ROTHIEMURCHUS ESTATE - FOREST BIODIVERSITY ACTION PLAN

1. Introduction

1.1 International and UK context

1.1.1 The UK Biodiversity Action Plan

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 established a major global impetus to ensure a sustainable future for the planet. The sustainable use of the worlds biodiversity was a major part of the convention. The UK government signed up to the convention in June 1992 and shortly after announced an 8-point plan for follow-up actions which included the proposal to publish 'Biodiversity: the UK Action Plan' (Government Report, 1994a) and 'Sustainable Forestry: the UK Programme' (Government Report, 1994b).

Since 1992, the UK Biodiversity Action Plan (UKBAP) has been progressed, and lists of target species and habitats have been drawn up, and Habitat Action Plans (HAP's) and Species Action Plans (SAP's) drafted for some of the most important ones (Government Report, 1995). The voluntary nature conservation organisations have made a significant contribution to this process through the publication of 'Biodiversity Challenge' (Biodiversity Challenge, 1993 and Wynne, et al. 1995). The Biodiversity Challenge Group also linked high priority species with habitats (Gibbons, Fisher and Avery, 1995), which represents a useful means of delivering species actions through habitat management, whereby the needs of several species can be addressed concurrently. Following the publication of the first tranche of HAP's and SAP's, further work is proceeding to refine these and to add to them.

Native Pine Woodlands have been targeted as an important ecosystem, an HAP has been drafted, and Species Action Plans (SAP's) have been drafted for some of the important pinewood species.

1.1.2 The Habitats Directive

The Habitats Directive is European law which provides for the creation of a network of protected areas across the European Union known as 'Natura 2000'. The main aims are to conserve the most important habitats and species in Europe and to promote the maintenance of biodiversity (Natura 2000, 1995).

Caledonian Forest (native pine) is listed as a priority habitat in the Habitats Directive. This designation is based on the view that this habitat, is in danger of disappearing in the European Community and requires special and urgent protection measures to ensure its survival and subsequent enhancement'.

1.1.3 The Helsinki Resolutions

The Ministerial Conference on the Protection of Forests in Europe at Helsinki in 1993 (Loiskekoski, et al, 1993), followed the 1990 conference in Strasbourg, which

established a basis for the sustainable management of European forests. The Helsinki conference considered the implications of UNCED for European forests and established guidelines for the sustainable management of forests and for the 'Conservation of the Biodiversity of European Forests'.

The guidelines on biodiversity recognised the conservation and appropriate enhancement of biodiversity as an essential component of sustainable management and stated that biodiversity should be considered in the preparation of forest policies, operational guidelines and legislation. *The protection of primeval and special forests was emphasised.*

1.2 The Scottish context

The forests of the Cairngorms are particularly significant, representing the most extensive example of boreal forest in Scotland. Much of the forest is relatively unmanaged, or it is managed on an extensive basis and contains high biological diversity. However, much of the forest is severely degraded in ecological terms. Most importantly, the continuity between different forest types, and between different structural types within forests, has to some extent been lost (Cairngorms Working Party Report, 1992. However, in a British context the woodland continuity and extent of large areas of forest or, Core Forest Areas (CFA) (Peterken, Baldock and Hampson, 1995), is good.

The highest densities of ancient semi-natural woodland in Scotland occur in the Cairngorms. The woods of Strathspey and Deeside include the large and important pinewoods of Ballochbuie, Glen Tanar, Glen Quoich, Glen Lui, Glen Derry, Rothiemurchus, Invereshie and Abernethy. There are also a number of important native broadleaved woodland types which occur in the area and which are detailed later.

The HAP for Native Pine Woodlands (Appendix 1), mainly addresses the expansion and restoration of natural diversity. *It aims to restore the natural diversity of composition and structure of woodlands listed in the Caledonian Pinewood Inventory, regenerate and expand 35% of the current wooded area (16,046 ha) by the year 2005, create the conditions for the regeneration of a further 35% of the area over the next 20 years, and establish new native pine woods over a cumulative total of 25,000 ha by 2005 (equivalent to a further 155% of the existing remnant pine wood area).*

1.3 Multiple benefits

All of the initiatives described above have emphasised that forest management needs to be focused on the delivery of multiple benefits. "The United Kingdom's forestry policy is based on the same fundamental tenet that forests and forest lands should be managed to meet the social, economic, ecological, cultural and spiritual human needs of present and future generations" (Government Report, 1994b). The Forestry Authority Biodiversity Initiative (Ratcliffe, 1993), and Ratcliffe and Peterken (1995) describe an approach to increasing biodiversity in managed forests. It is important that biodiversity conservation becomes fully integrated with the management of woodland for a range of purposes, and that nature conservation is not simply about the conservation of species and habitats in designated sites.

1.3 Local Actions

The Biodiversity Action Plan Steering Group (see Government Report, 1995) specifically addressed the development of guidance for the production of Local Biodiversity Action Plans (LBAP's). The guidance is provided in Biodiversity: the UK Steering Group Report (Government Report 1995). LBAP's are intended to focus resources to conserve and enhance the biodiversity resource by means of local partnerships, taking account of both national and local priorities in order to deliver the objectives of national HAP's and SAP's at a local level.. It is assumed that Local Authorities will usually lead and that the process will be linked to local or national grant funding schemes in order to stimulate the interest of land managers. Forestry Authority would be included as a major player.

The Government has also recommended that plans be developed for 'Prime Biodiversity Areas' (PBA). These are areas where concentrations of high priority habitats occur. The Cairngorms is an example of such an area and a recommendation has been made by RSPB to the CPB for the approval of the development of a LBAP for the Cairngorms. An early requirement of such a plan will be an audit of species and habitats present in the Cairngorms and local actions will need to be developed for priority species and habitats.

To some degree this approach has been used here and a preliminary audit of priority species and the actions necessary to safeguard them have been identified. It is hoped therefore that this plan will complement any work on the development of a LBAP for the Cairngorms PBA, and that it will provide some guidance for the preparation of Woodland Biodiversity Habitat Action Plans (WBHAP's) in other areas.

1.3.1 The Cairngorms Partnership.

In 1992 the Cairngorms Working Party (CWP) report to the Secretary of State for Scotland (CWP 1992), recommended the development of an integrated management strategy for the Cairngorms. The report proposed that a Cairngorms Partnership Board (CPB) be established to reflect the local, national and international interests of the area.

In addressing the requirements of a management strategy the CPB suggested three altitudinal zones :

1 The mountain and plateau zone : above the former natural tree line (about 600 metres).

2 The forest and moorland zone : the middle elevations of semi-natural and planted woodlands, moorlands and bogs between the mountain and plateau zone and the valley zone. Woodlands are mainly confined below the 600 metre contour.

3 The valley zone : the diverse, largely man-made environments of farmland, meadows, plantation forests and human settlements as well as the more natural river, loch, moor and semi-natural woodlands dispersed among these (generally lying below 300 metres in Strathspey and below 425 metres in upper Avonside and upper Deeside).

This plan is concerned with biodiversity in the woodlands of the forest and valley zone but there are interactions with the mountain and plateau zone, with many 'woodland' organisms foraging on the montane areas. The interactions between moorland, semi-natural and plantation woodland, bogs, wetlands and riparian areas are complex and dynamic. Therefore, while concentrating on the extant woodlands and forests, the effects of woodlands on adjacent ecosystems have been considered.

