

7. Rothiemurchus: The Forest, its Ecology and Future Management

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Introduction

Rothiemurchus is one of the largest and most important remnants of the once extensive natural forests of Scotland. Although pinewoods are the predominant woodland type at Rothiemurchus, it is important to perceive this within the wider context of a mosaic of interacting ecosystems incorporating riversides and riparian areas, bogs, muskeg and the natural forest tree-line. Birch and juniper are important constituents of the pinewoods and oak, willow and alder form separate associations in places. The forest supports relatively high levels of biodiversity, but this can almost certainly be improved upon.

Caledonian pinewoods are included as a priority habitat in the EC Habitats Directive. Thirty-three native pinewoods in Scotland are designated as Sites of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act of 1981. A number of these have been proposed as Special Areas of Conservation (SACs) under the Habitats Directive, and are expected to become part of the 'Natura 2000' network of sites. Within the UK Biodiversity Action Plan, Native Pine Woodlands are targeted as an important ecosystem and a costed Habitat Action Plan (HAP) has been drafted.

An important objective of the Native Pine Woodland HAP is to restore and expand the natural diversity of composition and structure of the woodlands, and on a local scale at Rothiemurchus, a Woodland Biodiversity Action Plan is being prepared. An important underlying principle is that the future vision for the forest – the Desired Future Condition (DFC) – is not constrained by visions of some past natural state which might have occurred at some particular point in history, such as the immediate post-glacial, neolithic or mediaeval periods. Instead the DFC should be developed based on the prehistoric and historic evidence, on recent experience, and on future expectations, which will guarantee the sustainable delivery of a wide range of outputs in the future.

Building on the requirements of a range of sensitive, rare and threatened species which occur at Rothiemurchus, a vision of the future forest which caters for the need of all these species is developed. It is suggested that by providing a range of ecosystem components (or biodiversity surrogates) such as dead and decaying wood, which mimic the structure of natural forests, many species currently unknown at Rothiemurchus will be maintained. A pattern of

woodlands, including some large patches, which are linked together to form a network can provide habitats of a size and contiguity which will support a wide range of species, while safeguarding the requirements of non-woodland species and land-uses.

Rothiemurchus in an international context

The Rio Conference

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 world's biodiversity was a major part of the convention. UNCED led to a number of initiatives in Europe and in the UK which were designed to deliver the commitments made in Rio, including the sustainable management of forestry and the maintenance of biodiversity. Ratcliffe (1997) provides further details of these and the way in which they might influence local actions to increase forest biodiversity.

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 (Department of the Environment, 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.

The Helsinki Resolutions

The Ministerial Conference on the Protection of Forests in Europe at Helsinki in 1993 (Loiszekoski et al, 1993) established a basis for the sustainable management of European forests. The Helsinki conference established guidelines for the sustainable management and the conservation of biodiversity in European forests, recognising that the conservation of biodiversity is an essential component of sustainable management, and that it should be embodied in the preparation of forest policies, operational guidelines and legislation. The protection of primeval and special forests was emphasised.

Biodiversity: the UK Action Plan

Since 1992, the UK Biodiversity Action Plan (UKBAP) (Government Report, 1994a) has been progressed, and lists of target species and habitats have been drawn up, and Habitat Action Plans (HAPs) and Species Action Plans (SAPs) drafted for some of the most important ones (Government Report, 1995).

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Sustainable Forestry: the UK Programme

This programme laid the foundations for the sustainable management of forests in the UK:

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 Cairngorms

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 degraded in ecological terms and the continuity between different forest types, and between different structural types within forests, has to some extent been lost (Cairngorms Working Party, 1992). However, in a British context the woodland continuity and extent of large contiguous patches of forest is good.

Apart from Rothiemurchus, the woods of Strathspey and Deeside include other large and important pinewoods including those of Ballochbuie, Glen Tanar, Glen Quoich, Glen Lui, Glen Derry, Glen Feshie, Glen More and Abernethy. There are also a number of important native broadleaved woodland types which occur in the area.

The HAP for Native Pine Woodlands 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).

