ground habitats is unlikely to provide nest sites in regions where cliffs or crags are sparse. Moreover, there are instances where the planting-up of small crags has resulted in the abandonment of eyries (Ratcliffe 1980).

8 Red Grouse *Lagopus lagopus*

Legal status

Protected under Annex III/1 of EC Directive 79/409 on the Conservation of Wild Birds; Appendix III of the Berne Convention.

Population status

Formerly considered an endemic species to Great Britain, red grouse is now recognised as a distinct endemic sub-species of the willow grouse - a bird of Scandinavia, much of northern Europe, Canada and Alaska. Red grouse, however, are confined to Scotland, northern and south-west England, Wales and Ireland (Sharrock 1976). Thom (1986) records this species as breeding in all Scottish mainland districts during the period 1968-72.

Long-term population trends in Wales, northern England and Scotland have been estimated by shooting-bag returns and by research carried out by the Institute of Terrestrial Ecology and the Game Conservancy (e.g. Jenkins *et al.* 1967). Analysis of annual shooting-bag returns have indicated several phased declines since the mid-1930s, with only one period of sustained increase throughout Britain as a whole. In Scotland a gradual and continuing decline was initially noted in the early 1900s (Leslie 1911), and has continued since, such that by the early 1970s shooting-bags were only 10% of what they had been in the 1900s (Thom 1986).

The decline in red grouse numbers in recent decades has been attributed to a variety of causes. These include:

i) reduced keepering with consequent poorer moor management

ii) over-grazing by increasing numbers of sheep and red deer resulting in the replacement of heather-dominated vegetation by a grass dominated sward

iii) increase in tick-borne disease

iv) agricultural improvement of moorland to re-seeded grassland

v) loss of moorland as a consequence of afforestation

Red grouse population estimates in Britain, as for other countries, are difficult to assess due to large population fluctuations from year to year (Barnes 1987). Sharrock (1976), however, suggested that the British and Irish population probably do not exceed 500,000 pairs. The present population status in Tayside is unclear.

Ecology

Throughout their range red grouse inhabit open, treeless moorland dominated by ericaceous vegetation, e.g. heather, crowberry *Empetrum nigrum* and blaeberry *Vaccinium myrtillus*. In the wetter climate of western Scotland, grouse also occurs on blanket bog where heather is sparse (Sharrock 1976). Winter and summer distributions of red grouse are alike (Lack 1986; Sharrock 1976).

Adult red grouse diet consists predominantly of young heather and bilberry shoots, but with a dietary shift in the actual proportion taken occurring throughout the year. Inflorescences of cotton grass *Eriophorum* species are particularly favoured in the spring, with berries, grass and sedge seeds also being taken in the summer and autumn (Watson & Miller 1976).

Stuart & Lance (1983) have shown that gripping (drainage) of flushes and damp areas within moorland results in the loss of invertebrate-rich feeding areas which are important for young grouse. Stuart & Lance established that grouse broods using such abundant supplies of invertebrates have higher rates of

growth and survival than broods in drier areas. The practice of altering moorland hydrology as part of afforestation programmes can, therefore, potentially deprive chicks of a critical food source at a time when high levels of nutrients are most required.

Grouse moor management aims to promote a mosaic of heather age classes, and the retention of wet flushes (Miller 1980). It has been suggested that this management regime provides an ideal environment for both breeding grouse and waders alike (Reed 1985).

Effects of forestry

The declining economic viability of grouse moors, due in part to a decrease in the red grouse population, and fiscal support for afforestation (in the form of tax incentives and planting grants) has caused the transformation of many upland moors to large-scale forests. Decreases in local populations, due to afforestation, have been reported in south-west Scotland, Argyll, parts of Perthshire and the north-east (Thom 1986), and it is probable that grouse numbers will continue to decline as a consequence of afforestation.

Afforestation of heather-dominated moorland results in the replacement of suitable grouse habitat with an unsuitable one. This results in the loss of grouse once the plantation has reached the thicket-stage, when the associated moorland vegetation is out-shaded (Parr 1990).