Woodlands cover about 61,400 ha or 11.8% of the area. The woodlands can be described in nine types ;

1 self-sown birch
2 other self-sown native broadleaves
3 mixed native and non native broadleaved trees (mainly planted)
4 planted Scot's pine
5 Caledonian pine
6 self-sown Scot's pine (from planted trees)
7 non-native conifers (almost all planted)
8 self-sown native pine and birch mixtures
9 planted conifers and broadleaves (native and non-native)

Areas of semi-natural forest are affected by neighbouring land uses, and the extension of semi-natural forest through natural regeneration will require changes in land use from grouse moor, open hill stalking, plantation forestry and agriculture (Bayfield and Conroy, 1996).

2 A vision for the future

The CWP considered that the full range of forest ecosystems from the mainly deciduous riverine woodland of willow, alder and oak in the valleys through the native pine and birch woods on the intermediate ground to the birch and juniper scrub at the treeline should be represented in the Cairngorms.

"we recommend that over time all existing native woodland should be conserved, improved and extended to provide long term environmental, recreational and timber benefits. This strategy will create a mosaic of native woodland interspersed with heather moorland, grassland, peatland and wetland
and, on the lower ground in particular, agricultural land and productive forest of native and non-native species. Heather moors will still be extensive in some parts and used for grouse shooting and open hill deer stalking..... The proposed forest expansion should take place over a very long time-scale of more than 100 years with perhaps half occurring in the first 50 years. The natural heritage, employment, tourism, sport, wildlife and the owners of the land should all benefit greatly from the major changes proposed "

The CPB draft strategy for Badenoch and Strathspey (Cairngorms Partnership, 1996), identifies two time spans, 20-25 years and 100-200 years. *"In the former we envisage achieving the consolidation and regeneration of existing native woodlands to guarantee their future. This will include the restructuring of plantations to create a more diverse age structure and range of native species. In the longer term we*

envisage that a substantial amount of new regenerated native woodland will have matured and new woodlands will be established where parent trees are no longer present, thus linking and expanding those woodlands that already exist. This will create extensive areas of interconnected woodland which will provide the base for a thriving sustainable forestry industry, recreation and tourism, as well as extensive areas of natural forest ecosystems."

In terms of multi-objectivity, the draft strategy highlighted the following aspects of forest management in order to achieve their vision,

1 native species predominating
2 a sustainable source of timber
3 a presumption in favour of natural means
4 *increased biodiversity*
5 increased opportunities for outdoor recreation
6 *forestry techniques that are sensitive to the wildlife importance of woodlands,* as well as the quality and quantity of fresh water
7 consideration of the impact of woodland siting and management on the landscape and views.

The vision of the future forests should not be constrained by impressions of past eras of the wildwood or particular periods of human occupance, but should be an effective representation of the presently highly valued components, coupled with a plan to conserve the present range of species in perpetuity and to allow sufficient flexibility to enhance biodiversity and land-use outputs in accordance with the wishes of future generations.

That our future management should be sustainable (in the widest sense; ie including biodiversity, soil quality, etc.) is the only constraint that we should work to. Current public funding to restore and regenerate the forests cannot be expected to continue at the same level indefinitely and income generation must expand. The sustained extraction and utilisation of timber from the native forest is an important economic activity in Strathspey and on Deeside and this needs to be continued, and extended if possible.

A vision, or Desired Future Condition (DFC) for Rothiemurchus, is elaborated upon later when the actions required to support the important species and habitats have been described.

3 Objective

To describe the strategy and tactics for assessing, maintaining and increasing biodiversity, within the natural, chemical and physical constraints of the sites, and consistent with the ecology of all of the woodlands, including non-native species and those managed for commercial objectives.

The specific characteristics of the native woodlands, and their influence on adjacent non-native woodlands and non woodland ecosystems, in accordance with the international, national and Cairngorms ethic established earlier, will be emphasised.

4 Biodiversity

Biodiversity is a term which describes the variability among living organisms, and relates this to the ecosystems of which they are a part. In this plan we are concerned with woodland ecosystems, but there are a number of other ecosystems which are integral or adjacent to this, such as the riparian, river and bog ecosystems. Ecotones, such as tree-lines, gullies and farmland boundaries also add to the overall biodiversity of the Rothiemurchus forest.

Biodiversity is about the diversity of species, within species (genetic variability) and of ecosystems. It is not simply about species numbers. The 'quality' of biological diversity is also important, and 'characteristic' species, which are specifically associated with particular ecosystems are more important than ubiquitous species. For example, manipulation of the forest to create more woodland edge may increase the number of edge species, and total species number. However, if this results in the decline of scarce or characteristic pine wood species, then it would be unacceptable.

It is particularly important to conserve the habitats of 'Keystone' species. These are species which have a degree of relevance to the ecosystem which is greater than their own contribution to biodiversity. For example, mycorrhizal fungi are vital to the productivity of many plants, decay organisms are vital to preparing the woody substrate for attack by other organisms and ants play a part in the dispersal of woodland plants.

Biodiversity is difficult to measure, and there are few ecosystems on a world scale where it can be claimed that there are complete species lists, to say nothing of the genetic diversity. It is therefore, useful to try to conserve all of the components of ecosystems in an attempt to guarantee the continuing maintenance, or enhancement of biodiversity. For example, coarse woody debris (CWD) (moribund, dead and decaying wood, in the form of fallen branches, fallen trees and standing dead trees (snags)), is an important 'surrogate' for a wide variety of epiphytes, invertebrates and decay organisms, and by safeguarding a range of stages of CWD it is likely that many of these organisms will also be safeguarded. However, without some knowledge of, at least, some of the requirements, of some of the species, it is rather difficult to proceed. This presents a dilemma which is addressed later.

5 Developing a strategy for managing biodiversity

In developing a strategy which will maintain or enhance biodiversity on a working estate, it is important to ensure that the Desired Future Outputs (DFO's) from all current and potential land-uses are fully appraised during the process. These should be given careful consideration as the plan develops so that the Woodland Biodiversity Action Plan (WBAP) becomes an integral component, along with the Forestry Long Term Working Plan (FLTWP), of a wider estate plan which details the broad strategy for delivering all of the estates objectives and covers the long term economic viability of the estate. This principle goes a long way to prevent later conflicts of interests and to find solutions.

It seems unlikely that there will be any undesirable impacts on landscape and recreation objectives, caused by managing for biodiversity, except that some areas may require reduced access from visitors to permit seclusion for sensitive species.

Deer stalking on the open hills of Scotland is an important land-use and something that attracts deer stalkers, sportsmen and photographers from many countries. It is the unique experience of stalking deer on the open hills of Scotland which provides the attraction, and not the size or quality of the trophy. Foreign stalkers do not come here to stalk deer in woodlands, they can usually get plenty of that at home! It is important, therefore that woodland restoration does not proceed to cause the large scale demise in open range deer stalking. However, the desired extension of forests in this area will require a reduction in deer numbers, and thus in the scale of deer stalking activity, and in some 'priority locations' local and seasonal impacts from deer will need to be reduced to very low levels.

A number of species of conservation importance are dependent on non-woodland habitats, while others benefit from the woodland / non-woodland mosaic. It is therefore of paramount importance that the woodland expansion envisaged is located in the optimum places, and that the important species in all habitats benefit if possible.