The Cairngorms Partnership

In 1992 the Cairngorms Working Party (CWP) report to the Secretary of State for Scotland (Cairngorms Working Party 1992), recommended the development of an integrated management strategy for the Cairngorms. This resulted in the establishment of the Cairngorms Partnership Board (CPB) with representatives from local, national and international interests in the area.

In addressing the requirements of a management strategy the CWP suggested

three altitudinal zones :

- 1 The mountain and plateau zone: above the former natural tree line (about 600m.).
- 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 m. 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 m. in Strathspey and below 425 m. in upper Avonside and upper Deeside).

This chapter is concerned primarily with the ecology of the woodlands of the forest and valley zones but there are interactions with the mountain and plateau zones and with moorland, with many 'woodland' organisms foraging outside the woodlands. The interactions between moorland, semi-natural and plantation woodland, bogs, wetlands and riparian areas are complex and dynamic. Woodlands cover about 61,400 ha or 11.8% of the Cairngorms.

Local Actions

The Biodiversity Action Plan Steering Group developed guidance for the production of Local Biodiversity Action Plans (LBAPs) (Government Report 1995). LBAPs 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 to deliver the objectives of national HAPs and SAPs at a local level. It is assumed that Local Authorities will usually lead and that the process will be linked to local or national funding to stimulate the interest of land managers.

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 is an audit of species and habitats present in the Cairngorms, and local actions will need to be developed for priority species and habitats (*pers. comm.*: Clifton Bain, RSPB; Janet Adamson, CPB).

The development of a Woodland Biodiversity Action Plan (WBAP) at Rothiemurchus was considered to be an effective way of determining priorities on an individual estate basis. The objective of the Rothiemurchus WBAP is to describe the strategy and tactics for assessing, maintaining and increasing biodiversity within the forest. A preliminary audit of priority species has been

conducted and some actions considered necessary to safeguard them have been identified. It is hoped that this plan will complement the development of a LBAP for the Cairngorms PBA, and that it will provide some guidance for the preparation of WBAPs in other areas.

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 tree-line – 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 with the higher grassland areas being important as deer summering grounds. 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. (CWP, 1992)

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.

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.



7.1: Rapid increase in seedling establishment and growth following a reduction in deer numbers. Photograph: P R Ratcliffe

Our vision of the future forest should eventually be translated into a more detailed description of the Desired Future Condition (DFC) (Ratcliffe and Peterken, 1995). It should not be constrained by impressions of past eras of the wildwood or particular periods of human occupancy, but should build on the prehistoric and historic evidence, on recent experience and on future expectations. We should 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, timber production, economics, etc.) is the only major constraint that we should work to.

Biodiversity

Biodiversity describes the variety of living things. Although here we are concerned primarily with the forest, 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 add to the biodiversity of 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 is 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 secondary attack by other organisms; and ants play a part in the dispersal of plant seeds.

Proposed increases in biodiversity should be carefully managed within the natural, chemical and physical constraints of the sites, and be consistent with the ecology of all of the woodlands, including non-native species and those managed for commercial objectives.

Biodiversity is difficult to measure, and there are few ecosystems where there are adequate species lists available, 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. The concept of managing biodiversity surrogates in a holistic way is very important in ecosystem management. However, without some knowledge of at least some of the requirements, of some of the species, it is rather difficult to proceed.

How can biodiversity be improved upon?

Although Rothiemurchus is one of the largest native forest remnants left in Britain, it actually represents a mosaic of small fragments of the post-glacial forest and it is this fragmentation that has resulted in losses in biodiversity. It seems likely, therefore, that a wide range of species will benefit from a reversal of fragmentation.

The importance of fragmentation to particular species is dependent 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.

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 (DFOs) 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 WBAP becomes integrally linked with other aspects of estate planning, such as the Rothiemurchus Forestry Long Term Working Plan (Hackett, Milner and Orr, 1996).

It is important that woodland restoration does not proceed to cause the large scale demise of non-woodland ecosystems and land-uses, such as grouse moors and open range deer stalking. However, the extension and restoration of forests will frequently require a reduction in deer numbers, and thus in the scale of deer stalking activity. In some priority areas local and seasonal impacts from deer will need to be reduced to very low levels.