The decline of grouse-moor management, i.e. muirburn, in areas of moorland immediately adjacent to plantations means that the heather becomes tall. Red grouse and moorland waders have been found to avoid extensive areas of such tall or `leggy' heather (Reed 1985).

A further edge-effect of afforestation on surrounding open moorland is the potential increased rate of predation on open ground nesting birds such as grouse. Afforestation provides cover for predators, notably fox and crows (e.g. Barnes 1984; Parr 1986; Watson 1983).

Curtailment of afforestation on key moorland areas would enable more habitat to survive, thus facilitating the survival of this internationally important species (Batten *et al.* 1990).

9. Black Grouse *Lyrurus tetrix*

Legal Status

Protected under the Game Acts (close season: 11 December - 19 August); Annex II/2 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 3 of the Berne Convention.

Population Status

Black grouse were formerly much more widespread, but during the late 19th and early 20th centuries disappeared from many English counties (Gladstone 1924). A similar decline occurred in Scotland following a period of increase and abundance in the late 1880s and early 1890s (Rintoul & Baxter 1927). The fate of this species during the 19th century in Wales appears to have been similar to that in England and Scotland (Hope Jones, in press). During the period 1940 to the mid-1970s, however, the population is thought to have increased and expanded its range. Since 1975 numbers have again declined (Cayford & Hope Jones 1989).

In Britain, the majority of the present population is found in Scotland with analyses of Scottish bag records revealing a decline of over 75% in the numbers shot since 1935 (Baines 1990). The present population status in Tayside is unclear.

Ecology

Black grouse occupy vastly differing habitat types. In Sweden and Norway, for example, where numbers are relatively stable, their main habitats include young boreal forest with some clear-felled areas and open bog (Angelstam 1983; Kolstad *et al.* 1985). In Scotland, a mixture of moorland, low intensity agricultural land, coniferous plantation and naturally regenerating young and old boreal forest are all occupied (Johnstone 1969).

The variation in habitat use by black grouse has been explained by Baines (1990), in a three-year study in Scotland. Baines showed black grouse to appear to have three periods when food requirements may be construed to be a limiting factor on populations. Firstly, prior to nesting when grouse require a food source rich in protein and calcium to produce eggs, secondly when young chicks require an easily

digestible protein diet and thirdly, during harsh winter conditions when a food source needs to be maintained. Black grouse therefore exhibit a seasonal variation in habitat preference associated with this shift in dietary requirements.

In Baines' study grouse were generally not associated with moor or blanket bog in spring but fed selectively on buds of larch *Larix* species and birch *Betula* species. In summer habitat preferences changed, with the grouse moving back onto the open moorland where the occurrence of insect-rich flushes provided the chicks with a protein-rich diet. Habitat preferences were seen to change yet again in late summer to drier moorland (withblaeberry and cowberry *Vaccinium vitis-idaea* fruit being taken) before the return to predominantly birch woodland in late autumn.

This seasonal variation in diet requires a combination of habitat types within each individual's home range, if populations are to remain viable.

Research on home range size requirements has shown a considerable variation between workers; Johnstone (1969) found that home ranges of lekking males in north-east Scotland were about 500 ha, Robel (1969b) showed that on the same estate measured home ranges for individual males were up to 700 ha. and Picozzi (1986), again in north-east Scotland, showed home ranges of males to be 355 ha. The requirements of a viable population of black grouse in Tayside clearly includes large areas of suitable mixed habitat, based on moorland.

Effects of Forestry

Although not strictly an open ground bird, black grouse occupy both woodland and moorland, and it is this juxtapostion of habitats which is required to maintain populations (Baines 1990). Afforestation can substantially alter availability of these habitats and in so doing affect the carrying capacity for black grouse.

Plantations can initially be of benefit; however, since the late 1970s forestry practices have involved the ploughing of deep drains prior to planting. This improves drainage and provides a drier base for tree establishment. The effect of this practice is to destroy mires recognised as important feeding areas during the breeding season (Picozzi & Hepburn 1986; Baines 1990).