5.1 Fragmentation and connectivity

Fragmentation of habitats is one of the principal causes of losses in biodiversity and one of the reasons behind restoring woodlands in the Cairngorms is to establish woodlands of sufficient size that a wide range of species can benefit. In the absence of sufficient area of suitable woodland habitat the provision of corridors connecting isolated fragments is considered to be valuable. There is an enormous theoretical literature on this topic and a case has been made for establishing woodland networks in Scotland (Peterken, et al 1995), and in the Cairngorms (Ratcliffe and Peterken, 1997, in press). The importance of fragmentation to particular species is dependant on such ecological factors as their dispersal performance in relation to distances between habitat fragments, home range size, minimum viable population size, minimum patch size requirements and densities.

Some of the larger animals which are now extinct in Scotland almost certainly became so due to habitat fragmentation alone, or more likely in combination with persecution. This suggests that any reversal of fragmentation will improve conditions for these species should future decisions be taken to reintroduce them. "The aim of a forest habitat network is not simply to increase the area of habitat, but to develop a pattern which both maximises opportunities for species requiring many habitats or large territories, and the successful movement of all species over both short and long distances. It requires shifts in the emphasis of nature conservation policy from species to habitats, from sites to ecosystems, and from local to national and international measures." (Peterken *et al*, 1995).

5.2 Genetic effects and Minimum Viable Population Size

The minimum viable population size (MVP), is the genetically effective population size that must be maintained to ensure its survival, and it is generally expressed as a probability of the population surviving for a particular period of time . This concept is based on the fact that random genetic drift and inbreeding increase as populations decrease in size. The inevitable consequence of this is extinction in populations which are below a certain demographic threshold. The problem is that the information required to calculate and make use of these values (not least the actual population size of rare species!), is frequently unavailable.

It is important however, to be aware of the advantages and disadvantages of genetic isolation. Isolation will maintain genetic sub-populations and allow the continuity of speciation, while it might also restrict gene flow and lead to extinction. The particular result will depend upon the size of the actual population under consideration. The redistribution by man of the natural global distributions of deer of the genus *Cervus*, may lead to the extinction of some species, or sub species (Ratcliffe, 1987). However, where man has not redistributed species, many existing sub-populations will be relicts of a previous continuum which are different because of evolutionary adaptation to differing environmental circumstances (eg Scots pine). If this is the case then linking isolated populations is unlikely to be harmful.

5.3 Effects of patch size

The degree to which woodland types will influence the presence and dispersion of organisms within them is highly dependent upon the size of patch relative to the ranging and dispersion distances of the particular species. For example, small patches may provide all of the requirements of immobile, 'old-growth' invertebrates, while simply representing 'edge' to wide ranging mobile species. The need for large patches of contiguous habitat is likely to be far more important to large, wide ranging woodland specialists, than to small immobile ones.

With regard to the view expressed earlier that any expansion of the forests of the Cairngorms should be considered over a long time scale (c.100years), patch sizes which are compatible with a wide range of extant and extinct species should be planned for. This will result in the provision of extended habitats for currently rare or threatened species as well as for potential reintroductions. The socio-economic climate may never be appropriate for the reintroduction of some species but, by providing continuous (in time) and contiguous (in space) habitats at the appropriate scale we are providing the choice for future generations, while not compromising current needs.

5.4 Corridors

Linking patches of woodland together is generally considered to be beneficial however, against the potential benefits of providing habitat linkages there are some disadvantages. Increased gene flow between habitat patches could reduce the adaptive fitness of the previously isolated populations. In addition, corridors can facilitate the spread and colonisation of unwanted species such as the Japanese sika deer and grey

squirrel . Grey squirrels are present on lower Deeside while sika deer are present on the periphery of the Cairngorms. It is assumed that these species would not be welcome colonists elsewhere. Clearly, the likely benefits from providing corridors or networks are very dependent upon a knowledge of the species being targeted.

Linkages between woodlands may create isolation of other habitats by preventing the passage of organisms across the woodland corridors. In general, however, the benefits seem to outweigh the disadvantages but local needs must be carefully addressed.

6 Woodland classification and biodiversity

Definitions of 'woodlands' and 'forests' are provided in Bayfield and Conroy (1996), and classifications relevant to the Cairngorms are reviewed. Nine classes are proposed as a compromise relevant to the present availability of data, but which allows the diversity of woodlands in the area to be described. These are ;

Broadleaved woodland
- self-sown birch (Betula spp)
- other self-sown native broadleaves
- mixed native and non-native broadleaved trees (mainly planted)

Coniferous woodland
- planted Scots pine (Pinus sylvestris)
- Caledonian pine
- self-sown Sots pine (from planted pines)
- non-native conifers (almost all planted)

Mixed coniferous/broadleaved woodland
- self-sown, native pine and birch
- planted conifers and broadleaved trees (native and non-native)

Bayfield and Conroy (1996) provide details of this classification, with examples which enables comparisons with the system used here to be made.

Further classifications are proposed which reflect the degree of 'nativeness' and ultimately, the species, age and structure of woodlands, while recognising that intergrades of all of these types will create difficulties. The ultimate classification suggested by these authors is one which is based on plant community structure (Bayfield and Conroy, 1996).

The value of such classifications is accepted as are existing classifications such as the Land Cover for Scotland ; 1988 (LCS 88) and the National Vegetation Classification (NVC). However, a classification which will assist in developing actions to maintain biodiversity must take account of the fact that many species of wildlife are not associated with particular classifications such as NVC types, and are more dependent upon the availability of a range of spatial and structural conditions, often encompassing several NVC types.

A classification of woodland types, which reflects the requirements of important species, has been proposed for the Cairngorms (Ratcliffe, Peterken and Hampson, 1997, in prep). NVC types are a useful part of this, but need to be related to particular structural types of forest, such as thicket, old-growth, etc. These forest types are associated with specialised flora and fauna, and the degree to which these types, and 'old-growth' core areas, for example, can 'export' species and genotypes to other forest types is of great importance in landscapes with a high anthropogenic element.

6.1 Woodland types present in Rothiemurchus

There are 11 NVC types present in the Cairngorms, all are also represented at Rothiemurchus. These can be incorporated in the current classification (Ratcliffe et al, 1997, in press) as follows;

Riparian woodland

Woodland and scrub on floodplains, beside rivers and along low level flush zones. Soils under the influence of a high watertable, but usually well-drained in the surface horizons.

Mainly NVC W3, W4, W7. May include W8 and W10 on fertile alluvium. This type may also include secondary birch woodlands, Alder/sallow scrub, birch and pine scrub on acid mires (possibly W18d) and pine/alder mixtures .

Mesic broadleaved woodland

Oak/ash/elm/hazel woodlands on base-rich soils, usually on well drained soils in the lowland zones. Most suitable ground is currently used for agriculture or habitation. NVC 7,8,9,10.

May include secondary birch woodland. May also include pine woods on base rich soils.

Acid oak and birch woods

Oak/hazel and oak/birch woods on acid well drained soils. Virtually all survive in the lowland areas. NVC W11, 17.

Oak/pine woods are intermediate between this and the next type.

Pine, birch, juniper woodlands

Pine is the major constituent. Birch and juniper are usually present. Strongly associated with strongly acidic, podsolised soils and mire margins. Some examples are dominated by birch with no pine. In some pine woods juniper is locally dominant. Often appears as 'parkland' in mosaic with heaths. NVC W18, W19(part).

This type grades into sub-montane scrub. Bog forest (muskeg) is within this type but grades into riparian woods. Also intergrades with conifer plantations Mixtures

dominated by birch may be mainly birch/pine or birch/oak, intergrading with NVC W11, 17.