Biodiversity can be increased in riparian areas by restoring native woodlands adjacent to rivers and their tributaries and this can also enhance the productivity of fish populations and aquatic life. In this way the recreational and social benefits associated with fishing, as well as the biological benefits, can be increased.

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. In order to minimise adverse impacts on non-woodland habitats, woodland expansion must be limited and, in this context, the provision of corridors connecting isolated fragments is considered to be valuable.

Forest Habitat Networks

A Forest Habitat Network (FHN) (Peterken, Baldock and Hampson, 1995) provides a means of increasing the area of habitats for a range of woodland species while minimising the adverse impacts on non-woodland land-uses and ecosystems. The FHN allows the development of a landscape mosaic which optimises opportunities for species requiring large habitat patches simply by

increasing patch size. But more importantly it links patches together to increase the *effective* area of available habitat while minimising encroachment onto non-woodland areas. In addition it permits the dispersal and movement of a wide range of species over both short and long distances.

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 they simply represent edge to wide ranging mobile species. The need for large patches of contiguous habitat is therefore likely to be far more important to large, wide ranging woodland specialists, than to small immobile ones.

Given that any expansion of forests in the Cairngorms should occur over a long time scale (c.100 years), patch sizes which are big enough to accommodate a wide range of extant and extinct species should be planned for. This will result in the provision of extended habitats for currently sensitive, 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.

Against the potential benefits of increasing connectivity 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 grey squirrel and Japanese sika deer. Grey squirrels are present on lower Deeside while sika deer populations occur at a number of locations around the Cairngorms. The nearest sightings of sika deer to Rothiemurchus have been near Kingussie. However, there is already sufficient cover to allow the spread of sika deer into Strathspey, and the high proportion of conifers in the forests of upper Deeside seem to have prevented rapid colonisation by grey squirrels.

Clearly, the likely benefits from providing corridors or networks are very dependent upon a knowledge of the species being targeted and the pluses and minuses need to be carefully considered. However, the benefits usually seem to outweigh the disadvantages.

Woodland types present in Rothiemurchus

A classification of woodland types, which reflects the requirements of important species, has been proposed for the Cairngorms (Ratcliffe, Peterken and Hampson, 1998). These 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. All of these seven forest types occur in Rothiemurchus.

1 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. This type may also include secondary birch woodlands, alder/sallow scrub, birch and pine scrub on acid mires and pine/alder mixtures.

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

3 Acid oak and birch woods

Oak/hazel and oak/birch woods on acid well drained soils. Virtually all survive in the lowland areas. Oak/pine woods are intermediate between this and the next type.

4 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. 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.

5 Sub-montane scrub

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

6 Coniferous plantation

Plantations usually established on heathy sites and former mires. Usually colonised by birch, rowan, alder and willow. Occur in lowland, riparian to sub-montane zones.

7 Policy woodlands

Derived from plantations of a wide range of exotic species in nineteenth century or earlier.



7.2: A well established rowan seedling which has been repeatedly browsed by deer, preventing it emerging from the surrounding heather canopy.

Photograph: P R Ratcliffe

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:

1 Establishment

Most of the trees are less than 1 m. high 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.

2 Pre-thicket

This is the stage when trees are between 1 m. high 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.

3 Thicket

Most trees are between three and ten metres high. 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 its 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.

4 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.

5 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 CWD. There will be significant gaps in the canopy, adding to the complexity of the mosaic. There will be a well developed, multi-layered understorey. The availability of a wide range of ecological niches, especially those associated with CWD, will support a wide range of specialist species.

Biodiversity conservation

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. 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 species (often the charismatic mega-fauna). 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 considering species. But, which ones?

The approach adopted here is based on the selection of a number of sensitive, rare and threatened species in Rothiemurchus. After considering their detailed requirements in terms of patch size, dispersal distance, habitat requirements, etc., ecological similarities were identified in an attempt to link these together and 'rebuild' the ecosystem approach based on surrogate habitat components to the mutual benefit of most if not all of the species.

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 these species are, by definition, most at risk and therefore most in need of positive management.