Burning of moorland prior to planting (an idea developed also in the 1970s) removes nest cover for the initial spring following planting; however, nest cover may be adequate in the subsequent years before canopy closure occurs. Herbicides, however, are often used to eliminate regrowth of dwarf shrub heath, thereby adversely affecting black grouse habitat (Cayford 1988). After canopy closure occurs ground cover is reduced and gradually lost resulting in the loss of areas for ground feeding or nest cover (Parr & Watson 1988).

Dense plantations, therefore, are avoided which suggests that black grouse will benefit from afforestation only if efforts are made to preserve areas of suitable habitat within or close to plantations. Afforestation of whole or partial areas of suitable habitats will result in further reductions of this species' population and contraction of its range. Parr & Watson (1988) suggested that the decline of black grouse is due mainly to habitat destruction and impoverishment, arising from changes in land-use and management of which commercial afforestation is probably a major factor.

10. Golden Plover *Pluvialis apricaria*

Legal status

Listed in Schedule 2 of the Wildlife and Countryside Act 1981; Annex 1 of the EC Directive (79/409) on the Conservation of Wild Birds; Appendix 3 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

The British breeding population of golden plover is currently estimated to be 23,000 pairs, representing over 90% of the EC population (Stroud *et al.* 1990). A suspected continuing decline is thought to have occurred in recent decades. Documented losses have occurred in northern England and southern Scotland (Parslow 1967), and north-east Scotland (Stroud *et al.* 1987).

Stroud *et al.* (1987) documented the loss of open moors and blanket bogs to afforestation in Caithness and Sutherland, where a 19% decline has been observed on a population originally representing about

18% of the national population. Further losses have also occurred in Wales, the North York Moors, Cheviots, Southern Uplands and the Eastern Highlands. These are estimated to account for at least 2,000 pairs (Stroud *et al.* 1987). Population trends in golden plover have recently been reviewed by Boobyer (in press). The current population in Tayside Region is unknown.

The British wintering population is estimated at about 200,000 birds (Fuller & Youngman 1979). This represents, together with maritime France and Ireland, the major wintering ground for European golden plover. Britain's responsibility for holding this proportion of the biogeographical wintering population of the EC breeding population is of international importance. The golden plover population status within Tayside Region is presently unknown. Aspinall and Dore (1983) reported them as surprisingly scarce and absent from many areas but are known to favour moorland managed for grouse.

Ecology

Golden plover are distributed throughout upland areas of Britain, breeding in a range of semi-natural biotopes including, hill grasslands, moorland and peat bogs (Sharrock 1976). It has been suggested that grouse moor management provides ideal breeding habitat (Reed 1985). Typically they are associated with gently sloping ground, with the highest densities of breeding birds occurring at 240-600 m above sea level (Ratcliffe 1976). Marginal low intensity agricultural land has also been reported to be of importance for supplementary feeding during the summer.

Nests are mostly found where the dominant vegetation cover is short and usually under 15 cm in height (Ratcliffe 1976). On damp peaty ground nests are often placed on hummocks where they will remain dry. Golden plover almost always nest on unenclosedground.

In winter the majority of golden plover are found on agricultural land, particularly lowland permanent pasture (Fuller & Youngman 1979; Fuller & Lloyd 1981). Feeding occurs mainly on permanent pasture, probably because of greater near-surface invertebrate densities, particularly earthworms.

Golden plover are well known for their use of particular feeding areas, returning to certain traditional fields each winter (Fuller & Youngmam 1979). Roosting areas have also been shown to consist of preferred areas, usually occurring on ploughed fields and winter cereals (Fuller & Lloyd 1981).

Effects of forestry

The documented decline of golden plover throughout much of Britain has in many regions been attributed to afforestation of its open ground habitats. Loss of grouse moors to afforestation is recognised to be of particular concern (Batten *et al.* 1990). A direct loss of breeding habitat is the most obvious effect of afforestation, with most of the species' breeding ground being located on lands which have a potential to be afforested (Ratcliffe 1976).

Indirect effects of afforestation are thought to include increased predation on breeding grounds, both on eggs and young (Parr 1989). Plantations abutting open ground biotopes afford predators shelter from which they can then hunt. Parr (1980) showed that predation of golden plover nests accounted for 75% of plover eggs during one breeding season, although the rate of predation varied considerably from year to year. Crows were determined as the main egg predators.