Sub-montane scrub

Scrub above the tree-line, intergrading with virtually all other types. NVC W19, 20.

Coniferous plantation

Plantations usually established on heathy sites and former mires. Usually colonised by birch, rowan, alder and sallow. Occur in lowland, riparian to sub-montane zones. No NVC type

Policy woodlands

Derived from plantations of a wide range of exotic species in 19th century or earlier. No NVC type.

Structural types

Most of the preceding woodland types can be represented by different age and growth stages. In terms of supporting different species of organisms, these 'structural types' are often of more significance than the particular species composition of the woodland, though clearly these two factors interact. The main structural types have been defined as follows;

Establishment

Most of the trees are less than 1 metre and the field layer plants dominate. Plant diversity and the degree to which this will support animals is heavily dependent on the level of grazing intensity, usually from deer, sheep, hares and rabbits. Many animals normally associated with open habitats are present.

Pre-thicket

This is the stage between 1 metre and canopy closure. The tree species are a more dominant component, influencing the microclimate and subsequently the species which occur there. Grazing pressure is almost always relatively low, enabling tree seedlings and saplings to put on height growth. 'Woodland' birds and insects colonise as patches develop from establishment to pre-thicket. Large mammals which depend upon the availability of cover, such as roe deer, colonise.

Thicket

Most trees are between 3 and 10 metres. This stage follows canopy closure through to a rather ill-defined stage when the canopy becomes less dense, lower branches die and ground vegetation biomass begins to increase. Through much of this stage ground vegetation is patchy or non-existent due to the lack of light reaching the forest floor. During this stage edaphic factors, especially the water table, influence tree growth

more strongly, and patches of different woodland and structural types can begin to develop, initiating the development of a complex mosaic of vegetation structure, which will ultimately form the mature forest with it's intermix of dense trees, open muskegs, riparian areas, heaths and grasslands. Only 'woodland species' will be associated with this stage, but patch size will influence the presence or absence of particular organisms.

Maturing

The trees are close to their ultimate height. The canopy remains relatively 'closed', though increasing light reaches the ground, allowing an increase in ground vegetation. Limited regeneration of shade-bearers occurs in shaded patches. Open patches will occur and light-demanders will regenerate into these gaps if they are big enough (c. >0.5 ha). Many trees will be producing seed, which will support increasing numbers of seed-eating animals, and their predators and parasites. In managed stands of trees, some thinning will be occurring in this stage, and some patches will be clear-felled, making way for the beginning of a further Establishment stage.

Old-growth

The ultimate height of trees is achieved, though trees may continue to grow slowly, increasing in girth. Some large trees will have blown down, or died *in-situ* and fallen branch-wood will be considerable, heralding a substantial increase in amounts of Coarse Woody Debris (CWD). There will be significant gaps in the canopy, adding to the complexity of the mosaic. There will be a well developed, multi-layered understory. The availability of a wide range of ecological niches, especially those associated with CWD will support a wide range of specialist species.

7 Selection of species

7.1 General principles

The general principle of conserving all of the components of an ecosystem, and the use of 'surrogates', to safeguard specific elements or species was made earlier (section 4). The reason for this approach is because our knowledge of ecosystems is incomplete both in terms of function and species composition, and that it is exceedingly difficult to manage an ecosystem based only on the individual needs of a few (often the charismatic mega-fauna) of the species. Management becomes especially difficult when conflicts arise between the needs of different species.

However, although it is impossible to consider the specific requirements of all species in an ecosystem, it is difficult to progress the application of theories and generalisations (for example on habitat fragmentation and connectivity) to the real world, without viewing these through the eyes of some particular species or species groups. The development of this plan is therefore based on the selection of a number of key species in Rothiemurchus. After considering the requirements of particular species in some detail it is important to identify common factors and 'rebuild' the ecosystem approach based on surrogate measures.

The species have been selected as objectively as possible by first using the list derived by the Biodiversity Challenge Group which linked species of conservation importance with native coniferous habitats (see section 1.1.1). Subsequently, the Invertebrate Site Register for Rothiemurchus, Freeman (1995) and Edgar (1995) were used to confine the list to those likely to be found at Rothiemurchus, and to add important species not selected by the 'Biodiversity Challenge' process. In addition, species specialists were approached to identify gaps and to provide autecological information. This work was developed concurrently with that of Ratcliffe, et al (1997, in press) and the same methodology is used here.

Every effort is made to represent a wide range of organisms and to ensure that important 'keystone' elements in the ecosystems are included, avoiding the recent inclination in discussions on biodiversity, to exaggerate the importance of the 'charismatic megafauna and flora'. Decomposers, for example, are a major contributor to energy flow in mature woodland ecosystems. Endemic, threatened and 'keystone' species are identified, the benefits of connectedness through woodland networks evaluated and the requirements of characteristic, late-successional, and immobile organisms are considered.

The emphasis has been to concentrate on the relatively rare, threatened and characteristic species of some of the important woodland types in the Cairngorms. The justification for this does not imply any disregard for common species, but the view has been taken that rare, threatened and characteristic species are, by definition, most at risk and most likely to benefit from improvements.

Candidate species for inclusion fall into two main types, those large, wide-ranging animals with rather narrow niche requirements, such as capercailie and red squirrel, and those sedentary species with poor powers of dispersal and narrow niche requirements such as the saproxylic invertebrates and soil microfauna. The main requirements of the former group is for sufficiently large areas of suitable habitat within their home ranges; the spatial distribution of habitat patches and the structure of woodlands are usually more important than tree species.

The latter group require habitat connections which will allow relatively free exchange between sub-populations, when these are sufficiently small to present a risk of extinction should environmental changes occur, or if the habitat patch becomes reduced in size. Conversely, isolation may be desirable where sub-populations are of a viable size and where local genotypes are evolving (section 5.2). These species may require particular woodland types or growth stages, or be dependent on particular tree species. Any kind of woodland may not be acceptable.

Large animals are often 'keystone' species (they have a special significance to other species and components of the ecosystem) and they may be critical for the maintenance of species diversity. It is therefore, wise to consider their conservation. In Scotland, the large carnivores which were characteristic of upland woodlands are now absent, but the largest extant species can be considered in the same way. Candidate species might therefore be the Golden eagle, osprey, pine marten and wild cat. However, these species are relatively catholic in their requirements and they appear to thrive in a range of ecosystems. Indeed, they appear to benefit from a mosaic of habitat types. Large

ungulates can be equally important and an appropriate level of grazing by red and roe deer is important in shaping a woodland structure which will benefit a number of the important pinewood species.

The Biodiversity Challenge Group (Gibbons et al, 1995) related species to habitats in order to identify the habitats which support the highest numbers of sensitive, threatened or rare species. In this way habitats were prioritised on the basis of the species of conservation concern that they support. Broadleaved woodland habitat in the UK is of primary importance for 232 species of conservation concern. The relative figure for native coniferous woodland is 37, for productive coniferous woodland 38 and for scrub 48. The particular species encompass most taxonomic groups.

7.2 Methodology

Native pinewoods (Pine-Birch-Juniper woodlands) are the most extensive woodland type in the Cairngorm area, forming the main forest matrix throughout the Spey valley, Glen Avon, Highland Deeside and the Don valley. They are, along with 'natural' woodlands of plantation origin, also the most widespread woodland type at Rothiemurchus. Consequently, this woodland type has been targeted rather more intensively than other woodland types.