The species fall into two main types: the large, wide-ranging animals with rather narrow niche requirements, such as capercaillie and red squirrel; and those sedentary plants and animals with poor powers of dispersal and narrow niche requirements such as the ancient woodland plants, 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. 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 and they may be critical for the maintenance of biodiversity. It is, therefore, wise to prioritise their conservation. In Scotland, the large carnivores which were characteristic of upland woodlands are now extinct, 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.

Native pinewoods (pine-birch-juniper woodlands) are the most extensive

woodland type in the Cairngorm area. They form the main forest matrix throughout the Spey valley and are the most widespread woodland type at Rothiemurchus. Consequently, this woodland type has been targeted rather more intensively than other woodland types.

The species

The species were selected as objectively as possible by linking species of conservation importance – identified by the UK Biodiversity Action Plan process (Government Report, 1995) – with particular woodland habitats (see also Gibbons et al, 1995). Subsequently, the Invertebrate Site Register for Rothiemurchus (SNH), 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 so far selected. In addition, species specialists were approached to identify gaps and to provide autecological information.

However, it is important to note that the reason for using surrogates as a means of conserving biodiversity is based on the fundamental principle that we cannot expect to acquire the knowledge required for the conservation of every species of concern, and therefore any species list can only represent a part (hopefully a representative part) of the overall biodiversity. It is also impossible to specify in detail which species actually occur within the estate boundaries of Rothiemurchus, nor is it considered particularly helpful to do so. This is because biological recording has not been focused within the estate boundary, but rather more on the parts of Rothiemurchus which occur within the SSSIs and within the Cairngorms NNR, which include substantial amounts of non-wooded habitats. Equally, the selection of species is biased to those which occur in pinewoods and this may result in the omission of some species which are associated predominantly with woodland ecotones which intergrade into other habitats such as wetlands. For example, the rare dragonflies, *Aeschna caerulea*, *Somatochlora arctica* and *Coenagrion hastulatum* which breed in the forest mires and lochans, have been omitted from consideration here.

The selection of species is also influenced by different classifications of species into categories such as rare, sensitive, threatened and local. For example, eleven invertebrate RDB species and 84 notable species have been found in the North Rothiemurchus SSSI, and the area is rated as of Regional Importance by the British Lichen Society (Freeman, 1995). Clearly all of these species could not be considered here, but this classification has provided a relatively objective means of simplifying the list to a workable number of representative species.

This work was developed concurrently with that of Ratcliffe, et al (1999) and the same methodology used. The species accounts are presented without justifying all statements with references, for clarity. Full references are available in Ratcliffe, et al (1999).

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 ant species to fragmentation due to difficulty in dispersing over 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: possibly c.100m. *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.

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 pinewoods 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 its 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. They appear to be intolerant of human disturbances.

Habitat requirements: Sunny edges and clearings in pine woods (usually their southern aspects). 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.

3 *Formica lugubris* (northern wood ant)

Current status: Localised, but widely distributed in northern Europe. Locally distributed in the pinewoods of Speyside.

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. Therefore, good dispersal prospects and an ability to colonise young growth. c.2 km.

4 *Blera fallax* (a hoverfly)

Current status: Rare. In Scotland known only from Speyside 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 rufa* (a hoverfly)

Current status: Rare. Recorded from about thirty 10km squares in the UK 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 100 years 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 Kincaid 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)

A rare cleptoparasitic wasp parasitizing *Osmia uncinata* (see above). No further 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: Unknown.

9 *Diplocephala 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 diversely 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 in Scotland.

Causes of loss or decline relevant to habitat connectivity: unknown

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 and it is not always afforded full species status. It is mainly confined to native pinewoods or old established plantations. Recent reports suggest that there about 1,500–2,500 individuals in the UK, but numbers seem to fluctuate widely between years and counting is made difficult due to large irruptions of common crossbills from the continent. 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.

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.



7.3: The highest natural tree-line in Scotland at Creag Fhiaclach, Rothiemurchus (c. 600m). Stunted native Scots pine. Photograph: P R Ratcliffe

14 *Parus cristatus* (crested tit)

Current status: A localised breeding population occurs in the Moray catchment and Speyside. 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 of Rothiemurchus, Abernethy and Glen More carried the largest populations during the early 1970s, 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. 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 four metres above the ground.