Parr (1986) found that afforestation of parts of his study area in Kincardinshire resulted in a dramatic decline in the population of golden plover, from 111 birds in 1977 (Parr 1980) to only 12 in 1985. This decline was shown to be attributed to increased predation on nests by carrion crows and fox. Common gull *Larus canus* (a component of the open ground bird assemblage in many regions throughout Scotland) was also shown to be a major predator.

The potential edge effect of plantations on surrounding open ground has, in recent years, been much discussed and most recently reviewed by Avery & Leslie (1990). It would seem that vegetational changes occurring principally as a result of the cessation of moor-burning adjacent to plantations tend not to favour the short vegetation preferred by golden plover. Moreover, the potential increase in the rate of predation adjacent to plantations can also justifiably be termed as an edge effect. These conclusions would therefore tend to agree with Stroud and Reed (1986) who established that a considerable zone extending out from plantations is avoided by waders such asgolden plover.

Wintering golden plover regularly return to `flock-ranges' outside which they rarely occur. Land-use changes in the lowlands, particularly commercial afforestation of traditional wintering roosting and feeding areas could, if unplanned, have an impact on wintering populations. This type of bird interest

should be taken into account in the planning of future afforestation.

11 Greenshank *Tringa nebularia*

Legal status

Listed in Schedule 1 of the Wildlife and Countryside Act, 1981; Annex 2 of EC Directive (79/409) on the Conservation of Wild Birds; Appendix 3 of the Berne Convention; Appendix 2 of the Bonn Convention.

Population status

Estimates of the British breeding population of greenshank vary from 400-750 pairs during the period 1968-72 (Sharrock 1976), 805-905 pairs in 1977 (Nethersole-Thompson 1979) and 960 pairs in 1985 (Stroud *et al.* 1987). Intensive surveys have shown numbers vary quite considerably from year to year. Assuming the figure given by Stroud *et al.* (1987) of 960 breeding pairs as representing the best approximation, this represents the entire EC breeding population and is therefore recognised as being of international importance.

Breeding in the British Isles is confined to northern, western and central Scotland (apart from one pair which nests at a regular site in Ireland). The breeding population within Tayside Region is presently unclear due to its dispersed nature and remoteness of its breeding habitat. However, the peatlands of Rannoch Moor are thought to remain the greenshank's stronghold in Tayside.

In northern Europe and USSR greenshanks breed in huge forest marshes, but in Scotland they are birds of open peatlands and moorlands. Only in very few areas, e.g. forests of Strathspey, have greenshank occupied (in recent times) their continental ecological niches. In these Strathspey forests, such as Abernethy and Rothiemurchus, extensive felling and forest fires periodically created habitats favoured by colonising greenshank.

Ecology

In northern Europe and USSR greenshanks breed in huge forest marshes, but in Scotland they are birds of open peatlands and moorlands. Only in very few areas, e.g. forests of Strathspey, have greenshank occupied (in recent times) their continental ecological niches. In these Strathspey forests, such as Abernethy and Rothiemurchus, extensive felling and forest fires periodically created habitats favoured by colonising greenshank.

Breeding greenshank require a large extent of open ground, characterised by an abundance of open shallow water, most often utilising areas of blanket bog or wet heath, often broken up by rocky ground (Thom 1986). These large territories mean that one pair typically occupies 100-300 hectares (Nethersole-Thompson1951). Thus, substantial areas of suitable habitat are required to support viable breeding populations.

The main food items of greenshank include small fish, invertebrates associated with open water and wet ground. Like many other waders greenshank families may move several kilometres from the nesting area to concentrate feeding on loch/lochan shores, along burns or mires (Nethersole-Thompson & Nethersole-Thompson 1943). Young greenshank have been shown to move 1.6 km from the nest site to a lochside to feed and adults have been recorded feeding up to 4 km from the nest site

Effects of forestry

The adverse effects of forestry on greenshanks can be divided into those which occur as a direct result of afforestation and those occurring due to indirect effects. A direct loss of breeding habitat is the most noticeable effect, and in recent years the concentration of planting on biotopes favoured by greenshank, e.g. peatlands, has had serious deleterious consequences. Stroud *et al.* (1990) considered greenshanks to be severely threatened by widespread afforestation of the Scottish peatlands. An example of this is in Highland Region where Stroud *et al.* (1987) estimate that 130 pairs of greenshank have been lost through afforestation in the peatlands of Caithness and Sutherland.