The species associated with 'Native Coniferous Woodland' in the 'Linking Species to Habitats ' report were identified, and their status in Rothiemurchus determined as far as is possible. A number of species were dropped from the list at this stage because of their favourable conservation status in the UK or in Scotland (their inclusion on the original list being due to an unfavourable status in Europe or globally), because they are not specifically dependent on native pinewood or because they do not occur in Rothiemurchus.

The next stage was to determine the local status of these species at Rothiemurchus and to see whether other important species had been missed. The same process was used to determine the relevant autecological data for the selected species, and to determine how management might improve their status. Some effort has also been made to identify sensitive, threatened or rare species dependent upon some of the other important woodland types in the Cairngorms area.

Searches of the literature were disappointing and the required autecological information has proved difficult to obtain. In the view of many specialists the information necessary for the conservation of many of the rarest species is simply not known. However, considerable useful information was gathered from unpublished reports, but the majority was gleaned from informal interviews with species specialists.

8 The species

The species were selected in an identical way to that used by Ratcliffe, et al (1997, in press) for the whole Cairngorms area. The species accounts are presented without justifying all statements with references for clarity. Full references are available in Ratcliffe, et al (1997, in press).

8.1 Species accounts

1 Formica aquilonia (Scottish wood ant)

Current status : Widespread and locally abundant in the highlands, but severe declines have been reported in some areas during the past twenty years. Listed by IUCN as threatened . Ants disperse a large number of forest plants, and are therefore keystone species.

Causes of loss or decline relevant to habitat connectivity : The replacement of open , traditionally managed woodlands by more dense plantations or thickets has created dark unsuitable conditions. The most vulnerable of the three species to fragmentation due to it's difficulty in dispersing long distances.

Habitat requirements : Usually closely related to trees and sheltered areas in undisturbed open woodland. Thrives in woodlands with a diverse and open structure with glades. All three ants require arboreal aphids for food.

Minimum patch size : not known but said to be larger than for *F. exsecta* or *F.lugubris*. 5-10 ha ?

Mobility and dispersal potential : Ants disperse and colonise new areas in three main ways ;

by nest budding, that is by a queen, accompanied by workers, from a multi-queen nest walking to a new site and founding a new nest. Only relatively short distances through reasonably suitable habitats can be covered. *F.aquilonia* mainly recolonises by this means.

by a queen flying to a the nest of another species, killing the resident queen and laying her eggs in the nest. *F. exsecta* and *F. lugubris* commonly use this method.

by a queen flying to a new location and founding a new nest. This method is rarely used by *F. aquilonia*, but is more common in *F. lugubris* and *F. exsecta*

F. aquilonia is very loyal to the vicinity of the nest site and new colonies usually occur close to their parents, thus having low colonising ability. However, they can, due to their ability to produce multi-nest, polygynous colonies, colonise large areas of suitable habitat. Such supercolonies can exclude other ant species, such as *F. lugubris* which is better adapted to more isolated fragments, which are more difficult for *F. aquilonia* to colonise. It follows that this species will be less able to disperse to isolated fragments than the other two species; possibly c.100m.

2 Formica exsecta (narrow headed ant)

Current status : Localised, but widely distributed in Europe, it has been recorded in lowland heathland in southern England and in native pine woods in Scotland. Historical records in Scotland are from mid-Strathspey, Easter Ross and Rannoch. Scottish populations are currently known to exist in Glen More, at Abernethy and Carrbridge. Eighty nests were located in a recent survey. The species has experienced a dramatic decline throughout it's range, with many sites lost in the Spey valley. It is listed as endangered on the GB Red List.

Causes of loss or decline relevant to habitat connectivity : Habitat fragmentation leading to potential inbreeding and loss of reproductive fitness has occurred. Intensive management of moorlands for deer and gamebirds, and the loss of semi-natural pine habitats have also contributed to their decline. Planting of dense stands of Sitka spruce has led to shading out of nests. They appear to be intolerant of human disturbances.

Habitat requirements : Sunny edges and clearings in pine woods (usually their southern aspects). Nests are called 'solaria' due to their function of trapping solar radiation on their southern aspect to raise brood temperature. Vegetation below 40cm high is favoured. Nests are often amongst heather, but grassy sites are probably suitable. The presence of relatively isolated shrubs of juniper, oak birch and gorse in clearings seems to be important.

Minimum patch size : Preference for sunny glades enables this species to use edges, and therefore to make use of relatively small patches with a large edge to interior ratio. Not known. 5 ha ?

Mobility and dispersal potential : This species seems more able to move sites than does *F. aquilonia* or *F. lugubris*, but major changes to the surrounding habitat can leave them with no options. It is well adapted to the temporal dynamics of woodland structure, and can exploit clearings and glades caused by disturbances. The distance that queens will disperse from one nest to another, how they select a site on which to land and the circumstances under which they will found a new colony are not known. *F exsecta* has been described as a facultative social parasite, newly mated queens entering the nest of another species, killing the resident queen and allowing the workers to raise her brood. The most likely host in Scotland is *F.lemani*, which appears to be common, suggesting that this might be an effective means of colonising new habitats, However, only one mixed worker nest was found by them. Perhaps the creation of more suitable connected habitats would facilitate their spread by this means? Dispersal distance c. 2 km ?

Species Action Plan (Government Report, 1995); proposed action relevant to site connectivity : Encourage research on the ecology(habitat requirements) and distribution of this species. Consider artificial rearing and translocation.

3 Formica lugubris (northern wood ant)

Current status : Unknown

Causes of loss or decline relevant to habitat connectivity : Unknown.

Habitat requirements : Similar to *F.aquilonia* but in Finland found to be more common in younger forests with more open canopies and closer to forest edges.

Minimum patch size : Probably smaller than for *F.aquilonia* ; c.5 ha ? In Finland, has benefited from some fragmentation.

Mobility and dispersal potential : Primarily disperses by queens flying to new sites and colonising by nest parasitism or by founding a new nest (see above). Therefore, good dispersal prospects and an ability to colonise young growth. c.2 km.

4 Blera fallax (a hoverfly)

Current status : Rare. Known only from one 10 km square on the basis of one adult and one puparium.

Causes of loss or decline relevant to habitat connectivity : not known

Habitat requirements : breeds in water filled holes in decaying pine stumps and roots. Suspect that pine stumps remain in a suitable state over long periods, and that it can remain in the same stump for several generations.

Minimum patch size : not known

Mobility and dispersal potential : not known

5 Callicera rufra (a hoverfly)

Current status : Rare. Recorded from c.30 10km squares since 1990.

Causes of loss or decline relevant to habitat connectivity : Not known

Habitat requirements : Breeds in tree rot holes and water-filled decaying stumps in Scots pine and occasionally larch. Not found in trees less than approximately 100years old. Can occur in suitable trees in non-woodland locations, ie roadsides.

Minimum patch size : Probably an individual tree.

Mobility and dispersal potential : Good. Probably approximately 5 km.

6 Osmia uncinata (a bee)

Current status : A recent addition to the British list and poorly known. Mainly recorded in the Spey valley between Kincraig and Nethy Bridge. A major host of the rare cleptoparasitic wasp, Chrysura hirsuta.

Causes of loss or decline relevant to habitat connectivity : loss of native pinewood.

Habitat requirements : Open, sunny and floristically rich sites (especially Lotus corniculatus).

Minimum patch size : unknown

Mobility and dispersal potential : unknown

7 Chrysura hirsuta (a wasp)

No information.