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. Two birds were recorded at Linn of Dee which may have travelled through the Lairig Ghru (Grant, 1984).

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 around 1770, but the population expanded after introductions in the nineteenth century, initially at Taymouth Castle in 1837, and their numbers seemed to fluctuate with the availability of habitat up to about 1960. A tenfold decline in numbers has occurred over the past 20–30 years and numbers are considered to be around 2,000 birds at present.

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. Many birds have been killed by flying into deer fences, and this mortality may also be contributing to their 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 300–400 ha based on one lek, but a minimum of 1000 ha, of not necessarily continuous forest, is necessary to support a viable population.

Mobility and dispersal potential: Some hens are known to have moved over 20 km 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 spread of grey squirrels, habitat fragmentation and disease. Red squirrels appear to be unable to compete with greys in woodlands with large proportions of large-seeded broadleaved trees. 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 conifers 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.

17 *Castor fiber* (European beaver)

Current status: Extinct in Britain since sixteenth century. Serious declines throughout Europe have been countered by re-introduction programmes (eg in Norway, Poland, Holland and France). Scottish Natural Heritage are investigating the feasibility of reintroducing the species to Scotland (SNH, 1996).

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. 5 km²

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 m. of the waters edge. They do not seem to disperse

across open country away from water courses.

18 The characteristic pinewood plants: creeping lady's tresses (*Goodyera repens*), twinflower (*Linnaea borealis*) and one flowered wintergreen (*Moneses uniflora*).

Current status: All are rare.

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

Habitat requirements: Largely restricted to pinewoods. All are mycorrhizal and all require damp conditions.

Minimum patch size: Unknown.

Mobility and dispersal potential: Most spread is by vegetative means, which limits their 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.



7.4: A previously suppressed Scots pine sapling with multiple leading shoots due to repeated browsing by deer. Recent reductions in deer numbers have allowed a rapid increase in growth. Photograph: P R Ratcliffe

19 The aspen saproxylic insect community (Table 1).

Current status: The first species (Table 1) is new to science, the second is a new record in Britain and the next six are Red Data Book Species. The remainder are all 'Notable' species. Aspen woods are a scarce resource in highland Scotland (total area of 157 ha), and woods larger than 1 ha are largely confined to the Spey valley between Newtonmore and Grantown-on-Spey. Consequently any species dependent on aspen are likely to be under threat. The saproxylic species listed have not been recorded on other species of tree. Not all the species in Table 1 have been recorded at Rothiemurchus, but small areas of aspen are present.

Causes of loss or decline relevant to habitat connectivity: Possibly loss of habitat and fragmentation.

Habitat requirements: Moist, rotting cambium of dead aspen.

Minimum patch size: About 2 ha. Woods of less than 1 ha are usually poor in saproxylic invertebrates. Woods larger than 4.5 ha are required to support the full range of species.

Mobility and dispersal potential: Possibly relatively mobile in terms of moving through adjacent wooded habitats, though unlikely to be able to traverse more than about 1 km through very hostile (non-wooded) habitats.

Table 1: The aspen saproxylic insect community of conservation significance in the Cairngorms

	Status
<i>Ecataetia</i> spp (a fly)	New species
<i>Mycetobia obscura</i> (a fly)	New species to Britain
<i>Hammerschmidtia ferruginea</i> (a hoverfly)	RDB 1 (Endangered)
<i>Homalocephala albitaris</i> (a fly)	RDB 1
<i>Strongylophthalmyia ustulata</i> (a fly)	RDB 1
<i>Tachypeza heri</i> (a fly)	RDB 2 (Vulnerable)
<i>Tachypeza truncorum</i> (a fly)	RDB 3 (Rare)
<i>Medetera insspissata</i> (a fly)	RDB 3
<i>Gnophomyia viridipennis</i> (a fly)	Notable (Occurrence in 16-100 10 km grid squares)
<i>Clusoides apicalis</i> (a fly)	Notable
<i>Stegena coleoptera</i> (a fly)	Notable
<i>Lonchaea peregrina</i> (a fly)	Notable
<i>Systemus pallipes</i> (a fly)	Notable
<i>Xylota tarda</i> (a fly)	Notable
<i>Criorhina ranunculi</i> (a hoverfly)	Notable
<i>Saperda carcharius</i> (a beetle)	Notable

Further sensitive, rare and endangered species were identified from the Scottish Natural Heritage site registers for the National Nature Reserve and Sites of Special Scientific Interest (Table 2). These species do not necessarily occur in

Rothiemurchus but probably do so. There appears to be little autecological information on these species, and conservation management must rely on the precautionary principle to maintain suitable conditions until such information is available.