Young plantations have been used by greenshank for breeding but as the plantation matures and the ground vegetation diminishes both feeding and breeding habitat is lost. Nethersole-Thompson & Nethersole-Thompson (1986) noted that greenshanks in Strathspey vacated breeding territories in forest clearings once the tree canopy closed.

Apart from the direct loss of habitat, it is thought that the conservation value of areas abutting plantations is also depressed. Similar to other waders, moorland burning and grazing favours greenshank (Sharrock 1976) but tends to cease after planting due to problems of forest fires and fragmentation of grazing lands and grouse moor. These changes in land-use practices tend not to favour the short vegetation preferred by greenshank.

In addition to the vegetational changes outwith the plantations, the plantations themselves provide shelter for a higher number of predators than the open ground would otherwise support. These predators, include foxes and crows, all prey on ground nesting birds (see A III.9 Golden plover).

12 Short-eared owl *Asio flammeus*

Legal status

Listed in Annex 1 of EC Directive 79/409 on the Conservation of Wild Birds; Appendix 2 of the Berne Convention.

Population status

The numbers of short-eared owls breeding in Britain are unclear; the best available estimate is over 1,000 pairs (Sharrock 1976). Trends of population changes are difficult to ascertain due to periodic fluctuations in small mammals, particularly cycles in vole numbers which in turn affect breeding densities of short-eared owl (Village 1987).

The British population is of international importance, both in terms of its size and for the maintenance of part of the traditional breeding range. The current breeding population in Tayside Region is unknown.

Ecology

Throughout Scotland short-eared owls inhabit open ground biotopes, including moorland, heaths, marshes, bogs and sand dune systems (Thom 1986). In recent decades young forestry plantations have also been utilised for feeding and breeding.

Short-eared owls prey predominantly on small mammals; the prey species depends on their relative abundance and availability (Clark 1975; Roberts & Bowman 1986). For successful breeding owls require extensive areas of open ground supporting a high population of small mammals, including: pygmy shrew *Sorex minutus*, common shrew *S. araneus*, field vole *Microtus agrestis*, bank vole *Clethrionomys glareolus* and mice *Apodemus* spp.

Effects of forestry

An important factor influencing populations of short-eared owls is afforestation of their open ground habitats. Effects of afforestation should be viewed in respect of not only the short-term but also their long-term implications. New plantations are fenced to protect the young trees from herbivores such as sheep and deer. As a result the vegetation grows unchecked, providing ample food and cover for small mammals in the short-term. Similarly, these areas in turn provide the owls with a plentiful short-term supply of prey.

The presence of plantations in many upland areas throughout Scotland has in recent times, particularly since the 1970s, resulted in high densities of this species occurring sporadically in such habitats. Plantations and their use by owlshas resulted in considerable changes in their breeding distribution, as for example shown in the Atlas of Breeding Birds in Britain and Ireland (Sharrock 1976). Where planting has recently taken place on land formerly heavily grazed the area of suitable habitat will have increased and a consequent expansion in range and increase in numbers can be expected to have occurred.

However, as for many open ground birds which utilise plantations for breeding and/or feeding, plantation-use is limited to the early stages of tree growth. Once the trees prevent light from reaching the ground the vegetation eventually dies and renders the site unsuitable for small mammals and inaccessible to short-eared owls.

Utilisation of re-stocked areas by owls could prove to be an important factor in areas where open ground habitats have been largely replaced by afforestation. Very little is known concerning the willingness of this species to occupy re-stock areas. To ensure the viability and distribution across the

traditional range, the location of future afforestation should be directed away from habitats where short-eared owl populations presently exist, e.g. moorland areas.