8 Clubonia subsultans (a spider)

Current status : Widespread in Europe, but in the UK only known at Abernethy forest and near Coylumbridge in the Cairngorms, and the Blackwood of Rannoch.

Causes of loss or decline relevant to habitat connectivity : Loss of native pine forest

Habitat requirements : Found on bark, branches and in litter of Scots pine, and on juniper below pine trees.

Minimum patch size : Not known. 5 ha?

Mobility and dispersal potential :

9 Dipoena torva (a spider)

Current status : Widely distributed in the native pine forests of Rannoch, Rothiemurchus and Abernethy. Apparently not recorded on Deeside.

Causes of loss or decline relevant to habitat connectivity : Loss of old and senescent trees providing suitably fissured bark and loss of an open woodland structure.

Habitat requirements : Fissures on the bark of Scots pine. Feeds on wood ants. Open diversey structured pine forests.

Minimum patch size : Not known 5 ha ?

Mobility and dispersal potential : not known

10 Pelecopsis elongata (a spider)

Current status : Well established in Rothiemurchus and Abernethy forest. Also recorded near Loch Rannoch. Widespread in Europe.

Causes of loss or decline relevant to habitat connectivity : Conversion of open pine forests to dense plantations is thought to be the main threat. Grazing to maintain an open structure is considered to be important.

Habitat requirements : Mainly in dry pine litter amongst rocks and on the lower branches of juniper.

Minimum patch size : Not known. 5 ha ?

Mobility and dispersal potential : unknown

11 Xylophagus cinctus (a fly)

Current status : Rare. Known from about ten 10km squares.

Causes of loss or decline relevant to habitat connectivity :

Habitat requirements : Under the bark of recently fallen large Scots pine trunks, this species is a predator on the larvae of other Diptera and Coleoptera.

Minimum patch size : Probably about 10 ha, based on the requirement for a newly fallen large tree (>60 years old) about every three years.

Mobility and dispersal potential : About 5-10 km, based on current evidence of the species being found up to 45 km from native pinewoods, but with 'stepping-stones' of pine plantations interspersed between.

12 Medetera exellens (a fly)

Current status : Known from about twenty-five 10 km squares throughout the highlands, since 1990.

Causes of loss or decline relevant to habitat connectivity : not known.

Habitat requirements : Under the bark of small fallen Scots pine trees and larger branches. Found in Scots pine plantations of about 30 years old and in mixed woods where pine is not always dominant.

Minimum patch size : Probably about 2.5 ha.

Mobility and dispersal potential : Probably at least 5-10 km.

13 Loxia scotica (Scottish crossbill)

Current status : This is the only species of bird which is considered to be endemic to the UK. However, there is confusion over the taxonomic position with regard to common and parrot crossbills. It is mainly confined to native pinewoods or old established plantations. Recent reports suggest that the species has declined and currently numbers about 1,500 in the UK. It is listed in Annex 1 of the EC Birds Directive and Appendix II of the Berne Convention. It is protected under the Wildlife and Countryside Act, 1981.

Causes of loss or decline relevant to habitat connectivity : None known. Research is required on the need for connections between fragmented patches of habitat (the need for breeding populations to be interconnected) and on the effects of different pinewood characteristics. (Government Report, 1995).

Habitat requirements : Pinewoods with high structural diversity.

Minimum patch size : Not known. 25 ha?

Mobility and dispersal potential : Not known, but thought to be highly mobile. Ensure as far as possible the continuity of existing isolated woodlands within the existing range of the species.

14 Parus cristatus (crested tit)

Current status : A localised breeding population occurs in the Moray catchment and Speyside. Birds are occasionally seen on Deeside and some breeding may have occurred but it has never firmly established there. The species is widely distributed in Europe, but the Scottish population is considered to be a separate race, P.cristatus scoticus. The total Scottish population was estimated to be 885 breeding pairs in 1979-80 based on densities of 0.01 breeding pairs /ha in plantations and 0.15/ha in open pine forest.

Causes of loss or decline relevant to habitat connectivity : Unknown, but their absence on Deeside could possibly be due to lack of connectivity. Past replacement of semi-natural pine woods with plantations, and intensive management causing a decline in the shrub layer and availability of suitable stumps in which to nest, could have had an effect.

Habitat requirements : Tall, bushy heather in open pine forests. The old pinewoods in Rothiemurchus, Abernethy and Glenmore carried the largest populations during the early 1970's, and probably still do, where they will nest almost to the tree line. Forests derived from plantations, which provide a similar structure to semi-natural woods, with a well developed shrub layer are frequented in the lower Spey valley, and nest boxes are used. The most favoured habitats in a range of ten Scottish woods included, few small trees, high numbers of stumps for nest sites, a virtual absence of birch, high field layer diversity and hummocky ground. The reduction in large herbivores might benefit crested tits by allowing dense stands of trees to grow. Although most foraging was in Scots pine woods, Lodgepole pine and larch were used, but never spruce. A strong association between crested tits and dead wood on standing trees has been demonstrated. Dead stumps (snags) more than 22 cm diameter and higher than 0.5 m are required for nesting, and nests are seldom more than 4 metres above the ground. An increase in the breeding density of crested tits has been demonstrated at Abernethy following the translocation of rotting pine and birch stumps to an area of thinned pine plantation. Stumps left from felling operations are unlikely to provide suitable nest sites due to differences in the fungal colonists, and the dynamics of decay.

Minimum patch size : 25 ha

Mobility and dispersal potential : Usually sedentary and will not disperse much more than about 2 km from their nest site. However, in years when surplus birds are present, following a succession of mild winters, longer dispersal may occur, and two birds were recorded at Linn of Dee which may have travelled through the Lairig Ghru.

15 Tetrao urogallus (capercaillie)

Current status : In Britain this bird is currently largely confined to the eastern highlands of Scotland. It became extinct in Scotland in the 18th century, probably due to the felling of native pinewoods. They expanded after introductions in the nineteenth century, and their numbers have fluctuated with the availability of habitat since then. A ten fold decline in numbers occurred between the 1960's and 1986.

Causes of loss or decline relevant to habitat connectivity : A reduction in the availability of open semi-natural pine forest is considered to be at least partially responsible for the current decline.

Habitat requirements : Open woodland of Scots pine with large, old 'granny' trees and an abundant field layer of blaeberry and heather are favoured, although some colonisation of planted forests of spruce and other tree species has occurred in recent years. Indeed, plantation forests can provide suitable habitat for capercaillie if they are managed to provide a structure which simulates the open pine woods.

Minimum patch size : 500 ha. The smallest unit for management should be about 3-400 ha based on one lek, but a minimum of 1000ha, of not necessarily continuous forest, is necessary to support a viable population.

Mobility and dispersal potential : Some hens are known to have moved over 20km during juvenile dispersal. They are thought to be able to disperse over relatively large distances across unsuitable habitat (K Duncan, pers.com.).

16 Sciurus vulgaris (red squirrel)

Current status : Within the UK the species has shown a reduction in numbers and range over the last 50 years and large populations are now confined largely to Scotland, which holds about 75% of the UK population (an estimated 120,000 animals) (JNCC, 1996). This reduction has been consistent with an increase in the range of grey squirrels (*Sciurus carolinensis*). Red squirrels are widely distributed in the Speyside area, mainly in pinewoods. Grey squirrels have been present in lower Deeside for some years now but do not seem to be extending their range substantially.