Table 2: Additional woodland species of conservation significance in the Cairngorms

Invertebrates

<i>Acanthocinus aedilis</i>	Timberman beetle	pine
<i>Thanasimus rufipes</i>	Chequered beetle	pine
<i>Rhizophagus parvulus</i>	a bark beetle	
<i>Ostoma ferrugineum</i>	saproxylic beetle	pine
<i>Chrysanthia nigricornis</i>	saproxylic beetle	pine
<i>Chamaesyrrhus caledonicus</i>	a hoverfly	pine
<i>Chamaesyrrhus scaevoides</i>	a hoverfly	pinewoods
<i>Rhyacionia duplana</i>	Elgin shoot moth	pinewoods

Fungi

<i>Boletus flavidus</i>		pinewoods
<i>Collybia aceroata</i>		
<i>Cortinarius pinicola</i>		
<i>Lactarius hyssiginus</i>		
<i>Lactarius musteus</i>		
<i>Mycena purpureofolia</i>		
<i>Russula paludosa</i>		
<i>Russula virosa</i>		
<i>Tricholema albobunneum</i>		
<i>Tricholema equestre</i>		
<i>Tricholema focale</i>		

Lichens

<i>Calicion hyperelli</i>		pinewoods
<i>Calicium</i> spp.		
<i>Chaenotheca</i> spp.		
<i>Xylographa</i> spp.		

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 3: Summary of data for selected species

Species	Dispersal distance	Minimum patch size	Habitat	Grazing required
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				
<i>Blera fallax</i>	?	? 1 tree	pine rot hole	-
<i>Callicera rufa</i>	c. 5 km	? 1 tree	pine rot hole	-
BEEES & WASPS				
<i>O. uncinata</i>				
<i>C. hirsuta</i>				
SPIDERS				
<i>Clubonia subsultans</i>	?	? 5 ha	open pine	some
<i>Diploena torva</i>	?	? 5 ha	open pine	some
<i>Pelecopis elongata</i>	?	? 5 ha	open pine	some
FLIES				
<i>Xylophagus cinctus</i>	5-10 km	10 ha	pine bark	-
<i>Medetera exellens</i>	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				
creeping lady's tresses	{ All these have limited powers of {dispersion and spread mainly {vegetatively			
twinflower				
one flowered wintergreen				

Common factors

Although there is a notable lack of information, certain important common factors emerge from an analysis of the species accounts. Several species seem unable to disperse much more than a distance of 1-2 km, and some areas of contiguous woodland, which are larger than the needs of the species with the largest minimum patch size, appear to be important.

Red squirrel and capercaillie require some patches larger than 500 ha. Red squirrels may be able to cope better than capercaillie in areas as small as 100 ha as long as sufficient suitable habitat occurs within 2 km of the patch. Both species seem to benefit when maximum distances between patches do not exceed 2 km. Scottish crossbills, crested tits and Scottish wood ants also appear to benefit from this pattern. Some patches can be smaller, but it seems that virtually all pinewood species will benefit from patches larger than 5 ha.

Many species require pinewoods with an open structure and a diverse herb and shrub layer, which in many places is 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 (in time) and contiguity (in space) of this habitat. The existing areas and structure of forest in Rothiemurchus appear to be sufficiently large to sustain red squirrel and capercaillie, and patches seem to be sufficiently close to each other to allow movement. There is much to be gained by maintaining existing links and in establishing new ones.

Developing the Desired Future Condition

Small scale lack of continuity may 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 most gaps to less than 1 km. There is an important need to establish and manage for continuity and contiguity of woodlands of an appropriate structure at this scale. Connections should be established, where existing woodland patches are isolated by distances greater than 1 km, by natural regeneration, where possible, but new planting may be necessary in some places. The planting of small patches of native woodlands in remote non-wooded areas can act as future seed sources for natural regeneration. This will help establish a temporal pattern of diversity.