Stroud *et al.* (1990) suggested that the long-term wellbeing of the short-eared owl population will depend to a large extent upon the maintenance of extensive areas of unafforestated moorland and rough grassland habitats. All these biotopes have been shown to be threatened by present commercial afforestation in much of Scotland (e.g. Ratcliffe 1991).

13 Raven *Corvus corax*

Legal status

Listed in Wildlife and Countryside Act, 1981 (Part 1, Section 1)

Population status

The raven population suffered greatly from persecution in the initial half of the 20th century, resulting in a large retraction of range and reduction in numbers throughout much of Britain. This period represented a continuation of the 19th century, when by the end of the first quarter of the 1800s, raven persecution by shepherds and gamekeepers was well established (Mitchell 1981). A recovery of the population during the World Wars, as a result of reduced keepering, was especially noticeable during the 1939-45 war and continued locally until the 1950s (Parslow 1973). Ravens, however, are still widely persecuted, particularly in north-east England and many parts of Scotland.

Throughout Scotland ravens are still widely distributed in the Highlands and Islands, but decreases in recent years have occurred, e.g. in central Scotland (Mitchell 1981) and the Southern Uplands (Marquiss *et al.* 1978; Mearns 1983). These decreases have coincided with changes in land-use, particularly afforestation, which has resulted in large tracts of open ground being lost.

The British breeding population is currently being assessed (Thomas, pers. com. 1991). It is evident that for areas within ravens' range quite substantial retractions have occurred since the most recent population estimates. Sharrock (1976) assumed an average density of 3 pairs/10 km square, and extrapolations from this suggested totals of approximately 4,000 pairs in Britain. Tayside Region currently holds an estimated 30 pairs of raven and is important in maintaining the population numbers and geographical range, as well as acting as a potential source for expansion into other regions.

Ecology

Ravens are now restricted to fairly remote upland areas and on cliff-bound coasts. In these habitats breeding populations have remained relatively constant, with populations stabilised at a level presumably compatible with territorial spacing and available food resources (Holyoak & Ratcliffe 1968). Whilst a preference for cliff nesting is prevalent (tree-nesting does also occur), the availability of suitable nesting sites has been shown to be only locally limiting (Marquiss *et al.* 1978).

Effects of forestry

In the 1950s a decline in the raven breeding population occurred, initially in the Galloway uplands, following extensive afforestation programmes (Holyoak & Ratcliffe 1968). Afforestation of open ground habitats affects carrion-feeding birds, such as raven, because of the reduction in carrion availability following cessation of upland sheep and deer management.

Diet analysis of ravens have revealed that sheep carrion is a major food component for both inland breeding pairs (Marquiss *et al.* 1978; Newton *et al.* 1982; Ratcliffe 1962) and coastal breeding pairs (Ewins *et al.* 1986; Ratcliffe 1962) throughout Britain. However, diet is highly varied with considerable variation between territories (e.g. Ewins *et al.* 1986). Of other food items, voles, rabbits, invertebrates, birds, bird-eggs, fish and domestic rubbish are all included in varying quantities.

Ravens therefore require large home ranges in which their unpredictable food supply is often unevenly and randomly distributed. Ratcliffe (1962) found that for 139 territories studied in inland England, Scotland and Wales, the average area was 20 km^2 or 2000 hectares. In upland regions throughout Scotland ravens are most numerous and territories smaller where sheep densities are high, with reasonable densities on grouse moor but only in low numbers with associated larger territories in the deer forest country (Sharrock 1976).

Work by Marquiss *et al.* (1978) in southern Scotland and northern England concluded that the decline

of this species was associated with commercial afforestation. Afforestation resulted in later and smaller broods, more non-breeding, through to complete territory desertion. The levels at which ravens deserted were shown to vary from pair to pair. It was concluded that good habitat could take more afforestation prior to forest development becoming inimical. Historical data from 1946 showed that until the 1960s the population remained stable from year-to-year. The breeding population by 1974-75, however, had declined such that only 55% of former regular nesting areas were still occupied. This decline was attributed to afforestation of the area. In particular results showed that breeding performance was associated with the extent of afforestation within 5 km of nest sites. Desertion, however, was more closely associated with afforestation within 3 km of nest sites.