Causes of loss or decline relevant to habitat connectivity : The Biodiversity Species Action Plan (Government Report, 1995) lists the spread of grey squirrels, habitat fragmentation and disease as the factors causing loss or decline. Grey squirrels seem to be better adapted to fragmented woodlands offering a mosaic of habitats with high proportions of 'edge'. Thus, red squirrels can apparently only effectively compete with greys in relatively large areas of contiguous woodland, especially conifers. Large unfragmented blocks of mixed conifer forest are considered to be the most suitable habitat for red squirrels in Britain.

Habitat requirements : Large tracts of coniferous forests. Mixtures of tree species provide more continuous food supplies than single species. Seems to thrive in relatively smaller woodlands in the absence of grey squirrels.

Minimum patch size : Minimum viable areas and population sizes are not known but some areas exceeding 2,000 ha should be aimed for, even though some Scottish populations persist in smaller areas.

Mobility and dispersal potential : Little understood, but open land or conifer forest buffer zones of at least 3 km will deter or prevent grey squirrels colonising. It is not clear whether we can infer similar distances to reds.

Species Action Plan (Government Report); proposed action relevant to site connectivity : None suggested but, seed producing areas should be connected by continuous bands of trees to prevent isolation and facilitate movement of red squirrels between them. SNH have prepared a 'position statement' which summarises recommendations which are thought to favour red squirrels as;

1 open land or conifer forest buffer zones of at least 3 km

2 minimising edge

3 A woodland structure with 50-60% of trees of seed bearing age, 30% aged 0-15 years, 30% aged 16-30 years and 40% older than 40 years. Young plantations of 16-30 years provide food and cover for red squirrels.

4 Large seeded broadleaves should be avoided. Scots pine, larch, Norway and sitka spruce, firs, yew, hawthorn and bird cherry will all favour reds.

17 Castor fiber (European beaver)

Current status : Extinct in Britain since 16th century. Serious declines throughout Europe. Scottish Natural Heritage are investigating the feasibility of reintroducing the species to Scotland.

Causes of loss or decline relevant to habitat connectivity : Habitat destruction, river pollution and hunting.

Habitat requirements : Riparian broadleaved woodland. Unpolluted water with abundant herbaceous vegetation for summer food and trees (aspen and willow are preferred) for winter food. The most suitable sites in Scotland for the reintroduction of beavers appear to be the Ness, Tay, Spey and Dee catchments.

Minimum patch size : c. $5km^2$

Mobility and dispersal potential : Young Castor canadensis, the North American beaver, disperse up to 5 km from the natal nest. European beavers range from 0.5 - 12.8 km along river banks depending on forage availability, feeding primarily within about 60 metres of the waters edge.. They do not seem to disperse across open country away from water courses.

18 The characteristic pinewood plants of conservation significance

Current status : All are rare.

Causes of loss or decline relevant to habitat connectivity : Fragmentation and isolation of habitats.

Habitat requirements : *Goodyera repens, Linnaea borealis* and *Moneses uniflora* are largely restricted to pinewoods. All are mycorrhizal and all require damp condition.

Minimum patch size : Unknown.

Mobility and dispersal potential : Most spread is by vegetative means, which limits there ability to spread to connected areas of suitable habitat. The seed producing component of populations is very small, but perhaps small amounts of seed produced sporadically could provide adequate dispersal if suitable habitats are available. It follows that the more fragmented the habitat the less becomes the probability of seeds encountering favourable conditions. It seems therefore, that dispersal distances should be assumed to be rather small.

8.2 Analysis of the species data

The species selected are presented in Table 1, along with a summary of the autecological data relevant to their association with woodland cover and structure. It is clear that for a number of the important species, there is insufficient data on which to base firm recommendations for their conservation, and it is necessary to invoke the precautionary principle to ensure that as far as is possible these species do not decline further. In many cases the only recommendation can be to ensure the long term future of the necessary habitat conditions. However, there are a number of clues as to how this might be taken forward. For many of the smaller, less mobile animals this means ensuring continuity of open diverse pinewood habitats, and trying to ensure that they are able to disperse freely into acceptable habitats.

Table 1 Summary of data for key species.

Species	Dispersal distance	Minimum patch size	Habitat	Grazing requ.
Ants				
Scottish wood ant	100m	5-10 ha	open pine	some
narrow-headed ant	2 km	5 ha	sunny glades	some
northern wood ant	2 km	5 ha	open pine	some
Hoverflies				
Blera fallax	?	? 1 tree	pine rot hole	-
Callicera rufa	c. 5 km	? 1 tree	pine rot hole	-
Bees & wasps				
O.uncinata				
C.hirsuta				
Spiders				
Clubonia subsultans	?	? 5 ha	open pine	some
Dipoena torva	?	? 5 ha	open pine	some
Pelecopsis elongata	?	? 5 ha	open pine	some
Flies				
Xylophagus cinctus	5-10 km	10 ha	pine bark	-
Medetera exellens	5-10 km	2.5 ha	pine bark	-
Birds				
Scottish crossbill	v. high	?c.25 ha	pinewoods with high structural diversity	some
crested tit	2 km	25 ha	open pine, tall heather, snags	Reduced grazing beneficial
capercaillie	20 km	500 ha	open pine old trees, diverse shrub layer	some
Mammals				
red squirrel	1-2 km	100 / 2000 ha	mixed conifers	-
beaver	5 -12 km	500 ha	riparian broadleaved woods	-
Pinewood plants				
Goodyera repens (creeping lady's tresses)		All these have limited powers of dispersion and spread mainly vegetatively		
Linnaea borealis (twinflower)				
Moneses uniflora (one flowered wintergreen)				
Pyrola media (intermediate wintergreen)				
Orthilia secunda (toothed wintergreen)				
Ptilium crista-castrensis				

8.3 Common factors

Certain important common factors emerge from a consideration of the species accounts. There is also a notable lack of information available. However, we must work with what is available and try to safeguard the necessary habitats.

Several species seem unable to disperse much more than a distance of 1-2 km. It also seems sensible to plan for at least some contiguous areas of woodland of a size equivalent to the needs of the species with the largest minimum patch size.

1 Red squirrel and capercaillie

These species require some patches larger than 500 ha, although red squirrels may be able to cope better than capercaillie with areas as little as 100 ha as long as sufficient suitable habitat occurs within 2 km. Both species seem to require minimum distances between patches of about 2 km. Scottish crossbills, crested tits and Scottish wood ants will also especially benefit from this pattern.

2 Other pinewood key species

In other areas patches can be smaller, but it seems that all other pinewood species will benefit from patches greater than 5 ha. In other words patches of less than 5 ha are likely to be substantially less able to support the range of key species.

3 Woodland structure and grazing

Many species require pinewoods with an open structure and a diverse herb and shrub layer, which is frequently maintained by a low level of grazing, usually by deer. A large number of species require dead wood, and it seems important to maintain continuity and contiguity of this habitat.

For the species currently extant in the Cairngorms area relatively small scale habitat continuity appears to be a more important requirement than total area. Existing CFA's in the Spey valley and on Deeside appear to be sufficiently large to sustain the larger species such as red squirrel and capercaillie, though both species are said to be declining. It also appears that nearest neighbour distances are sufficiently small to allow movement between patches, thus enabling these two species to make use of separate patches as if they were one. There is much to be gained by establishing and maintaining existing links, between the large areas of native woodlands at Rothiemurchus and those on neighbouring estates.