The existing large forest areas should be maintained, and extended where appropriate to ensure continuity of habitat for the larger wide ranging species, specifically capercaillie and red squirrel. However, this should not be allowed to impact seriously on other land-uses such as deer stalking and grouse shooting, or on important non-wooded habitats. There should be a presumption against any further planting of large-seeded broadleaves to reduce the opportunities of grey squirrels colonising.

The extension linking of high altitude scrub tree-lines with lower ground at such places as Inshriach, Gleann Einich and the Lairig Ghru would provide

benefits. Improved connectivity of the fragmented birchwoods along the Spey, from Spey Dam in the west to Glenbeg and Lettoch downstream of Grantown-on-Spey in the east, could provide important linked riparian habitats through Rothiemurchus. In some situations relatively large scale planting should not automatically be ruled out, especially in places where very long time scales may be required before natural woodland colonisation will occur. An alternative is to establish small exclosures of native tree species in such places to provide seed sources for future colonisation. Some replacement of farmland by woodlands may be inevitable; however, this is likely to be relatively small scale, and it should not be hurried. The time scale will to some extent allow people to adjust to the changes.

Management should continue with the objective of trying to maintain a 'normal' forest structure (Hackett et al, 1996), 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. A management mix of continuous cover, silviculture, and small scale clear-cutting will mimic natural disturbance regimes, and these methods should be used to complement each other in achieving an appropriate balance of age classes and woodland structure. The existing LTWP appears to provide the means to achieve this.

The important range of selected invertebrate 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 (OGCAs) could be established where no removal of timber would be permitted, which could be connected by Extended Rotation Areas (ERAs), where a proportion of 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. ERA connectivity should be planned to prevent gaps of more than 1 km. This is as important for riparian woodlands as it is for native pinewoods. There is an important need to encourage the development of markets for big logs.

A large range of species require CWD in one form or another. Rot holes in tree stumps, humid and dry bark and dead wood in a variety of micro-climates provide habitats for a wide range of common and rare species (see Ratcliffe, 1993). Snags (standing dead trees with no top), more than 22 cm diameter and between 0.5-4.0 m tall are required as nesting sites for crested tits.

A recent survey (Hackett, 1996) has revealed rather low levels of CWD relative to what could be available in managed woodlands of these types. This may be restricting the viability of some species, and consideration should be given to increasing the amounts of dead wood. Removal of dead and fallen trees should be prevented and killing some trees by ring barking, and felling some trees from high stumps (c.>1.5 metres), could quickly increase the amounts of this important resource.

Many important 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, black grouse and other woodland birds caused by collisions with deer fences (Ratcliffe, 1998). The need to regulate the local and seasonal impact of deer may, however, require the use of temporary, small-scale fencing from time to time especially to protect sensitive species such as aspen, hazel and holly. 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.



7.5: Holly (rare in Rothiemurchus) protected from deer browsing by dense juniper. Mature Scots pine in background. Photograph: P R Ratcliffe

Acknowledgements

This work has drawn heavily on a previous study commissioned by Scottish Natural Heritage (Ratcliffe et al, 1998), and on a study to develop a Woodland Biodiversity Action Plan for Rothiemurchus conducted for Finlayson-Hughes of

Inverness and funded by the Forestry Authority. Many people, too numerous to mention, helped me but I am especially grateful to David Carstairs and Keith Duncan (SNH, Achantoul), Dave Phillips (SNH, Edinburgh) and Iain MacGowan (SNH, Battleby) for their help in compiling the species lists and providing much autecological information. Mairi Cooper (SNH, Edinburgh) provided recent information on red squirrels and on the feasibility of reintroducing the beaver to Scotland. Clifton Bain (RSPB) and Janet Adamson (CPB) provided information on the development of the LBAP for the Cairngorms. Last, but not least, I thank Johnny and Philippa Grant for their warm hospitality during my visits to Rothiemurchus, and for the privilege of working in one of the finest natural environments in Scotland.

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