It would appear that the decline of the raven is inextricably linked with a reduction in food availability, i.e. predominantly sheep carrion, as a result of the replacement of sheep walk with forestry. In some instances desertion has taken place after sheep were removed but prior to planting (Marquiss *et al.* 1978). Clearly, the retention of a viable population of raven in Highland, as elsewhere in `upland' Britain, requires maintenance of open moorland and hill ground, and the continuation of traditional land-use practices, e.g. extensive grazing of sheep.

14 Twite *Carduelis flavirostris*

Legal status

Listed in Schedule 3 of the Wildlife and Countryside Act, 1981; Appendix II of the Berne Convention.

Population status

Twite are one of only a very few passerine species breeding in Britain whose population is recognised as being internationally important (Stroud *et al.* 1990). The present European distribution represents a relict population, which became isolated during the retreat of the ice age (Voous 1960).

Great Britain and Ireland hold the entire EC population. However, accurate population estimates for this unobtrusive bird are not available. Density estimates from the Atlas of Breeding Birds in Britain and Ireland (Sharrock 1976) data (1968-72) of 25-75 pairs per 10 km square would suggest a population in the order of 19,625-58,875 for occupied squares (Davies 1988).

The main breeding concentrations are on the north and west of mainland Scotland, Orkney, Shetland, The Hebrides and western Ireland. An isolated breeding population is present in the Pennines, which appears to have undergone a steady increase in population and range (Orford 1973). In Scotland as elsewhere throughout most of its British range a considerable contraction has occurred, and is apparently continuing although the exact reasons for this decline are unclear. Changes in land-use and management, e.g. afforestation, has been suggested as possible reasons for the decline. Whilst these undoubtedly contribute, it seems likely that other factors are also involved, e.g. climatic changes (Thom 1986).

Ecology

In Scotland twite are associated predominantly with upland and paramaratime heather moorland (Thom 1986), where nests are built on or near the ground, usually amongst tall heather or sometimes gorse *Ulex europaeus*. The principal function of moorland is to provide breeding areas with adequate shelter for nest sites (Orford 1973). In suitable areas semi-colonial breeding may occur.

Feeding often takes place away from the breeding areas on pasture or improved grasslands, where food consists mainly of small seed and some insects. Some food, however, is obtained from moorland, and in particular females feed on heather during the incubation period (Orford 1973).

Effects of forestry

Loss and fragmentation of breeding areas, including moorland and feeding areas of pasture and improved grasslands as a result of afforestation pose a major threat to this species. Although several pairs have been shown to utilize plantations for breeding, as is the case for many open ground birds, plantations are recognised as being of value only in the initial years of establishment (Orford 1973). As the canopy closes so the light penetrating through to the ground is reduced and as a consequence ground vegetation is diminished and gradually lost thus destroying breeding and/or feeding areas. Fragmentation of breeding areas from feeding areas, with consequent disruption of flight paths, may also have a deleterious consequence.

Appendix IV: Summary of ornithological evaluation

Results of evaluation showing ornithological interest for each 10 km square throughout Tayside Region.

High ornithological interest

NN: 35, 43, 45, 46, 54, 55, 56, 57, 61, 62, 65, 66, 68, 71, 73, 75, 76, 77, 83, 84, 85, 94, 96, 97

NO: 03, 04, 05, 06, 08, 15, 16, 26, 27, 28, 36, 38, 46, 47, 48, 49, 57, 58, 67

Medium ornithological interest

NN: 33, 34, 44, 63, 64, 67, 70, 72, 74, 81, 82, 86, 87, 88, 90, 91, 93, 95, 98

NO: 00, 07, 10, 12, 14, 17, 20, 23, 25, 33, 34, 37, 64, 74

NS: 99

NT: 09, 19

Low ornithological interest

NN: 80, 92

NO: 01, 02, 11, 13, 21, 22, 24, 32, 35, 42, 43, 44, 45, 52, 53, 54, 55, 56, 63, 65, 66, 72, 75, 76,