In general, habitat continuity on a fairly small scale seems to be more important than total area, probably because we have lost all of the large, woodland-dependant far-ranging mammals such as brown bear and wolf. The largest mammal, with fairly precise habitat requirements, remaining in the area is the red squirrel and it is unsurprising that this species emerges as an important 'key' member of the fauna, especially as it's natural niche breadth has been compressed due to the competitive

pressures of the introduced grey squirrel. The larger mammals such as the pine marten, fox, roe and red deer are all catholic and relatively opportunistic in their requirements.

9 Recommended Actions

1 Small scale lack of continuity seems to be limiting the expansion of some of the more sedentary species such as the saproxylic fauna and the key species of ants and spiders. The main requirement here is to establish new native woodland connections and attempt to restrict any gaps to less than 1-2 km. There is an important need to establish and manage for continuity (time) and contiguity (space) of woodlands of an appropriate structure at this scale. Such connections should be established through new planting and natural regeneration where appropriate, where existing woodland patches are isolated by distances greater than 1-2 km.

2 The existing large CFA's should be maintained, and extended where possible to ensure continuity of habitat for the larger wide ranging species. Outside the lowland areas of Riparian, Mesic Broadleaves and Acid Oak and Birch woods, there should be a presumption against the use of large-seeded broadleaves to reduce the opportunities of grey squirrels colonising the predominantly coniferous red squirrel strongholds.

3 Management should continue with the objective of trying to maintain a 'normal' forest structure, and it is important in the context of native woodland regeneration not to attempt to achieve large increases in woodland cover over too short a time period. Continuous cover silviculture is probably the most effective means of maintaining an appropriate balance of age classes and woodland structure. The existing LTWP appears to provide the means to achieve this.

4 The important range of invertebrate key species will clearly require continuity of habitats, but if they are to expand well beyond the minimum viable population size linkages of old growth will be necessary. Old Growth Core Areas (OGCA's) could be established with a minimal intervention regime, which could be connected by Extended Rotation Areas (ERA's), where trees are removed at a range of ages beyond normally accepted rotations. This should provide the necessary connections to allow populations to disperse from the OGCA's into the areas managed for timber production. Such ERA's should be designed with the 2 km rule in mind, that is, ERA connectivity should be planned to prevent gaps of more than 2 km. This is as important for riparian woodlands as it is for native pinewoods. It may be necessary to consider a re-appraisal of the status of the current Managed Intervention and Minimal Intervention Zones at Rothiemurchus.

5 The Rothiemurchus deadwood survey (1996/7) has revealed very low levels of dead and decaying wood. This may be restricting the viability of some species, and requires urgent attention. Consideration should be given to increasing the amounts of dead wood by killing some trees and by bringing in stumps, logs and branchwood from elsewhere if possible. Removal of dead and fallen trees should be prevented.

6 The extension linking of high altitude scrub treelines with lower ground at such places as Inschriach, Gleinn Einich and the Lairig Ghru would provide benefits. Riparian ecosystems could be effectively linked through Rothiemurchus by joining the

fragmented birchwoods along the Spey from Spey dam to Glenbeg and Lettoch, downstream of Grantown on Spey.

7 Woodland continuity (time) will perhaps be best achieved by establishing small patches of woodlands in remote suitable locations to act as future seed sources for natural regeneration.

Deer

8 Many key species seem to require a habitat structure which will only be maintained in the presence of relatively low levels of grazing, or from some simulated management. Deer densities of 4-6 deer km^{-2} are compatible with the regeneration of native woodlands and would probably help maintain the conditions for many of the key species. The recent effects of reduced deer densities at Abernethy and Rothiemurchus support this. Clearly, the regulation of red deer densities at these levels will largely remove the need to fence against deer achieving recreational, landscape and wildlife benefits, including the prevention of mortality of capercaillie and other woodland birds caused by collisions with deer fences. The management of deer at Rothiemurchus is in close accordance with these requirements, and it is recommended that the current work to maintain deer densities at these levels is continued.

Potential replacement of farmland

9 The largest potential impact will come from the necessary replacement of farmland by forests, but this should not be hurried, and the time scale will to some extent allow people to adjust to the changes. Riparian corridors are likely to cause the most impact as these will inevitably replace some better quality farmland, and may lead to some overlap with fishing interests. The proposed linking of the Spey valley birchwoods is a possible example of this. However, there are important benefits to riparian and aquatic ecosystems, and to fisheries, to be gained from restoring woodland cover to river banks. It is important to plan carefully to achieve the correct balance and type of woodlands.

10 This plan should be reviewed annually and updated relevant to the requirements of the key species identified.

References

Bayfield, N.G. and Conroy, J.W.H. (1996) The Cairngorms Assets The Cairngorms Partnership, Grantown

Biodiversity Challenge Group (1993) Biodiversity Challenge: an agenda for conservation in the UK. RSPB, Sandy.

Cairngorms Partnership (1996) Managing the Cairngorms - a consultation Paper. Badenoch and Strathspey. The Cairngorms Partnership, Grantown-on-Spey.

Cairngorms Working Party (1993). Common Sense and Sustainability : a Partnership for the Cairngorms. The Report of the Cairngorms Working Party to the Secretary of State for Scotland. Scottish Office, Edinburgh.

Department of the Environment (1995) The Habitats Directive: How it will apply in Great Britain. DoE, London.

Edgar, A. (1994) Biological files search and data organisation. Cairngorms sub-area. Unpublished Report to Scottish Natural Heritage, Strathspey

Freeman, P. (1995) Rothiemurchus. A Summary of its Ecological Interest. Unpublished Report, Rothiemurchus.

Gibbons, D. W., Fisher, I. and Avery, M.I. (1995) Linking species to habitats A Report of a Survey by the Biodiversity Challenge Group to English Nature.

Government Report (1994a) Biodiversity: the UK Action Plan. London, HMSO.

Government Report (1994b) Sustainable Forestry: the UK Programme. HMSO, London.

Government Report (1995) Biodiversity: The UK Steering Group Report. Volume 1: Meeting the Rio Challenge. Volume 2: Action Plans. HMSO, London.

Loiskekoski, M., Mahonen, M., Puranen, R and Rizk, N. (1993) Ministerial Conference on the Protection of Forests in Europe, 16-17 June 1993 in Helsinki Ministry of Agriculture and Forestry, Helsinki.

MLURI (1993) The Land Cover of Scotland 1988. The Macaulay Land Use Research Institute, Aberdeen.

MLURI (1996). Predicted NVC woodland distribution for the Cairngorms. Map by MLURI, Aberdeen.

Peterken, G. F., Baldock, D. and Hampson, A. (1995) A forest habitat network for Scotland. Scottish Natural Heritage Research, Survey and Monitoring Report. No 44.

Ratcliffe, P. R. (1993) Biodiversity in Britain's Forests. the Forestry Authority, Edinburgh.

Ratcliffe, P.R. and Peterken, G.F. (1995) The potential for biodiversity in British upland spruce forests. Forest Ecology and Management. 79, 153-160.

Ratcliffe, P.R., Peterken, G.F. and Hampson A. (1997 in press). A forest habitat network for the Cairngorms. Scottish Natural Heritage, Edinburgh.

Wynne, G., Avery, M., Campbell, L., Gubbay, S., Hawkswell, S., Juniper, T., King, M., Newbery, P., Smart, J., Steel, C., Stones, T., Stubbs, A., Taylor, J., Tydeman, C. and Wynde, R. (1995) Biodiversity Challenge (second edition). RSPB, Sandy.

Appendices

1 Habitat Action Plan for Native Pine woodlands

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